AP® Biology
2010 Scoring Guidelines

The College Board

The College Board is a not-for-profit membership association whose mission is to connect students to college success and opportunity. Founded in 1900, the College Board is composed of more than 5,700 schools, colleges, universities and other educational organizations. Each year, the College Board serves seven million students and their parents, 23,000 high schools, and 3,800 colleges through major programs and services in college readiness, college admission, guidance, assessment, financial aid and enrollment. Among its widely recognized programs are the SAT®, the PSAT/NMSQT®, the Advanced Placement Program® (AP®), SpringBoard® and ACCUPLACER®. The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities and concerns.

Visit the College Board on the Web: www.collegeboard.com.
AP Central is the official online home for the AP Program: apcentral.collegeboard.com.

Question 1

Homeostatic maintenance of optimal blood glucose levels has been intensively studied in vertebrate organisms. ***NOTE: Points for parts (a), (b) or (c) may be found in any part of the response**.

(a) Pancreatic hormones regulate blood glucose levels. **Identify** TWO pancreatic hormones and **describe** the effect of each hormone on blood glucose levels. **(4 points maximum)**

Identification of hormone **1 point each** **(2 points maximum)**	**Effect of hormone on blood glucose levels** **1 point each** **(1 point maximum per hormone)**
Insulin (humulin)	• Decreases/lowers blood glucose level.
Glucagon NOTE: A hormone name beginning with "gly-" is not acceptable.	• Increases/raises blood glucose level.
Somatostatin	• Increases/raises blood glucose level.

(b) For ONE of the hormones you identified in (a), **identify** ONE target cell and **discuss** the mechanism by which the hormone can alter activity in that target cell. **Include** in your discussion a description of reception, cellular transduction, and response. **(4 points maximum)**

• **1 point**: target cell • **1 point**: description of reception	• **1 point**: discussion of transduction • **1 point**: discussion of response of target cell

Insulin

- **Target cells**: Any cell except red blood cells, or brain cells unless specified as neuroglial cells.
- **Reception**: Insulin binds to a specific receptor (tyrosine kinase) on the cell surface.
    - o Ligand binding to two adjacent monomers forms an active dimer (tyrosine kinase).
    - o Dimer and other proteins become phosphorylated.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way.
    - o Stimulates a cascade pathway/mediated by a second messenger/amplifies signal.
- **Response**: Transduced signal triggers a specific action by the target cell. Specify one of the following:
    - o Increases/raises cellular uptake of glucose.
    - o Increases formation of glycogen from glucose in liver/(skeletal) muscle cells as intracellular glucose is incorporated into glycogen (glycogenesis).
    - o Increases rate of intracellular catabolism of glucose.
    - o Increases fat synthesis from glucose in liver cells and adipose tissue.
    - o Decreases gluconeogenesis, the conversion of amino acids and glycerol from fats to new molecules of glucose.
    - o Phosphorylated transcription factors can alter gene expression.
    - o Facilitated diffusion of glucose. (Glucose is phosphorylated into glucose-6-phosphate to preserve the concentration gradient so glucose will continue to enter the cell.)
    - o Cells with more glucose transporters increase departure of glucose from blood.

Question 1 (continued)

Glucagon

- **Target cells**: Liver cells, (skeletal) muscle cells.
- **Reception**: Binds to a specific receptor on the cell surface (G-protein-coupled receptors on liver cells).
    - G protein-GTP activates adenylyl or guanalyl cyclase.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way. (G-protein binds to GTP and this activates other signal molecules such as adenylyl cyclase/amplifies signal.)
    - cAMP or cGMP active as second messenger/phospholipase C activation releases IP3 and DAG.
    - Kinase activation by cAMP or cGMP/phosphorylated effector proteins.
- **Response**: Transduced signal triggers the specific action by the target cell. Specify one of the following:
    - Releases glucose into the bloodstream from liver.
    - Increases breakdown (hydrolysis) of glycogen (glycogenolysis) to glucose in liver/(skeletal) muscles.
    - Increases gluconeogenesis, the conversion of amino acids and glycerol to glucose in the liver; new glucose enters the blood.
    - Decreases glucose breakdown/oxidation.
    - Increases glucose formation (gluconeogenesis).
    - Ca^{2+} release.

Somatostatin

- **Target cells**: Pancreatic cells (alpha and beta cells).
- **Reception**: Binds to a specific receptor on the cell surface (G-protein-coupled receptor).
    - G protein-GTP activates adenylyl or guanalyl cyclase.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way.
    - cAMP or cGMP active as second messenger/Phospholipase C activation releases IP_3 and DAG.
    - Kinase activation by cAMP or cGMP/phosphorylated effector proteins.
- **Response**: Transduced signal triggers the specific action by the target cell. Specify one of the following:
    - Decreases insulin secretion (from beta cells).
    - Decreases glucagon secretion (from alpha cells).
    - Ca^{2+} release.
    - Guanine nucleotide binding protein (GNAI 1) inhibits insulin.

