AP® Biology
2009 Scoring Guidelines

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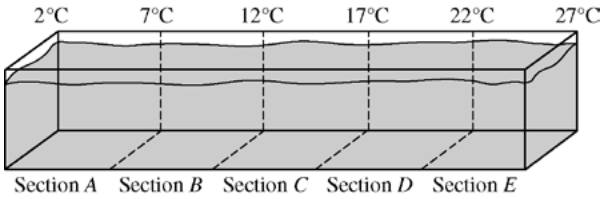
Question 1

An experiment on a species of small freshwater fish recorded their behavioral responses to different temperatures. Ten fish were each tested once, one at a time.

To begin the experiment, a fish was removed from a stock tank (maintained at 22°C) and placed in the temperature-gradient tank drawn below. After the fish had spent 30 minutes in the temperature-gradient tank, the section where the fish was located was recorded. Additional observations were recorded every 5 minutes, for a total of 7 observations per fish. A summary of the combined data for all 10 fish appears below.



Section	Fish/Section
A	9
B	11
C	34
D	12
E	4

(a) On the axes provided, **construct** the appropriate type of labeled graph showing the relationship between water temperature and fish distribution. **Summarize** the outcome of the experiment. **(4 points maximum)**

Graph **(1 point each; 3 points maximum for graph)**	**Summarize** **(1 point maximum for summary)**
• Correctly labeled and scaled axis o Temperature range may be indicated by section with legend • Correct orientation: *x*-axis = temp; *y*-axis = # fish observed • Correct bar graph/scatter plot o Discrete data points only if range is indicated o NO point for line graph	• Fish were distributed by temperature, e.g., most fish were observed at moderate temperature range, or 12–17°C

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Question 1 (continued)

(b) **Identify** TWO variables that were not specifically controlled in the experimental design, and **describe** how these variables might have affected the outcome of the experiment. **(4 points maximum)**

Variable* **(1 point each; 2 points maximum)**	**Describe** **(1 point each; 2 points maximum)**
Fish characteristics, e.g., age, size, sex, schooling, health	Age/mating behavior/sex, SA:V ratio, tendency to school may affect activity levels/distribution of fish
Tank characteristics, e.g., depth, shape, size, gravel, plants, sections/ends	Depth/shape/size/pressure/ends of tank may affect distribution of fish "control" tank at constant temperature
Water quality, e.g., pH, salt, chemicals, microbes	Attraction/avoidance influences fish response to temperature
Placement of fish, time in stock tank	Tendency of fish to remain where placed, effect of shock on fish
External stimuli, e.g., light, noise	Attraction/avoidance influences fish response to temperature
Oxygen concentration	Attraction/avoidance influences fish response to temperature
Time of day/biological rhythms or when observations recorded	Temperature preference or activity of fish differs with time of day, e.g., diurnal vs. nocturnal
Other acceptable variables**	Other acceptable descriptions

* 1 point for **each** variable, may include two from same category
** NOT type of fish, NOT temperature, since these were set by experimenters

(c) **Discuss** TWO ways that water temperature could affect the physiology of the fish in this experiment. (**4 points maximum)**

Effect (directional) **(1 point each; 2 points maximum)**	**Explanation of effect** **(1 point each; 2 points maximum)**
Metabolic rate/activity increase with temperature increase	Related to kinetic energy, enzyme activity (NOT denaturation)
Heart rate/circulation/blood flow increase with temperature increase	Related to kinetic energy, blood vessel constriction/dilation, etc.
Respiration rate, operculum movement, "breathing rate" increase with temperature increase	Related to diffusion rates, metabolic rates
Shock/stress prevent normal activity	Nervous system impairment alters fish movements
Gas exchange (O_2 or CO_2) altered at different temperatures	Dissolved oxygen increases at lower temperatures

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Question 2

ATP and GTP are primary sources of energy for biochemical reactions.

(a) **Describe** the structure of the ATP or the GTP molecule. **(1 point each; 2 points maximum)**
- Adenosine + 3 phosphates or guanosine + 3 phosphates.
- Elaborating on the phosphate bonds, e.g., unstable, negatively charged. Mentioning without explaining "high-energy bonds" is insufficient.
- Adenosine or guanosine described as adenine or guanine bound to ribose.

Note: adenine + ribose + 3 phosphates earns 2 points.

(b) **Explain** how chemiosmosis produces ATP. (**1 point each; 3 points maximum)**
- Electron transport, e.g., linked to proton pumps, coenzymes, NADH.
- H+ pumped to one side of the membrane, photosynthesis—inside thylakoid, respiration—outside cristae.
- Proton gradient established, has potential energy or capacity to do work.
- ATP synthases or channel proteins generate ATP.

