



## **AP<sup>®</sup> Biology 2013 Scoring Guidelines**

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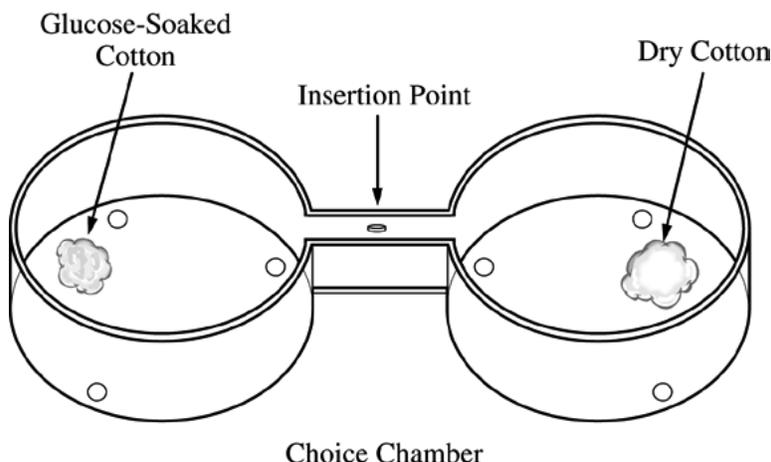
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## Question 1



In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10 percent glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

- (a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction. **(2 points maximum)**
- 1 point for predicting the location of the flies in the choice chamber
  - 1 point for justifying the prediction
- (b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment. **(4 points maximum)**
- Experimental control
  - Environmental factors

	Proposed Improvement (includes but not limited to) <b>(1 point maximum)</b>	Explanation <b>(1 point maximum)</b>
Experimental control	Replace the dry cotton ball with a water-soaked cotton ball.	Ensures that glucose is the attractant
	Constant light or temperature or duration of experiment or time of day, etc.	Other variables must be held constant

	Proposed Improvement (includes but not limited to) <b>(1 point maximum)</b>	Explanation <b>(1 point maximum)</b>
Environmental factors	<ul style="list-style-type: none"> <li>• Use different concentrations of glucose</li> <li>• Use different temperature(s)</li> <li>• Use different light levels</li> <li>• Use a different choice chamber (size/shape)</li> <li>• Vary duration of the experiment</li> <li>• Vary time of day when experiment is performed</li> </ul>	Attributes movement of flies only to glucose preference

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**Question 1(continued)**

- (c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

**Perform** a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below. **(2 points maximum)**

PART (c): CHI-SQUARE CALCULATION

<u>Null Hypothesis: (1 point)</u>			
The flies will be evenly distributed across the three different parts of the choice chamber.			
	Observed (o)	Expected (e)* (1 point)	$(o - e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	48.9
*Expected values must be those predicted by the null hypothesis provided in the student response, add up to 60, and include no cells equal to 0.			

- (d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation. **(1 point maximum)**
- Correct explanation with justification of why the stated null hypothesis is rejected or not rejected. Response must clarify each of the following:
    - degrees of freedom (df) = 2 and p = 0.05 (critical value = 5.99)
    - OR
    - degrees of freedom (df) = 2 and p = 0.01 (critical value = 9.21)
    - how the calculated test statistic compares to the selected critical value
    - whether the null hypothesis should be rejected

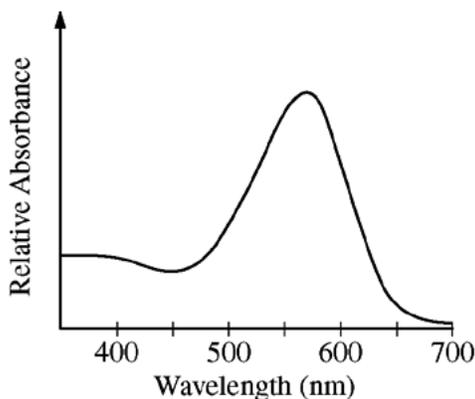
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**Question 1(continued)**

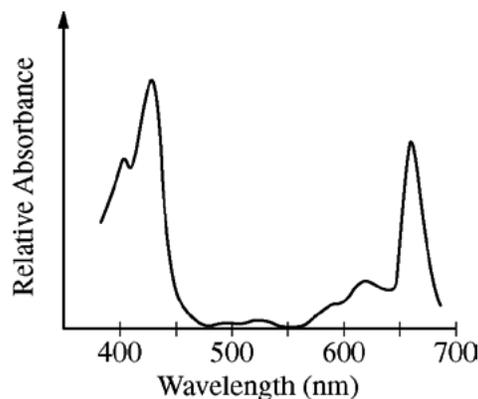
- (e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber. (**1 point maximum**)
- Stimulus → Response
  - Input →(possible integration) →Output