(c) Compare the cell-signaling mechanisms of steroid hormones and protein hormones. **(4 points maximum)**

Steroid hormone (2 points maximum)

- Mechanism of action — to alter gene expression in the target cell.
- Hydrophobic/lipophilic/nonpolar/fat-soluble molecules readily cross cell or nuclear membrane.
- Acts as ligand that binds to cytosol receptors.
- Binding changes the conformation/shape of the cytosol receptor; hormone-receptor complex then enters the nucleus as the activated transcription factor.

Question 1 (continued)

- Transcription from the genes is affected:
  - Releases HDACs and recruits HATs — histone acetylases — to end chromosome repression.
  - Complex acts as a transcription factor that binds to a promoter (including HRE, hormone response element).
- Actions are slow but sustained.

Protein hormone (2 points maximum)

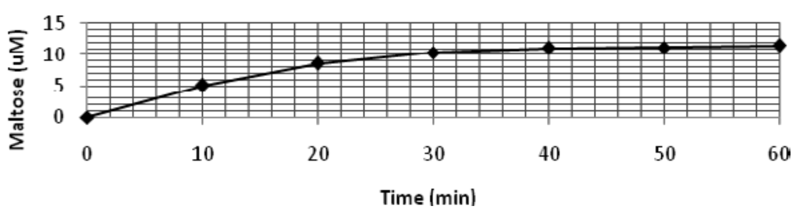
- Mechanism of action — to activate biochemical pathways/enzyme systems OR alter gene expression in a target cell.
- Hydrophilic/lipophobic/polar/water-soluble molecules do not readily cross cell membrane.
- Acts as ligand for membrane-bound receptors. Binds to receptor transmembrane proteins (either tyrosine kinase or G-protein receptors).
- Hormone is the ligand and the first messenger.
- Actions are brief but dramatic.

Question 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. **(4 points maximum)**



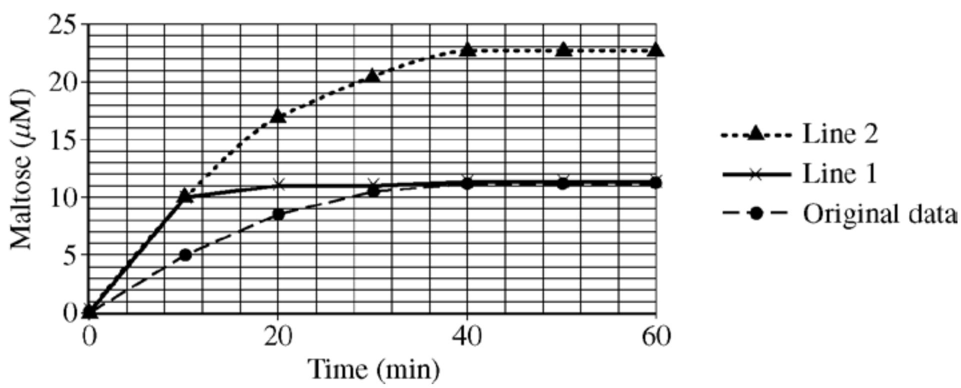
Graph **1 point each** **(3 points maximum)**	**Calculation** **(1 point maximum)**
• Correct orientation of the independent (time) and dependent (maltose) variables. • Correct display of units and intervals **(scale and labels)**. • Correct graphing of **all** data points on a properly scaled and oriented 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.)

Question 2 (continued)

(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.

(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.

Question 2 (continued)

(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).

Question 3

A new species of fly was discovered on an island in the South Pacific. Several different crosses were performed, each using 100 females and 100 males. The phenotypes of the parents and the resulting offspring were recorded.

Cross I: True-breeding bronze-eyed males were crossed with true-breeding red-eyed females. All the F_1 offspring had bronze eyes. F_1 flies were crossed, and the data for the resulting F_2 flies are given in the table below.

F_2 Phenotype	Male	Female
Bronze eyes	3,720	3,800
Red eyes	1,260	1,320

Cross II: True-breeding normal-winged males were crossed with true-breeding stunted-winged females. All the F_1 offspring had stunted wings. F_1 flies were crossed, and the data for the resulting F_2 flies are given in the table below.

