AP Biology
2000 Scoring Guidelines

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Question 1 Scoring Guide

Each bullet is worth one point:

<u>**Part a. (maximum 6 points)**</u>

- **Optimum** temperature and pH *concept* [must include <u>both</u> temp and pH]
- **Enzyme/Substrate Fit** *concept*
  (function dependent on conformation complementarity between enzyme and substrate)
- **Tertiary** (and sometimes quarternary) structure **determines** function
- Description of enzyme **structure or function**, e.g.

Structure	**Function**
Elegant description of primary to tertiary or primary to quarternary levels of structure	Increases rate of reaction
Protein folding/coiling	Increases proximity of reactants
Co-enzymes/co-factors	Decreases activation energy of the catalyzed reaction
Zymogens	Decreases time to reach equilibrium
Allosteric effectors	Induced fit and/or orbital steering ("bond stress")

- **Denaturation** *concept* [temp and/or pH] <u>linked</u> to decreased enzyme activity
  (e.g. "denaturation" in context or unfolding or change in 3D shape, **not** "enzyme breaks down")
- **How temperature affects** conformation
  (increased temperature breaks <u>specific bonds</u>, e.g. hydrogen, Van der Waals, disulfide bridges)
- **How pH affects** conformation
  (change in H^+ concentration causes a change in specific bond interactions, e.g. hydrogen; ionic; R-group interactions)
- **Kinetics** (increased or decreased molecular movement) <u>linked</u> to effect on enzyme activity due to increase or decrease in temperature up to the optimum

<u>**Part b. maximum 6 points**</u>

Experimental design must be relevant to the data shown in the graphs

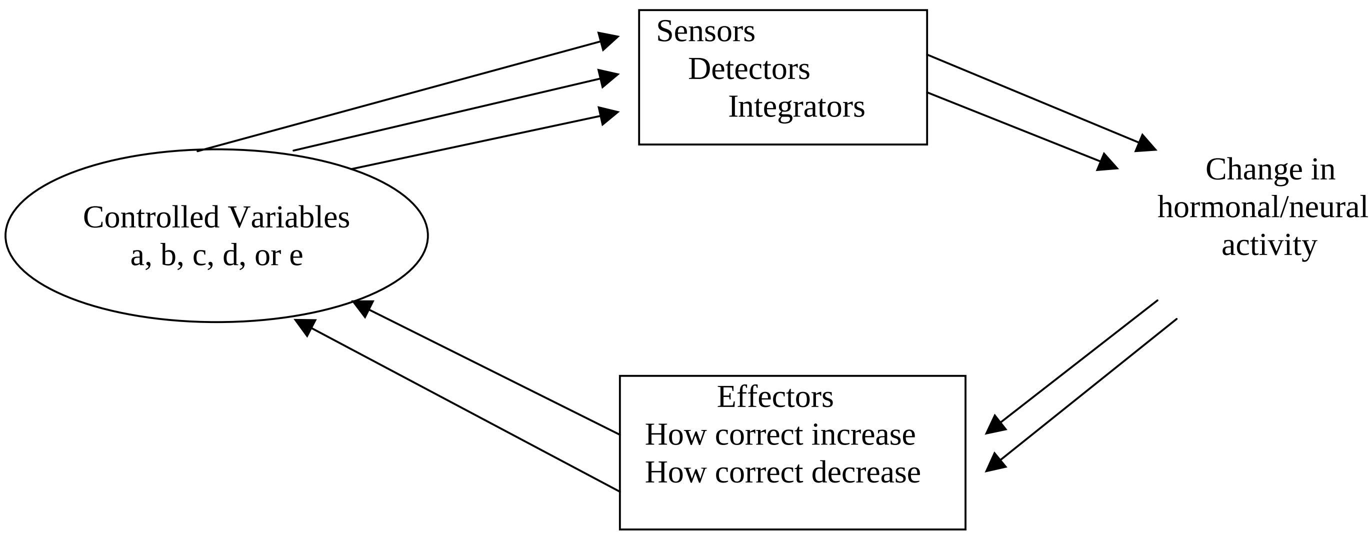
- **What is measured** (e.g. product formed or substrate used)
- **How is it measured** (titration or spectrophotometry or color change or bubbles counted, etc.)
- The **independent variable** (temperature/pH) is **manipulated** to produce the results [at least 3 data points are identified]
- The described experiment **could produce these data**
  (Experimental design included sufficient range, varied the temp/pH of the reaction mix <u>not</u> the enzyme, what was measured, and how it was measured)
- Held **experimental factors constant (**specified at least one **)**
- Specified a **control group for comparison** (no enzyme or boiled enzyme or no substrate)
- **Verified** results (e.g. repeated trials; results represent an average)
- **Hypothesis** clearly related to experiment of choice, and clearly identified as a hypothesis; can use the if/then…form.