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**Question 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

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. (3 points maximum)

<b>1 point per box</b>
<b>Identify</b> BOTH pigments: Graph 1 = bacteriorhodopsin AND graph 2 = chlorophyll <i>a</i>
<b>Explain</b> 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.
<b>Explain</b> that an organism containing chlorophyll <i>a</i> appears green because the pigment absorbs light in the red and blue ranges of the light spectrum and/or reflects green light.

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**Question 2 (continued)**

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

<p>Proposal that includes an environmental selective pressure:</p> <ul style="list-style-type: none"> <li>• Green light was being absorbed by aquatic organisms using bacteriorhodopsin.</li> <li>• Unabsorbed wavelengths of light were available resources that organisms could exploit.</li> <li>• Absorbing visible light at all wavelengths may provide too much energy to the organism.</li> <li>• Absorbing light from ultraviolet wavelengths (shorter wavelengths = higher energy) could cause damage to the organism.</li> <li>• Absorbing light with longer wavelengths may not provide sufficient energy for the organism.</li> </ul>
<p>Appropriate reasoning to support the proposal:</p> <ul style="list-style-type: none"> <li>• Natural selection favored organisms that rely on pigments that absorb available wavelengths of light.</li> <li>• Endosymbiosis: chloroplasts evolved from cyanobacteria with pigments that used only certain wavelengths.</li> <li>• Genetic drift eliminated pigments that absorbed certain wavelengths of light.</li> <li>• Mutation(s) altered the pigment(s) used by organism.</li> </ul>

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**Question 3**

Fossils of lobe-finned fishes, which are ancestors of amphibians, are found in rocks that are at least 380 million years old. Fossils of the oldest amphibian-like vertebrate animals with true legs and lungs are found in rocks that are approximately 363 million years old.

Three samples of rocks are available that might contain fossils of a transitional species between lobe-finned fishes and amphibians: one rock sample that is 350 million years old, one that is 370 million years old, and one that is 390 million years old.

(a) **Select** the most appropriate sample of rocks in which to search for a transitional species between lobe-finned fishes and amphibians. **Justify** your selection. **(2 points maximum)**

- Selection: Rocks from 370 MYA sample.
- Justification: Transitional fossils are found between 380 MYA (when lobe-finned fishes lived) and 363 MYA (when amphibians appeared) OR between different strata/layers in the correct order.

(b) **Describe** TWO pieces of evidence provided by fossils of a transitional species that would support a hypothesis that amphibians evolved from lobe-finned fishes. **(2 points maximum)**

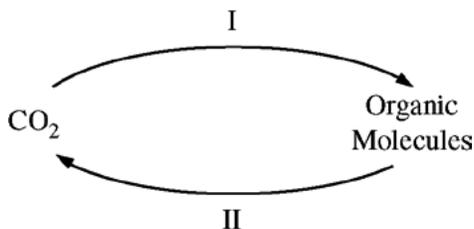
Descriptions include but are not limited to the following:

- Bones OR specific skeletal structures
  - legs /limbs/digits
  - vertebrae
  - flat skulls
  - (interlocking) ribs
  - flexible neck
- Scales
- Teeth
- Other homologous structures
- Has traits of both the lobe-finned fish and the amphibian
- Finding the transitional fossils in the same area/same environment as either the lobe-finned fish or the amphibian
- Molecular (DNA) evidence

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**Question 4**

Matter continuously cycles through an ecosystem. A simplified carbon cycle is depicted below.



- (a) **Identify** the key metabolic process for step I and the key metabolic process for step II and briefly **explain** how each process promotes movement of carbon through the cycle. For each process, your explanation should focus on the role of energy in the movement of carbon.