F_2 Phenotype	Male	Female
Normal wings	1,160	1,320
Stunted wings	3,600	3,820

Cross III: True-breeding bronze-eyed, stunted-winged males were crossed with true-breeding red-eyed, normal-winged females. All the F_1 offspring had bronze eyes and stunted wings. The F_1 flies were crossed with true-breeding red-eyed, normal-winged flies, and the results are shown in the table below.

Phenotype	Male	Female
Bronze eyes, stunted wings	2,360	2,220
Bronze eyes, normal wings	220	300
Red eyes, stunted wings	260	220
Red eyes, normal wings	2,240	2,180

Question 3 (continued)

(a) What conclusions can be drawn from cross I and cross II? **Explain** how the data support your conclusions for each cross. **(4 points maximum)**

Conclusion for cross I (1 point maximum)	**Possible explanations for cross I (1 point maximum)**
• Bronze dominant/red recessive • Autosomal (non-sex-linked)	• All F_1 /heterozygotes express dominant trait (bronze). • F_2 shows 3:1 ratio (bronze:red/dominant:recessive). • Equal distribution of F_2 phenotypes for both genders.
Conclusion for cross II (1 point maximum)	**Possible explanations for cross II (1 point maximum)**
• Stunted dominant/normal recessive • Autosomal (non-sex-linked)	• All F_1 /heterozygotes express dominant trait (stunted). • F_2 shows 3:1 ratio (stunted:normal/dominant:recessive). • Equal distribution of F_2 phenotypes for both genders.

(b) What conclusions can be drawn from the data from cross III? **Explain** how the data support your conclusions. **(4 points maximum)**

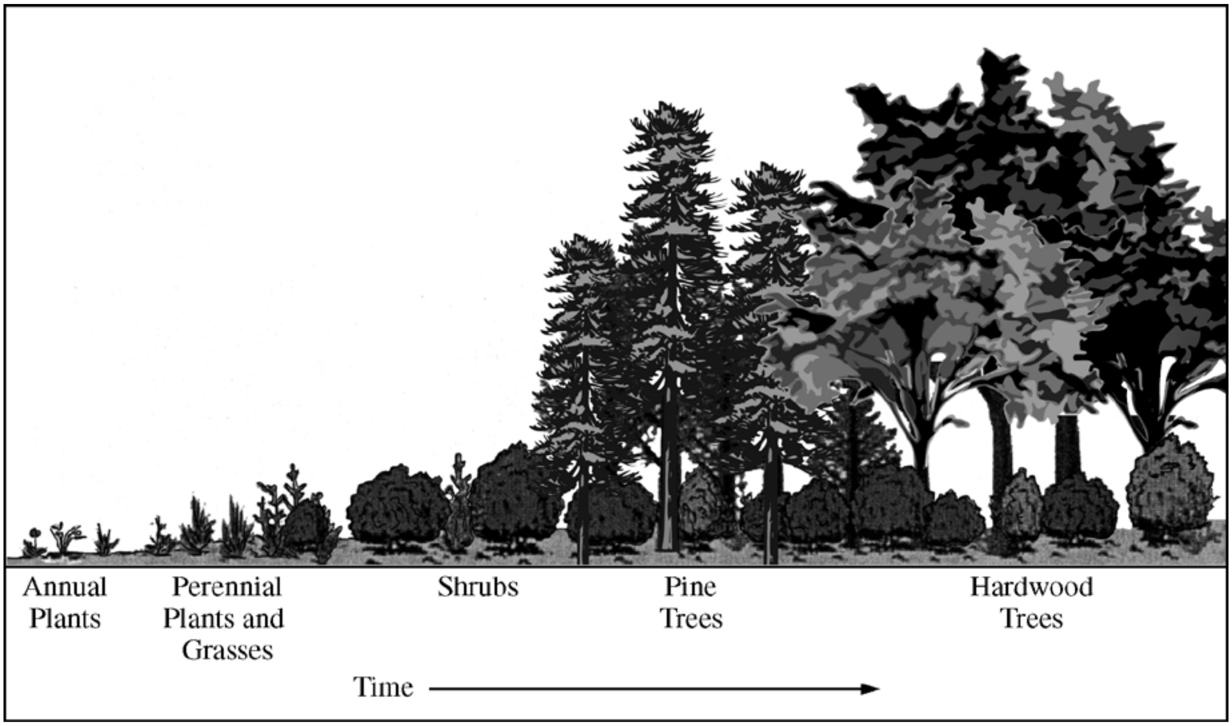
Conclusion for cross III (1 point per bullet; 2 points maximum)	**Explanation for cross III (1 point per bullet; 2 points maximum)**
• Genes linked • Crossing over • Genes 10 map units apart	• Not a 1:1:1:1 ratio (as predicted by independent assortment). • Not a 1:1 ratio/two recombinant phenotypes (unexpected). • Frequency of recombinant phenotypes was 10 percent (setup equation OK)/parental phenotypes (bronze/stunted and red/normal) are represented in 90 percent of offspring.