Question 2 Scoring Guide **Last modified on:** *Tuesday, June 6, 2000*

MAXIMUM OF 4 PTS FOR EACH CHOICE

a) blood glucose concentration
b) calcium ion concentration in blood
c) body temperature in mammals
d) osmolarity of the blood
e) pulse rate in mammals

What detects the change in the variable? Structure-sensor (cell, tissue, organ, gland) and <u>must</u> <u>have</u> <u>indication</u> <u>of</u> <u>detection</u> e.g., senses, detects, picks up, feels, recognizes,monitors, contains or holds receptors	**1 pt**
What corrects an INCREASE in the variable? Δ in hormonal/neural activity → effector (tissue being stimulated) → mechanism (physiological effect at site of action) **2 out of 3 of these must be correctly linked for both an increase and a decrease in the variable**	**1 pt**
What corrects a DECREASE in the variable? Δ in hormonal/neural activity → effector (tissue being stimulated) → mechanism (physiological effect at site of action)	**1 pt**
Explanation of chosen mechanism (must address previous discussion) **and/or additional details** **and/or demonstration of deep understanding of feedback → may be used only one time for the entire answer** ***** This list includes the most common responses, but many other explanation points are acceptable.	**2 pts max**



a) blood glucose concentration **4 pts max**

pancreas (islets of Langerhans, alpha cells, beta cells, membrane receptors)
↑ insulin (from pancreas) → all cell surfaces → lowers blood glucose levels
↑ glucagon (from pancreas) → liver → raises blood glucose levels

Normal range of glucose in blood: 75-125 mg/dL (1dL=100ml)

If blood glucose levels rise above a set point...

- insulin does the following:
  a) stimulates the liver and other body cells to absorb glucose
  b) slows glycogen breakdown in liver
  c) inhibits conversion of amino acids and fatty acids to glucose
  d) stimulates liver and muscle cells to convert glucose to glycogen for storage
  e) stimulates adipose tissue to convert glucose to fat for storage
  f) promotes transport of amino acids into cells
  g) increases protein synthesis
- only brain cells are able to take up glucose without insulin
- diabetes mellitus -- deficiency of insulin (Type I or juvenile) or loss of response to insulin in target tissues (Type II or late onset)
- insulin promotes facilitated diffusion of glucose across cell membranes with insulin receptors: cardiac muscle cells, adipose tissue cells, and resting skeletal muscle cells
- kidney excretes excess glucose

If blood glucose levels drop below the set point...

- glucagon does the following:
  a) stimulates the liver to release glucose from the breakdown of glycogen
  b) promotes the conversion of amino acids and fatty acids to glucose
- glucocorticoids from adrenal gland convert fats and proteins to glucose

b) calcium ion concentration in blood **4 pts max**

Receptors in thyroid, parathyroid
↑ **calcitonin (from thyroid) → bone (osteoblasts) → stimulates bone to take up calcium** (lowers blood Ca++ levels) **→ intestine → reduces calcium absorption** **→ kidney → reduces calcium reabsorption (increases excretion)**
↑ **PTH (from parathyroid) → bone (osteoclasts) → stimulates bone to release calcium** (raises blood Ca++ levels)

→ **intestine** → **increases calcium absorption** → **kidney** → **increases calcium reabsorption**
Normal range of calcium ions in blood: 10 mg/100 mL • calcitonin inhibits osteoclasts from releasing calcium • vitamin D enables PTH to increase calcium ion uptake by the intestines