Identification: **1 point maximum**

I = photosynthesis / Calvin cycle AND II = (cellular) respiration / citric acid cycle / Krebs cycle
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Explanation: **1 point each row; 2 points maximum**

Process	Carbon Input	Role of Energy in the Movement of Carbon	Carbon Output
Photosynthesis	CO <sub>2</sub> is fixed	Uses (light) energy OR ATP from light reactions	Organic molecules
(Cellular) Respiration	Organic molecules are hydrolyzed / broken down	Uses energy for cellular processes such as growth and /or ATP production	CO <sub>2</sub>

- (b) **Identify** an organism that carries out both processes. **(1 point maximum)**

- Plant
- Algae
- Photosynthetic protist (e.g., Euglena)
- Cyanobacterium
- CO<sub>2</sub> fixing bacterium
- Lichen (not fungus)

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**Question 5**

The table below shows the amino acid sequence of the carboxyl-terminal segment of a conserved polypeptide from four different, but related, species. Each amino acid is represented by a three-letter abbreviation, and the amino acid residues in the polypeptide chains are numbered from the amino end to the carboxyl end. Empty cells indicate no amino acid is present.

Species	Relative Amino Acid Position									
	1	2	3	4	5	6	7	8	9	10
I	Val	His	Leu	Val	Glu	Glu	His	Val	Glu	His
II	Val	His	Leu	Lys	Glu	Glu	His	Val	Glu	His
III	Val	His	Leu	Val	Glu	Glu	His	Val		
IV	Val	His	Leu	Val	Arg	Trp	Ala	Cys	Met	Asp

- (a) Assuming that species I is the ancestral species of the group, **explain** the most likely genetic change that produced the polypeptide in species II and the most likely genetic change that produced the polypeptide in species III. **(2 points maximum)**

Explanation: **1 point per row**

NOTE: Specific names of mutation types are not required.

Species	Genetic Change in DNA / Bases	Result of Change to Polypeptide / Protein
II	mutation / substitution / point mutation / missense mutation	an amino acid change only at position 4 (Val to Lys)
III	mutation (e.g., substitution / insertion / deletion / point mutation / frameshift mutation / nonsense mutation) that introduces a stop codon after the codon for Val	termination of the polypeptide after the Val at position 8

- (b) **Predict** the effects of the mutation on the structure and function of the resulting protein in species IV. **Justify** your prediction. **(2 points maximum)**

Predicted Change <b>(1 point maximum)</b>	Justification of Prediction <b>(1 point maximum)</b>
Protein may have a different structure and a change in function.	Change in amino acid sequence of the protein starting at position 5 could alter the overall structure or local structural regions, interfering with function of the protein.
Protein may have a different structure and no change in function.	Change in amino acid sequence alters the shape / conformation / folding / binding region / regulatory region of the protein, but does not affect the critical functional region(s) of the protein.
Protein structure and function may not be affected.	Change in amino acid sequence does not alter the protein shape / conformation / folding and does not alter function.

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### Question 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. (3 points maximum)

<u>Cell Type</u>	<u>Identify function</u>		<u>Explain how data support identification (1 point each correct pair).</u> <u>NOTE: No points for identification without explanation.</u>		
X	<ul style="list-style-type: none"> <li>Locomotion</li> <li>Movement / surface transport</li> </ul>	<b><u>AND</u></b>	Has cilia for movement <u>and</u> large amounts of mitochondria to provide energy for locomotion of cell itself (ciliated protist) or movement of particles (mucus / oocyte) along cell surface		
Y	<ul style="list-style-type: none"> <li>Secretion / exocytosis</li> <li>Protein synthesis</li> </ul>	<b><u>AND</u></b>	Has large amounts of rough ER <u>and</u> Golgi to produce and package proteins		
	<ul style="list-style-type: none"> <li>Lipid/hormone synthesis</li> <li>Detoxification</li> </ul>	<b><u>AND</u></b>	Has large amounts of smooth ER to produce lipids / hormones		
Z	<ul style="list-style-type: none"> <li>Transport</li> </ul>	<b><u>OR</u></b>	<ul style="list-style-type: none"> <li>Oxygen transport in animal cells</li> <li>Water transport in plant cells</li> </ul>	<b><u>AND</u></b>	Does not require these organelles
	<ul style="list-style-type: none"> <li>Protection</li> </ul>	<b><u>OR</u></b>	<ul style="list-style-type: none"> <li>Epidermal cells (stratum corneum, cork, nails)</li> </ul>	<b><u>AND</u></b>	
	<ul style="list-style-type: none"> <li>Support</li> </ul>	<b><u>OR</u></b>	<ul style="list-style-type: none"> <li>Ground tissue (sclerenchyma)</li> <li>Vascular tissue (xylem)</li> </ul>	<b><u>AND</u></b>	
	<ul style="list-style-type: none"> <li>Storage</li> </ul>	<b><u>OR</u></b>	<ul style="list-style-type: none"> <li>Maximizes volume / space available (hemoglobin, oxygen)</li> </ul>	<b><u>AND</u></b>	
	<ul style="list-style-type: none"> <li>No function</li> </ul>	<b><u>OR</u></b>	<ul style="list-style-type: none"> <li>Is a dead cell/is undergoing apoptosis</li> </ul>	<b><u>AND</u></b>	