Question 3 (continued)

(c) **Identify** and **discuss** TWO different factors that would affect whether the island's fly population is in Hardy-Weinberg equilibrium for the traits above. **(4 points maximum)**

Identification (1 point per bullet; 2 points maximum)	**Discussion of effect (1 point per bullet; 2 points maximum)**
• Large population	• Minimized genetic drift.
• Random mating	• No gene pool change due to mate preferences.
• No mutation	• No new alleles in population.
• No immigration/emigration/ migration (no gene flow)	• No gene pool change by addition/loss of alleles.
• No natural selection	• No alleles favored or disfavored by environment.

Question 4



The diagram above shows the succession of communities from annual plants to hardwood trees in a specific area over a period of time.

(a) **Discuss** the expected changes in biodiversity as the stages of succession progress as shown in the diagram above. **(2 points maximum; 1 point per bullet)**

Cannot simply list the organisms depicted (shrubs → gymnosperms → angiosperm hardwoods)

- Biodiversity increases (plants, animals, decomposers).

Explanation of why biodiversity increases/changes are observed:

- Some populations *facilitate* biodiversity/succession (by developing conditions more suitable for other species and/or developing conditions less suitable for their progeny).
- Some populations *inhibit* biodiversity/succession (by developing conditions less suitable for other species and/or developing conditions more suitable for their progeny).
- Increase in plant stratification (increased layering of plants; e.g., canopy, understory).
- More *niches/habitats* formed (plants, animals, decomposers).
- Pioneer plant species → dominants (more shade-tolerant plants emerge).
- Increase in producer diversity brings about increase in consumer diversity.

Other:

- Shift from more opportunistic (r) to more equilibrium (k) species.

Question 4 (continued)

(b) **Describe** and **explain** THREE changes in abiotic conditions over time that lead to the succession, as shown in the diagram above. **(6 points maximum)**

It is not enough to say the condition (e.g., light, temperature, humidity) changes. The description/ explanation must be of a directional change (increase/decrease) in abiotic conditions and must be of a type that would lead to the changes shown in the diagram.

The following list is not exhaustive. **(2 points maximum per abiotic condition — i.e., any two cells from a single row below)**

Description of change in abiotic condition (1 point)	**Explanation (why abiotic condition changes) (1 point)**	**Explanation (why it enhances succession) (1 point)**
Increase in soil quantity	More detritus increases humus; decreased erosion because more plants hold soil in place.	Provides more anchoring for plants.
Improvement in soil quality	Soil gains organic matter (humus).	Provides more nutrients for plant growth.
More N available to ecosystem	Caused by decomposition and/or by nitrogen fixation.	Favors plants with higher nitrogen needs.
More P available	Caused by decomposition.	Favors plants with higher phosphorus needs.
Increase in water retained in soil	Increased organic matter retains water; increased shading reduces evaporation from the soil.	More water is available for plants.
Decrease in pH of soil	Acids released during decomposition lower pH.	Mobilizes cations facilitating mineral uptake (e.g., Fe^{++}, Ca^{++}); favors acid-tolerant plants.
Increase in pH of soil	Soil gets more basic with increase in ammonia (NH_3).	Favors plants with higher N requirement; favors alkaline-tolerant plants.
Decrease in light availability	Caused by shading.	Increased shading favors shade-tolerant species; inhibits shade-intolerant species.
Decrease in temperature	Caused by shading.	Favors species that are not heat tolerant; inhibits plants needing higher temperatures.
Higher humidity	Caused by more transpiration.	Facilitates transition from relatively xerophytic plants to more mesophytic plants.

Question 4 (continued)

(c) For each of the following disturbances, **discuss** the immediate and long-term effects on ecosystem succession. **(4 points maximum)**

(i) A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.

(ii) A 10- square-kilometer portion of a mature forest is clear-cut.

- **1 point** for time *comparison* that primary succession takes longer than secondary succession
- **1 point** per box

	Immediate	Long-term
i. Volcano erupts	• Primary succession/no soil.	• Lava must be degraded by weathering, microbes, lichens, fungi to form soils. • Lots of light is available (photophilic organisms will thrive when soil is present).
ii. Mature forest is clear-cut	• Secondary succession/ soil present. • All life is not destroyed. • Seed banks are present. • Different/other habitats/ niches open/close.	• Loss of trees may lead to erosion and soil loss. • Lots of light is available. • Many smaller plants actually benefit.

Note: A student must earn points from all three sections to earn the full 10 points on the question.