c) body temperatures in mammals **4 pts max**

• **hypothalamus (or the word "brain" without modifiers)** • **peripheral/central thermoreceptors**
• **neural activity → peripheral vascular tissue (capillaries, skin surface, extremities) → vasodilation/increases heat loss** • **neural/hormonal activity → sweat glands → sweat production/evaporative cooling**
• **neural activity → peripheral vascular tissue → vasoconstriction/reduces heat loss** • **neural activity → skeletal muscle → shivering/generates heat** **→ papillary muscles → piloerection/hair raising/increases insulation** **→ skeletal muscle → muscle tone/generates heat** • **neural activity → brown adipose tissue → increases metabolic activity/generates heat**
When temperature of the body rises above the set point: • *evaporative* cooling (sweating, panting) **When body temperature drops below the set point**: • shunting • thyroxin increases metabolism (generates heat) • the blood is rewarmed by countercurrent exchange (heat conduction from the warm blood to returning blood is redirected to the internal parts of the body before reaching extremities) • electron transport is uncoupled in brown fat **Behavioral responses must be physiologically related to the choice and the link clearly made** Ex: neural activity → skeletal muscle → locomotion (e.g., seek warmth, seek shade)

d) osmolarity of the blood **4 pts max**

- **osmoreceptors**
- **hypothalamus (brain)**
- **kidney receptors (JGA=juxtaglomerular apparatus)**
- **baroreceptors**

↑ osmolarity = decreased water content

- **↑ ADH (posterior pituitary, hypothalamus, brain) → kidney tubules (dist coll ducts, nephron) → ↑ water conservation, ↑ Na absorption**
- **↑ aldosterone (adrenal cortex) → kidney tubules (dist coll ducts, nephron) → ↑ water conservation, ↑ Na reabsorption**

↓ osmolarity = increased water content

- **↓ ADH (posterior pituitary, hypothalamus, brain) → kidney tubules (dist coll ducts, nephron) → ↓ water conservation, ↓ Na absorption**
- **↓ aldosterone (adrenal cortex) → kidney tubules (dist coll ducts, nephron) → ↓ water conservation, ↓ Na reabsorption**

Osmolarity = total solute concentration expressed as molarity (moles of solute per liter of solution);
Osmolarity of human blood = 300 mosm/L

Osmolarity of blood can be increased by:

- ↓ in amount of water absorbed from large intestine
- dehydration, hypercalcemia, and diabetes mellitus
- responses to ↑ in blood pressure (inhibit release of ADH, more water excreted, ↓ blood volume)

special case: freshwater fish

- copious/dilute urine production
- no drinking of water
- uptake of salt through gills

special case: saltwater fish
- scant/concentrated urine production
- constant water intake
- secretion of salt
- high blood urea

Osmolarity of blood can be decreased by:
- hyponatremia, Addison's disease, and water intoxication
- responses to ↓ in blood pressure (↑ ADH production, water retained by kidney, ↑ blood volume)

e) pulse rate in mammals **4 pts max**

- **chemoreceptors (carotid receptors, aortic arch)**
- **baroreceptors**
- **medulla oblongata**

Vagus nerve or parasympathetic n.s. or acetycholine → SA node (heart) → ↓ pulse/heart rate (↓ contractions, slower depolarization)

Sympathetic n.s. or adrenal medulla (adrenaline, epinephrine) → SA node (heart) → ↑ pulse/heart rate (↑ contractions, faster depolarization)

SA node (pacemaker) affected by body temp (1^o C rise in temp = increase heart rate x10 bpm)
Brain influences cardiac control center (e.g., conscious thought, proprioception)
↑ CO_2 or ↓ O_2 or ↓ pH → central and peripheral chemoreceptors → ↑ pulse/heart rate
→ brain center (medulla oblongata) → ↑ pulse/heart rate
↓ CO_2 or ↑ pH → central and peripheral chemoreceptors → ↓ pulse/heart rate
→ brain center (medulla oblongata) → ↓ pulse/heart rate

Question 3 Scoring Guide

a) The genetic material in one eukaryotic cell is copied and distributed to two identical daughter cells. The maximum for part a is 6 points

Part a is asking for "copy" and "distribute", there is an **internal maximum of four points** for each.

a part 1 DNA Replication (max 4 points)

1 – <u>when DNA is copied</u> – interphase, S phase of cell cycle
1 - recognition of origin site on DNA
1 - concept of unwinding enzyme
1 - RNA primer
1 - DNA polymerase – functional definition
1 - Concept of complementary relationship among bases – semiconservative
1 - Discontinuous/continuous or lagging /leading or Okazaki fragments (due to antiparallel backbones and 5' to 3' generation of new segments)
1 - DNA ligase – functional definition
1 - Other/Elaboration – telomere replication, proofing by DNA polymerase, expanded details

a part 2 Mitosis (max 4 points)

1 - concept of chromatid pairs or 'doubled chromosomes'
1 - prophase – condensation, spindle formation
1 - metaphase – alignment of chromosomes
1 - anaphase – separation of chromatids or equivalent statement
1 - telophase or origin of cytokinesis – nuclear membrane reforms, cell plate or cell furrow
1 - Other or Elaboration – cell cycle control, cell surface area/volume ratio and mitosis, MTOC(microtubule organizing center), centromere or kinetochore attachment

b) The gene in a eukaryotic cell is transcribed and translated to produce a protein. There is a maximum of 6 points for this part.