(c) **Describe** TWO specific cell processes that require ATP and explain how ATP is used in each process. **(4 points maximum)**

	Description of process **(1 point per process; 2 points maximum)**	**How ATP is used** **(1 point per process; 2 points maximum)**
Mechanical	Muscle, sliding filament; cilia or flagella, propulsion; chromosome movement in mitosis or meiosis	ATP → ADP + P connected to process or energy coupling, e.g., conformational change in myosin head
Transport	Active transport or transport against gradient; sodium-potassium pump; endocytosis or exocytosis	ATP → ADP + P connected to process, e.g., phosphorylating the transport protein
Chemical	Hydrolysis or synthesis; specific chemical reaction, e.g., photosynthesis or glycolysis; kinase activity	ATP → ADP + P connected to process or energy coupling, e.g., phosphorylating glucose in glycolysis or PGA in Calvin cycle

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Question 2 (continued)

(d) An energy pyramid for a marine ecosystem is shown below. **Label** each trophic level of the pyramid and provide an example of a marine organism found at each level of this pyramid. **Explain** why the energy available at the top layer of the pyramid is a small percentage of the energy present at the bottom of the pyramid. **(3 points maximum)**

	Explanation **(1 point per box; 3 points maximum)**
Label trophic levels	Producer or autotroph → 1° consumer or herbivore → 2° consumer or carnivore → 3° consumer; no point for mentioning detritivores or decomposers
Examples of <u>marine</u> organisms	Algae → zooplankton → small fish → shark Type of plankton must be specified if used above producer level; "fish" can be used <u>once</u> if unspecified; top level may include terrestrial organisms
Energy transfer	Energy transferred due to metabolic activities, heat, work, entropy Mentioning without explaining 10% energy transfer between trophic levels is insufficient

Note: Students must receive points in all four sections to earn a score of 10.

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Question 3

Phylogeny is the evolutionary history of a species.

(a) The evolution of a species is dependent on changes in the genome of the species. **Identify** TWO mechanisms of genetic change, and **explain** how each affects genetic variation. **(4 points maximum)**

	Identification **(1 point each; 2 points maximum)**	**Explanation** **(1 point each; 2 points maximum)**
DNA (molecular)	Mutation, e.g., point, frameshift, insertions, deletions	Change in nucleotide sequence or amino acid sequence or protein structure or gene expression, or change in phenotype
	Duplication, e.g., gene, chromosome, genome, sympatric speciation	Gene "families," which then diverge by mutation; change in ploidy
	Rearrangement, e.g., gene order, inversions, chromosome fusion, transposons	Chromosome structure altered; change in crossover frequency
Cellular	Crossing over, independent assortment, segregation, nondisjunction (meiosis) Random fertilization (sexual reproduction)	Increase gamete diversity Many possible gamete combinations
Population	Genetic drift or bottleneck or founder effects Gene flow (migration) Geographic isolation or allopatric speciation Nonrandom mating (sexual selection) Sympatric speciation Natural selection	Population allelic/gene frequencies altered or gain or loss of alleles/genes Reproductive fitness/differential success

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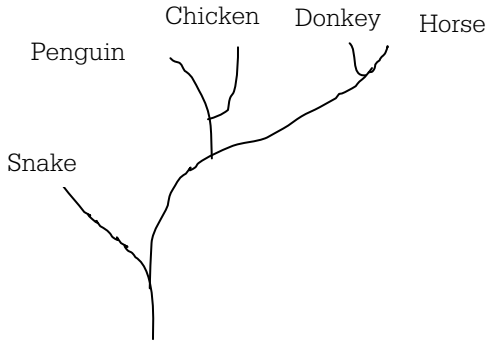
Question 3 (continued)

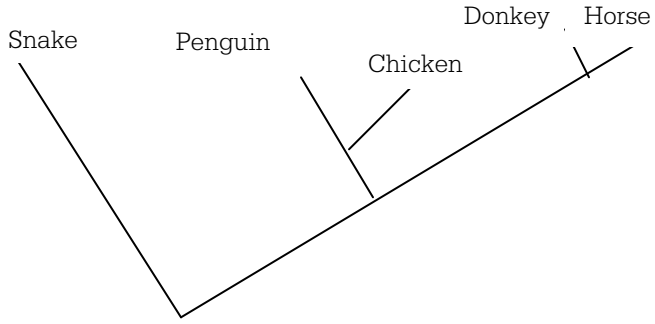
(b) Based on the data in the table below, **draw** a phylogenetic tree that reflects the evolutionary relationships of the organisms based on the differences in their cytochrome *c* amino-acid sequences and **explain** the relationships of the organisms. Based on the data, **identify** which organism is most closely related to the chicken and **explain** your choice. **(4 points maximum)**

