



AP[®] Biology 2012 Scoring Guidelines

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AP[®] BIOLOGY

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Question 1

Note: At least 1 point must be earned from each of parts (a), (b), (c), and (d) in order to earn a maximum score of 10.

The ability to reproduce is a characteristic of life.

- (a) **Describe** the process of embryological development in a typical vertebrate embryo, beginning with a fertilized egg and ending with the development of three tissue layers.
(4 points maximum)

| Embryological process | Description of embryological process (1 point per box) |
|---|---|
| Fertilization | <ul style="list-style-type: none"> • Egg is fertilized by sperm. • Zygote is formed. • Polyspermy is blocked. • Diploid number of chromosomes is restored. • Nuclei of egg and sperm fuse. • Sex of offspring is determined. • Polarity is determined. |
| Cleavage (can occur in other stages) | <ul style="list-style-type: none"> • Rapid cell divisions. • Cell divisions without cell growth. • Cleavage divisions form a small, solid ball of cells (morula). • Rapid DNA replications and mitotic divisions occur. • Cells get smaller in early cleavage with each division. |
| Blastulation | <ul style="list-style-type: none"> • Cleavage divisions form a hollow ball of cells surrounding a fluid-filled cavity. • Room for germ layers is developed. |
| Gastrulation | <ul style="list-style-type: none"> • Germ cell layers (ectoderm, endoderm, and mesoderm) are established. • Opening called a blastopore forms. • Cells near the surface of the blastula reorganize and move to an interior location. • Primitive digestive gut (archenteron) forms. |

- (b) **Identify** the developmental origin of TWO of the following tissues in vertebrates:

- central nervous system
- digestive system
- muscle

(2 points maximum)

| Tissue | Identification of developmental origin (1 point per box) |
|------------------------|--|
| Central nervous system | <ul style="list-style-type: none"> • Ectoderm / outer germ layer |
| Digestive system | <ul style="list-style-type: none"> • Endoderm / inner germ layer (lining) • Mesoderm / middle germ layer (other layers of digestive tract) |
| Muscle | <ul style="list-style-type: none"> • Mesoderm / middle germ layer |

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Question 1 (continued)

- (c) **Identify** and **explain** THREE differences between the embryological development of protostomes and the embryological development of deuterostomes.
(3 points maximum)

| Developmental differences: protostomes vs. deuterostomes | Explanation (1 point per box) |
|---|--|
| Pattern of cleavage | <ul style="list-style-type: none"> • Patterns of cleavage occur along different planes. • Spiral (diagonal planes in protostomes). • Radial (parallel/perpendicular in deuterostomes). |
| Determination of cell fate | <ul style="list-style-type: none"> • Determination of cell fate occurs in different developmental stages. • Early determination in protostomes (determinate). • Late determination in deuterostomes (indeterminate). |
| Blastopore fate | <ul style="list-style-type: none"> • Blastopore fate differs. • Mouth forms first; anus forms second in protostomes. • Anus forms first; mouth forms second in deuterostomes. |
| Coelom formation | <ul style="list-style-type: none"> • Coelom formation from mesoderm occurs by different processes. • Coelom forms from splitting of mesoderm in protostomes. • Coelom forms from outpocketing of mesoderm in deuterostomes. |

- (d) **Explain** TWO unique properties of human embryonic stem cells that distinguish them from other human cell types. **Describe** a current medical application of human stem cell research.
(3 points maximum)

| Unique properties | Explanation (1 point per box; 2 points maximum) |
|--------------------------|--|
| | <ul style="list-style-type: none"> • Totipotent: can become any type of cell, tissue, organ, or entire organism. • Pluripotent: can become many types of cells, tissues, or organs. • Undifferentiated: has the ability to follow any differentiation pathway. |
| | <ul style="list-style-type: none"> • Unspecialized: can give rise to specialized cell types. |
| | <ul style="list-style-type: none"> • Infinite reproduction: no restriction on cell types. |
| | |

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Question 1 (continued)

Description of a current medical application (1 point maximum)