This part asks for transcription and translation, there is an **internal maximum of four points** each.

b part 1 Transcription (max 4 points)

1 - Functional definition: DNA sequence to RNA sequence
1 - Promoter Recognition
1 - RNA polymerase – function
1 - Complementarity relationships (T to U)
1 - 5' to 3' – growth of new strand
1 - Start site/ Termination Sequences
1 - Introns/Exons – with general explanation
1 - Caps/ Tails – with general explanation
1 - Other or Elaboration: sense and antisense , transcription factors, spliceosomes, multiple RNA's, enhancers, conserved segments

b part 2 Translation (max 4 points)

1 - Functional Definition: base sequences to aa sequences

Initiation

1 - Sequence of events – complex(m-RNA, small unit of ribosome, first t-RNA)
1 - Structure of ribosomes – complete description – two subunits , 2 or more action sites, r-RNA and proteins

Elongation

1 - t-RNA structure – amino-acyl site and anticodon
1 - Complementarity – codons to anticodons, m-RNA base sequence to t-RNA base sequence

Translocation –with basic description
1 - Peptide Formation – amino acids joined by peptide bonds to form polypeptide.

Termination

1 - Stop codon + release polypeptide + release ribosomes (must have 2 of 3)

1 - Other or Elaboration – triplet code, recognition segments, wobble (redundancy)

One point can be granted to either section of part b for describing the movement of RNA from the nucleus to the cytoplasm.

c) The genetic material from one bacterial cell enters another via transformation, transduction, OR conjugation. There is a 6 point maximum on this part. Choose one only!

Transformation (max 6 points)

1 - Functional definition
1 - Competency – cell membrane permeable to fragments
1 - How to make competent – calcium chloride, heat shock, cold for stability, gene gun, electroporation
1- Parameters for individual DNA segments – size, double helix
1 - Description of Griffiths/Avery – information transfer emphasis
2 - Other or Elaboration – recognition of transfer – plasmid description, gene technology, antibiotic resistance

Transduction (max 6 points)

1 - Functional definition – viral vector
1 - Lytic Cycle – describe
1 - Virus transfers bacterial DNA
1 - Lysogenic Cycle – describe
1 - Introduce viral DNA into bacteria
1 - Excision
2 - Other or Elaboration – prophage, oncogene, gene technology

Conjugation (max 6 points)

1 Functional definition (contact and one-way)
1 - Pili – describe
1 - F+ factor – donor(+), recipient(-)
1 - Hfr Cells
1 - Replication of transferred segment
2 - Other or Elaboration – antibiotic resistance, plasmid, gene technology

Question 4: Single-Sheet Template for Point Distribution

Section a: maximum of four (4) points, to be earned only within the first category named*

1 pt. Description of how coloration or mimicry or behavior allows the organism to escape predation

1 pt. Example 1: Name of an organism tied to first description

1 pt. Example 2: Name of a different organism or a different aspect of the same organism; may be tied to first description or second description

*If student addresses coloration, use of the word mimic is acceptable if defined in context, e.g., an organism mimicing its background in order to blend.

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1 pt. max Elaboration or expansion

a) Elaboration of first description
b b) Elaboration of either example
c c) Second description within the category selected
d) Explanation of how the organism's survival leads to its reproductive success or to the survival of the population

Section b: maximum of four (4) points, to be earned only within the first category named, either bacteria or plants

1: Bacteria

1 pt. Identification of a threat
1 pt. Solution–must be tied to threat
1 pt. Second solution tied to that threat

Additionally,

1 pt. Identification of a second threat
1 pt. Solution tied to second threat

OR
2: Plants

Must identify threat within body of answer to earn points.

1 pt. Description of a solution (how)
1 pt. Name of a specific plant example (e.g., poison ivy) or a plant structure (e.g., cuticle)

Must identify threat within body of answer to earn points; can be same or different threat.