THE NUMBER OF AMINO ACID DIFFERENCES IN CYTOCHROME *c*
AMONG VARIOUS ORGANISMS

	Horse	Donkey	Chicken	Penguin	Snake
Horse	0	1	11	13	21
Donkey		0	10	12	20
Chicken			0	3	18
Penguin				0	17
Snake					0

Phylogenetic tree: rooted trees with common ancestor, and with snakes, birds, mammals in correct relative order **(1 point for tree)**





- Cytochrome *c*: the more differences in amino acids of cytochrome *c*, the less closely related, OR fewer differences, more closely related. **(1 point)**
- Penguin is most closely related to chicken. **(1 point)**
- Three amino acids differing between penguin and chicken/penguin has fewest differences from chicken. **(1 point)**

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Question 3 (continued)

(c) **Describe** TWO types of evidence—other than the comparison of proteins—that can be used to determine the phylogeny of organisms. **Discuss** one strength of each type of evidence you described. **(4 points maximum)**

Description **(1 point per box; 2 points maximum)**	**Strength** **(1 point each; 2 points maximum)**
Fossil Observe past organisms	Shows direct evidence of common ancestor, follow evolution (changes over time) from common ancestor
Homology: morphology Organismal structure/form Vestigial structures	Similarities in form(s) show common ancestry/DNA
Homology: embryology/development Morphology of embryos; changes in gene expression during development	Similarities in development show common ancestry/DNA
Homology: reproduction Comparison of reproductive strategies or life cycles: cell division, gamete production, gamete type, etc.	Similarities in reproduction strategies show common ancestry/DNA
DNA sequence Comparison of DNA sequences in specific genes; molecular homologies	Similarities in sequences show common ancestry
Biogeography Analysis of organism distribution(s)	Uses both past and present information to show common ancestry/DNA
Direct observation/behavior Watch organism in natural setting	Similarities in behaviors indicate common ancestry/DNA

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Question 4

The flow of genetic information from DNA to protein in eukaryotic cells is called the central dogma of biology.

(a) **Explain** the role of each of the following in protein synthesis in eukaryotic cells. **(5 points maximum)**

	Description (1 point each)
RNA polymerase	DNA → RNA
Spliceosomes (snRNPs)	Removes the introns and connects (splices) the exons in RNA
Codons	Codes for amino acids/signals
Ribosomes	RNA → protein or site of protein synthesis
tRNA	Transports amino acids

(b) Cells regulate both protein synthesis and protein activity. **Discuss** TWO specific mechanisms of protein regulation in eukaryotic cells. **(4 points maximum)**

Idea of the mechanism (1 point)	**Discussion (1 point)**	
Promotor	increases RNA polymerase binding	**Protein Synthesis**
Enhancer	increases transcription	
Methylation	adding methyl group inhibits transcription	
Acetylation	adding acetyl group promotes transcription	
DNA packaging	loosening/tightening chromatin promotes/inhibits transcription	
RNA processing	GTP cap or Poly-A tail	
RNA editing	removing of introns	
Alternative splicing	editing in different ways to get new/different RNA/polypeptides	
mRNA degradation	targets RNA for destruction (miRNA or siRNA)	
Protein processing	polypeptide → protein modifications (folding, chaperonins, cleavage, etc.)	
Protein degradation	proteases break down proteins	
Feedback: negative/positive	correct explanation of the identified feedback loop	**Intracellular Protein Activity**
Allosteric/noncompetitive	conformational change/binding to alternative site	
Competitive	binding to (or blocking) active site	
Environmental conditions	**intracellular** control by pH/temperature/substrate/enzyme concentration	
Phosphorylation	protein kinase/phosphorylase activating enzyme/altering 3-D shape	
Hormones	correct action for steroid or protein hormone	
Coenzymes/Cofactors	presence/absence controls reactions	

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Question 4 (continued)

(c) The central dogma does not apply to some viruses. **Select** a specific virus or type and **explain** how it deviates from the central dogma. **(3 points maximum)**

Names a specific RNA virus or type of RNA virus (HIV, flu virus, etc.)	**(1 point)**
Deviation from the central dogma (RNA → DNA or RNA → protein or RNA → RNA)	**(1 point)**
More **detailed explanation** of the deviation from the central dogma	**(1 point)**