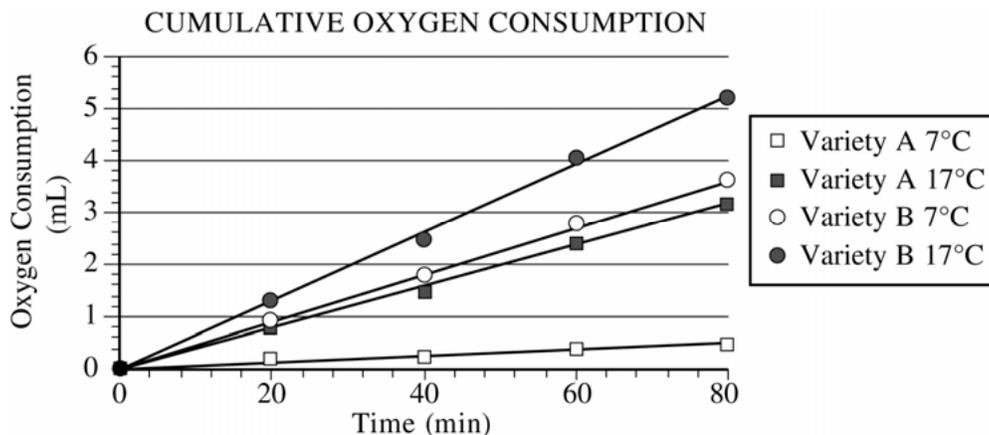
Acceptable responses include, but are not limited to, the following:

- Repair of brain and spinal tissues.
- Treatment of diseases such as leukemia, stroke, Alzheimer's, Parkinson's, diabetes, cystic fibrosis.
- Therapeutic cloning of human cells, tissues, and certain organs (e.g., bone, cartilage, muscle).
- Reprogramming of diseased cells.
- Testing of new drugs.
- Storage of umbilical cord stem cells.

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Question 2

An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



- (a) **Calculate** the rates of oxygen consumption in mL/min for each variety of wheat at 7°C and at 17°C. **Show** your work (including your setup and calculation). (3 points maximum)

- **1 point** for using the rate formula (Dy/Dx)
- **1 point** for using appropriate data to calculate the slope for at least three treatments
- **1 point** for giving answers in decimal format of mL/min

Note: Setup can choose any pair of points for the rise-over-run calculation of rate. The values used in the calculations can be greater or less than those shown in the examples below. Units of mL/min are implied by the question stem and need not be specifically shown.

| | |
|-------------------|---|
| Variety A at 7°C | $(0.5 - 0 \text{ mL}) / (80 - 0 \text{ min}) = 0.0062 \text{ mL/min}$ |
| Variety A at 17°C | $(3.2 - 0 \text{ mL}) / (80 - 0 \text{ min}) = 0.040 \text{ mL/min}$ |
| Variety B at 7°C | $(3.6 - 0 \text{ mL}) / (80 - 0 \text{ min}) = 0.045 \text{ mL/min}$ |
| Variety B at 17°C | $(5.2 - 0 \text{ mL}) / (80 - 0 \text{ min}) = 0.065 \text{ mL/min}$ |

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Question 2 (continued)

- (b) **Explain** the relationship between metabolism and oxygen consumption. **Discuss** the effect of temperature on metabolism for each variety of seedlings.
(4 points maximum)

Explanation of relationship (1 point)

- As metabolism increases, oxygen consumption increases.
- OR,**
- As metabolism decreases, oxygen consumption decreases.

Discussion (1 point per bullet; 3 points maximum)

Interpretation of graph

- General statement that increasing temperature increases metabolic rate/oxygen consumption (no specific mention of variety A or B).

OR,

- Variety A: rate of metabolism/oxygen consumption increases with an increase in temperature.
- Variety B: rate of metabolism/oxygen consumption increases with an increase in temperature.

Comparison of varieties

- Variety B has a higher metabolism/oxygen consumption than variety A at either temperature.
- Variety B has better metabolism/oxygen consumption at lower temperatures than variety A.

Elaboration of temperature

- Kinetic energy increases with temperature.
- Enzyme reaction rates increase with temperature.
- Effects on electron transport chain (ETC)/system.