1 pt. Description of a solution (can be same solution, but to a different threat)
1 pt. Name of a specific plant example (can be same or different plant) or a plant structure

Section c: maximum of four (4) points

1 pt. Overview; answer conveys an understanding of what constitutes the primary response and what constitutes the secondary response

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3 pts. max. Any three similarities or differences between the primary and secondary immune responses

No points will be earned for stating that the primary immune response is activated upon first exposure to the antigen whereas the secondary immune response is activated upon subsequent exposure to the antigen. This is restating the question.

What follows is a listing of descriptions, defenses, organisms, structures, etc. commonly found in introductory and upper-level college biology textbooks. This listing is not intended to be exhaustive.

Animal Defenses Against Predation

Use of adaptive coloration, mimicry, or behavior as a defense against predation:

Adaptive Coloration

I: Description: Cryptic/camouflage coloration; matches organism to surroundings

Examples:
- Seasonal changes in coloration (pineal involvement)
- Salamander
- Chameleon
- Tree frog
- Walking stick
- Arctic hare
- Jackrabbit
- Eye-spots on wings of io moth
- Inchworm caterpillar

II. Description: Aposematic/warning coloration; a warning to predators; also involves chemical defenses; bright colors (reds, blacks, oranges, yellows); depends on learning by predator

Examples:
- Gila monster
- Red-and-black African grasshopper
- Yellow-and-black stripes of wasps
- Coral snake
- Blue-ringed octopus
- Reef fishes
- Poison arrow frog
- Monarch butterfly

Mimicry

III: Description:
- Mimicry; superficial resemblance of mimic to another species (the model); may be visual or auditory or chemical
- Batesian mimicry; palatable species mimics model that is distasteful
- Müllerian mimicry; two or more aposematically-colored, distasteful species resemble each other
- Mertensian mimicry; mimic may be more dangerous than model; may involve social learning by predator con-specifics

Continuation of Animal Defenses Against Predation

Examples:

Hawkmoth larva that looks like a snake head (B)
Abdominal banding of bees and wasps (Mu)
Tephritid fly wings resemble jumping spiders (B)
Gopher snake that sounds like rattlesnake (B)
Burrowing owl emits rattlesnake-like calls in nest tunnel (B)
Flower fly, longhorn beetle, and sesiid moth resemble yellow-jacket wasps (B)
Eye-spots on wings of io moth (B)
Viceroy and monarch butterflies (Mu)
Red-spotted purple butterfly resembles pipevine swallowtail butterfly (B)

Behavior

IV: Description:

Any protective behavior; attacking predator, evasion from predator, various vocal or visual displays, use of chemical defenses, etc.

Examples:

Noctuid moth changes flight pattern in response to ultra-sonic sounds emitted by bats
Activity at times when predators are less active
Activity at times when predators are less likely to see prey
Removal of objects that provide visual cues to predators, e.g., egg shells at nest site
Alarm signals and mobbing behavior by flocking birds, prairie dogs, Belding's ground squirrels
Alarm pheromones
Predator distraction displays
Immobility, crouching posture
Hiding; moving to treetops, cliff's edge, underwater
Moving to a location where organism matches surroundings
Selfish herding or schooling
Stinging, foul exudates, boiling sprays, sticky secretions, disgusting excretions, repellant regurgitates
Spraying by skunks
Curling by porcupines
Tropical birds that nest near bee, wasp, and ant colonies
Thompson's gazelles stot upon spotting a cheetah
Noctuid moths spray formic acid
Black widows release sticky strand when attacked
Salamanders release sticky secretions when attacked
Australian sawflie larvae regurgitate sticky aromatic oils
Hedgehog grooms itself with a foam that contains toxins
Monarch's toxic chemicals derived from milkweed
Lures that are expendable and move when detached, e.g., lizard tails
Screaming by prey when captured

Bacterial Defenses Against Environmental Threats

Protection for bacterial cells against viruses, host organism defenses, abiotic environment, and other environmental threats:

Phages, Anti-Microbial Compounds

I: Solution:

Cell wall (a physical barrier against penetration of a phage or the penetration of anti-microbial compounds)

Bile, Host Defenses, Viruses

II. Solutions:

Lipopolysaccharide(s) (LPS) attached to the outer membrane of gram-negative (G–) bacteria; LPS contains the O-antigen (outward-facing)

LPS repels fat-dissolving molecules such as bile, which might damage the bacterial cell membrane

Changing the O-antigen (via mutation) protects against host's defenses (e.g., antibodies, memory B-cells, memory T-cells, plasma cells, etc.)