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**Question 7**

In an experiment, rats averaging 300 g of body mass were tested several times over a three-month period. For each individual rat, urine was collected over a three-hour period after ingestion of 10 mL of liquid (water, 1 percent ethyl alcohol solution, or 5 percent ethyl alcohol solution). The volume of urine was then measured, and the results were averaged for all individuals within each experimental group. The data are shown in the table below.

THREE-HOUR URINE OUTPUT FOLLOWING FLUID INGESTION

Fluid ingested (10 mL)	Water	1% Ethyl Alcohol	5% Ethyl Alcohol
Average urine output (mL)	3.5	3.8	4.7

- (a) **Pose** ONE scientific question that the researchers were most likely investigating with the experiment. (1 point)

Appropriate questions include but are not limited to the following:

- How does alcohol consumption affect urine output in rats (or any mammal)?
- How does alcohol consumption affect regulation of the kidney?

- (b) **State** a hypothesis that could be tested to address the question you posed in part (a). (1 point)

Appropriate hypotheses include but are not limited to the following:

- Alcohol consumption increases urine output in rats.
- Alcohol consumption increases water retention/reabsorption in rat kidneys.
- Alcohol consumption reduces urine output in rats.
- Alcohol consumption has no effect on urine output in rats.

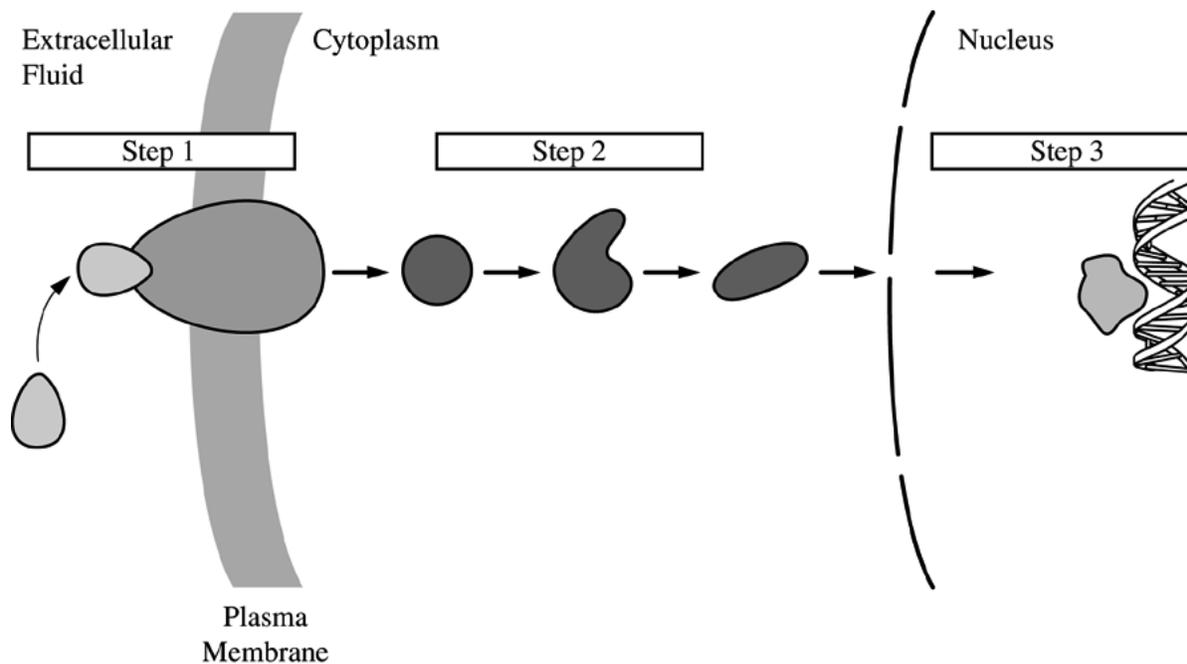
NOTE: This point may be earned without earning the point in part (a)

- (c) Using the data in the table, **describe** the effect of ethyl alcohol on urine production. (1 point)

- Alcohol consumption increases urine output.

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**Question 8**



The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression. (**3 points maximum**)

- 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