- (c) In a second experiment, variety A seedlings at both temperatures were treated with a chemical that prevents NADH from being oxidized to NAD⁺. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.
(5 points maximum)

Prediction (1 point each; 2 points maximum)

- Metabolism/respiration stops/declines/decreases/slows down.
- Oxygen consumption stops/declines/decreases/slows down.

Explanation (1 point each; 3 points maximum)

- Glycolysis/Krebs cycle/ETC will stop.
- ATP levels will drop/decline/decrease.
- Oxygen cannot accept electrons from ETC.

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Question 3

Note: At least 1 point must be earned from each of parts (a), (b), (c), and (d) in order to earn a maximum score of 10.

Information flow in cells can be regulated by various mechanisms.

(a) **Describe** the role of THREE of the following in the regulation of protein synthesis:

- RNA splicing
- repressor proteins
- methylation
- siRNA

(3 points maximum)

| | Description (1 point per box) |
|--------------------|--|
| RNA splicing | <ul style="list-style-type: none">• Exons spliced together.• Introns removed.• snRNPs/spliceosomes help remove introns. |
| Repressor proteins | <ul style="list-style-type: none">• Inhibit transcription.• Inhibit translation.• Silence genes.• Inactivate gene expression. |
| Methylation | <ul style="list-style-type: none">• DNA or histone methylation prevents transcription.• Protects against restriction enzymes. |
| siRNA | <ul style="list-style-type: none">• Facilitates degradation of mRNA.• Inhibits translation. |

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Question 3 (continued)

- (b) Information flow can be altered by mutation. **Describe** THREE different types of mutations and their effect on protein synthesis.
(4 points maximum)

| Type of mutation (not limited to the following) | Description (1 point per box) | Effect (1 point per box) |
|--|--|---|
| Silent | Nucleotide change. | No change in amino acid/protein sequence. |
| Missense/substitution | Nucleotide change causes new codon. | Different amino acid/protein sequence. |
| Nonsense/substitution | Nucleotide change causes stop codon. | Protein not formed OR truncated protein. |
| Frameshift (insertion/deletion) | Nucleotide insertion/deletion alters reading frame after mutation. | Changes amino acid/protein sequence OR nonfunctional protein OR no protein. |
| Regulatory region | Nucleotide insertion/deletion/substitution. | Alters gene expression OR alters splice site. |
| Translocation | Chromosome segment moves to different site. | Alters gene expression. |
| Nondisjunction | Chromosomes fail to separate. | |
| Duplication | Chromosome segment doubles. | |
| Deletion | Chromosome segment is removed. | |
| Inversion | Chromosome segment is reversed. | |
| Transposition | Chromosome segment moves to a different site. | |

- (c) **Identify** TWO environmental factors that increase the mutation rate in an organism, and **discuss** their effect on the genome of the organism.
(4 points maximum)

| Environmental factor (not limited to the following) (1 point each; 2 points maximum) | Discussion (1 point each; 2 points maximum) |
|---|---|
| <ul style="list-style-type: none"> • UV light | <ul style="list-style-type: none"> • T-T/thymine dimers. |
| <ul style="list-style-type: none"> • Carcinogens <ul style="list-style-type: none"> ○ Cigarette smoke ○ Asbestos ○ Radon gas • Radiation <ul style="list-style-type: none"> ○ X-rays ○ Gamma rays/cosmic rays • Chemical mutagens <ul style="list-style-type: none"> ○ Nitrites ○ EtBr ○ Aflatoxin ○ Pollution | <ul style="list-style-type: none"> • DNA is altered/damaged (e.g., deamination, depurination, double strand breaks). |
| <ul style="list-style-type: none"> • Viruses | <ul style="list-style-type: none"> • Disrupt gene sequence. |

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Question 3 (continued)

- (d) Epigenetics is the study of heritable changes in the phenotype caused by mechanisms other than changes in the DNA sequence. **Describe** ONE example of epigenetic inheritance.
(1 point maximum)

Description of an epigenetic example (1 point maximum)

Acceptable responses include, but are not limited to, the following:

- DNA or histone modifications
- Inactivated X chromosomes (Barr bodies, calico cats)
- Heterochromatin
- Tumor suppressor genes (inactivation of *p53*)
- Cellular aging
- Environmental/in utero influences
- Maternal diet
- Agouti mice
- Heavy metals
- Famine study
- Pollution
- Twin studies (e.g., identical twin variations)
- Stress-induced alterations (e.g., post-traumatic stress disorder)
- Genomic imprinting (e.g., Prader-Willi syndrome, Angelman syndrome)

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Question 4

Note: At least 1 point must be earned from each of parts (a), (b), and (c) in order to earn a maximum score of 10.

The element carbon is contained in all organic compounds.

- (a) **Discuss** the role of photosynthesis and cellular respiration in carbon cycling in the biosphere.
(2 points maximum)

| Discussion (1 point per box) | |
|-------------------------------------|--|
| Photosynthesis | <ul style="list-style-type: none"> • Removes CO₂ from the atmosphere. • Reduces (or uses) CO₂. • Fixes carbon into organic molecules (sugars). |
| Cellular respiration | <ul style="list-style-type: none"> • Metabolizes (oxidizes, catabolizes) organic molecules (sugars). • Returns CO₂ to the atmosphere. • Releases CO₂. |

- (b) For THREE of the following, **predict** and **explain** the effect on the carbon cycle if:

- decomposers were absent
- deforestation occurred
- volcanic dust accumulated in the atmosphere
- the average ocean temperature increased

(6 points maximum)

| | Prediction (1 point per box; 3 points maximum) | Explanation (1 point per box; 3 points maximum) |
|-------------------------------------|---|---|
| Decomposers absent | <ul style="list-style-type: none"> • Less CO₂ in atmosphere. • More carbon stored in dead organisms. | <ul style="list-style-type: none"> • CO₂ is not released. • Organic material is not degraded. |
| Deforestation | <ul style="list-style-type: none"> • More CO₂ in atmosphere. • Fewer carbon compounds in organisms. | <ul style="list-style-type: none"> • Decreased photosynthesis. |
| Volcanic dust in atmosphere | <ul style="list-style-type: none"> • More CO₂ in atmosphere. • Fewer carbon compounds in organisms. | <ul style="list-style-type: none"> • Less solar radiation causes less photosynthesis. |
| Average ocean temperature increased | <ul style="list-style-type: none"> • More CO₂ in atmosphere. • Less CO₂ in ocean. | <ul style="list-style-type: none"> • Increased decomposition/rate of respiration. • Decreased CO₂ solubility (less photosynthesis). |
| | <ul style="list-style-type: none"> • Less CO₂ in atmosphere. | <ul style="list-style-type: none"> • Increased photosynthesis (e.g., algae blooms). • Decreased O₂ solubility, resulting in decreased respiration. |
| | <ul style="list-style-type: none"> • No net change in CO₂ reservoirs. | <ul style="list-style-type: none"> • Increased photosynthesis AND respiration. |

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Question 4 (continued)

- (c) **Explain** how increased CO₂ in the atmosphere results in greater acidification of oceans and **describe** the effect on marine organisms. **Include** in your discussion TWO examples of how human activity can increase atmospheric CO₂.

(4 points maximum)

| | |
|--|--|
| Explanation (1 point) | <ul style="list-style-type: none"> CO₂ dissolves, forming an acid (carbonic acid); the release of H⁺ ions decreases pH. $(\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-)$ |
| Effect (1 point) | <ul style="list-style-type: none"> Decreases ability to make corals/shells/exoskeletons. Decreases availability of CO₃²⁻ for formation of CaCO₃ because more H⁺ combines with CO₃²⁻. Decreases efficiency of enzymes in suboptimal pH. |
| Examples (1 point each; 2 points maximum) | <ul style="list-style-type: none"> Combustion of gasoline/diesel. Combustion of coal. Combustion of natural gas. Combustion of wood. Combustion/decomposition of wastes. Deforestation reduces photosynthesis. <p style="text-align: right;">} OR Combustion of fossil fuels.</p> |