Changing the O-antigen protects against viruses that utilize the O-antigen for bacterial cell recognition

Phagocytes, Antibodies, Viruses, Desiccation, Nutrient Deprivation, Waste Products

III: Solutions:

Glycocalyx (capsule or slime layer)–any network of polysaccharides or glycoproteins secreted outside of the cell wall

Protects bacteria from being engulfed by host phagocytes

Protects bacteria from host antibodies

Protects bacteria against desiccation

Allows bacteria to form a spherical clump, protecting bacteria in interior

Allows bacteria to form a layer on host tissue, protecting bacteria not directly exposed to extracellular fluid (ECF)

Provides a reservoir for nutrients that bind to glycocalyx; these nutrients then are made available to bacterial cell

Accumulates and stores waste products, preventing them from interfering with bacterial cell metabolism

Continuation of Bacterial Defenses Against Environmental Threats

Viruses, Foreign DNA

IV. Solution: Restriction enzymes (endonucleases), DNA methylases

Antibiotics

V. Solutions:

- R-plasmids
- F-plasmids
- Mutations for antibiotic-resistance that are already present in population (accumulate due to rapidity of binary fission)
- Any other genetic mechanisms of antibiotic resistance

Miscellaneous

b Solutions:

- Sporulation/dormancy (temperature, desiccation)
- Heat shock proteins (pH, temperature, some chemicals)
- Pigment production (UV radiation)
- Altered metabolism (antibiotics)

Plant Defenses Against Environmental Threats

Protection for plants against predation, infection, water stress, nutrient deprivation, salinity, cold stress, heat stress, oxygen deprivation, and other environmental stresses:

Predation

I. Solution: Thorns, hooks, spines, needles, sharp-edged leaves, etc.
Examples/Structures: Spines on cacti
Holly leaves
Crystalline deposits in plant tissues

II. Solution: Distasteful or harmful chemicals in plant tissue
Examples: Alkaloids and glycoalkaloids are present in various plant tissue
Tobacco contains nicotine
Coniferous trees contain resin
Certain plant hormones mimic the action of insect hormones, disrupting insect development
Opium poppy contains morphine
Rhubarb leaves contain oxalic acid
Members of genus *Strychnos* contain strychnine
Foxglove, rhododendron, lily-of-the-valley, oleander, azalea, milkweed, and other plants contain cardioglycosides
Fruits, tea, legume forages, legume trees, grasses, and other plants contain tannins
Poison ivy, poison oak, and poison sumac contain topical irritants
Castor bean seeds contain ricin, a potent cytotoxin
Jackbean contains L-canavanine, a non-protein amino acid that causes insect death
Jimsonweed contains atropine, hyoscine (aka scopolamine), and hyoscyamine, all of which are toxic
Locoweed and milkvetch contain an alkaloid, a nitropropanol-bearing glycoside, and selenium metabolites, all of which are toxic
Members of the genus *Atropa* contain atropine
Cycads contain neurotoxins

III. Solution: Mutualistic relationship between a plant and an insect
Example: Symbiosis between swollen-thorn acacias (*Acacia collinsii*, *A. cornigera*) and the acacia ant (*Pseudomyrmex ferruginea*)

Continuation of Plant Defenses Against Environmental Threats

Infection

IV. Solution: Synthesis of anti-microbial compounds, aka phytoalexins, aka stress metabolites, and pathogenesis-related (PR) proteins after infection
Chemical/physical barriers to pathogens

Examples/Structures: Phytoalexin synthesis in a variety of plant groups:
- Members of the *Solanaceae* and the *Malvaceae* produce sesquiterpenoid phytoalexins
- Members of the *Brassica* produce indole ring-based phytoalexins
- Members of the *Leguminosae* produce isoflavonoid and polyacetylene phytoalexins
- Orchids produce dihydrophenanthrene phytoalexins
- Grapes produce resveratrol
- *Arabidopsis* produces camalexin

Any plant displaying suberin deposition and localized necrosis at a wound site (prevents penetration of pathogens)
Bark, cork cambium, cuticle

V. Solution: Hypersensitive response
Example: Any example of a plant displaying genetic-based disease resistance

VI. Solution: Systemic acquired resistance (SAR)
Example: Any example of a plant displaying SAR or carrying SAR Genes

Water Stress, Desiccation

VII. Solution: Any responses that restore water status
Examples/Structures:
- Water-impermeable cuticle
- Recessed stomates or "hairy" stomates
- Closing of stomates by action of guard cells
- CAM/C_4 plants
- Plants that suppress leaf growth
- Plants displaying wilting and leaf rolling
- Plants displaying leaf drop
- Seed coat
- Vascular tissue for water transport
- Plants with reduced leaf surface area (needles, spines)
- Highly dispersed, shallow root growth to absorb flash rains
- Root growth in unlikely places (e.g., water mains)
- Cactus needles' shading of cactus stem
- Plants that display hydrotropism
- Plants that release allelopathic compounds (inhibit the growth of nearby competitors)

Continuation of Plant Defenses Against Environmental Threats

Nutrient Deprivation, Nutrition Competition

VIII.	Solution:	Any responses that secure additional nutrients or conserve nutrients
	Examples:	Insectivorous plants Plants that grow roots in unlikely places (e.g., septic systems) Plants that arrest growth Plants that arrest reproduction Plants that display leaf drop Plants that form mycorrhizae Plants that release allelopathic compounds (inhibit the growth of nearby competitors) Any example of a plant with an effective method of seed dispersal

Shading, Light Competition

IX.	Solution:	Any responses that enable plants to enhance exposure to illumination
	Examples:	Plants displaying curvature growth (hormone-mediated) toward light Plants displaying increased vertical growth Plants displaying increased leaf surface area

Salinity

X.	Solution:	Any responses that mitigate high salt concentration
	Examples:	Any example of a plant that regulates water uptake via changes in water potential of root cells Any example of a plant that regulates salt uptake due to selective permeability of root cell membrane Plants having salt glands (halophiles)

Herbicides

XI.	Solution:	Genetic-based resistance to chemicals, either synthetic or naturally-occurring
	Examples:	Any legitimate examples of such

Continuation of Plant Defenses Against Environmental Threats

Cold Stress

XII.	Solution:	Any responses that mitigate cold temperatures
	Examples:	Plants that change the angle at which the petiole is presented in response to cold (e.g., rhododendron)
		Plants displaying changes in lipid composition of membranes
		Plants accumulating solutes in cytoplasm, which serve to depress freezing point

Heat Stress

XIII.	Solution:	Any responses that mitigate high temperatures
	Examples:	Evaporative cooling
		Heat-shock proteins

Oxygen Deprivation

XIV.	Solution:	Any responses that secure additional oxygen
	Examples:	Aerial roots
		Air tubes in submerged roots

Other Environmental Stresses (UV, Heavy Metals, etc.)

XV.	Solution:	Any mechanism that mitigates such environmental threats
	Examples:	Any legitimate examples of such

Primary Immune Response vs. Secondary Immune Response

Similarities and Differences Between the Two Immune Responses

1. Both immune responses result in antibody secretion.

2. Both immune responses utilize B-cells and/or T-cells.

3. Both immune responses utilize cell-mediated immunity.

4. Both immune responses result in the creation of a line of memory cells (B and/or T and/or lymphocytes).

5. In the secondary immune response, antibody titer is higher than in the primary immune response.

6. In the secondary immune response, antibody production is swifter than in the primary immune response.

7. The secondary immune response is usually rapid enough to prevent disease onset; the primary immune response is often too sluggish to prevent disease onset.

8. The secondary immune response utilizes a line of memory cells (B-memory and T-memory); the primary immune response does not (or a statement that the primary immune response produces memory cells that the secondary immune response utilizes).

9. In the secondary immune response, the number of B-cells capable of recognizing the antigen is much greater than in the primary immune response.

10. The secondary immune response lasts longer than the primary immune response.

11. In the secondary immune response, the affinity of the antibody for the antigen is greater than in the primary immune response.

12. The secondary immune response works poorly against antigens that change greatly over time; this is not necessarily true for the primary immune response.

13. The secondary immune response results in the secretion of several immunoglobulins, including IgM and IgG; the primary immune response results in the secretion of IgM only.

Note: An accurate, complete, and labeled sketch of a graph showing antibody concentration (dependent variable) as a function of time-after-antigen-exposure (independent variable), with accompanying text, will be sufficient to earn three (3) points, *viz*., nos. 1, 5, and 6 above.