AP® Biology
2014 Scoring Guidelines

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Question 1

Trichomes are hairlike outgrowths of the epidermis of plants that are thought to provide protection against being eaten by herbivores (herbivory). In a certain plant species, stem trichome density is genetically determined.

To investigate variation in stem trichome density within the plant species, a student counted the number of trichomes on the stems of six plants in each of three different populations. The student used the data to calculate the mean trichome density (numbers of hairs per square centimeter) for each population. The results are provided in the table below.

TRICHOME DENSITY IN THREE PLANT POPULATIONS (number of trichomes/cm^2)

Population	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Sample Mean	Standard Error of the Mean (SEM)
I	8	11	9	10	8	6	9	1
II	12	6	15	9	13	8	11	1
III	13	17	9	14	12	16	14	1

(a) On the axes provided, **create** an appropriately labeled graph to illustrate the sample means of the three populations to within 95 percent confidence (i.e., sample mean ± 2 SEM). (**3 points maximum**; LO 1.1)

- Correctly labeled, scaled, with proper units
- Bar graph or modified bar graph with appropriately plotted means
- 2x standard error (SEM) above and below means

(b) Based on the sample means and standard errors of the means, **identify** the two populations that are most likely to have statistically significant differences in the mean stem trichome densities. **Justify** your response. (**2 points maximum**; LO 4.11, 4.19)

Identification (**1 point**)

- Populations I and III

Justification (**1 point**)

- The error bars/95 percent confidence intervals for populations I and III do not overlap
- (Sample mean + 2 SEM of population I) < (Sample mean − 2 SEM of population III)

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Question 1 (continued)

(c) **Describe** the independent and dependent variables and a control treatment for an experiment to test the hypothesis that higher trichome density in plants is selected for in the presence of herbivores. Also **identify** an appropriate duration of the experiment to ensure that natural selection is measured and **predict** the experimental results that would support the hypothesis. (**5 points maximum**; LO 1.5, 1.11)

NOTE: Points are earned in a single row only.

Independent Variable (**1 point**)	Dependent Variable (**1 point**)	Control (**1 point**)	Duration (**1 point**)	Prediction (**1 point**)
Presence of herbivores	Trichome density	Absence of herbivores	More than one generation	Increased trichome density relative to control
Trichome density in the presence of herbivores	Reproductive success OR # of plants	Plants with lower trichome density	More than one generation	Size of the population with higher trichome density will be larger than control population

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Question 2

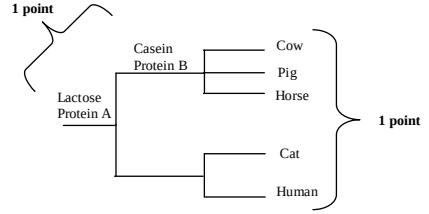
Mammalian milk contains antibodies that are produced by the mother's immune system and passed to offspring during feeding. Mammalian milk also contains a sugar (lactose) and may contain proteins (protein A, protein B, and casein), as indicated in the table.

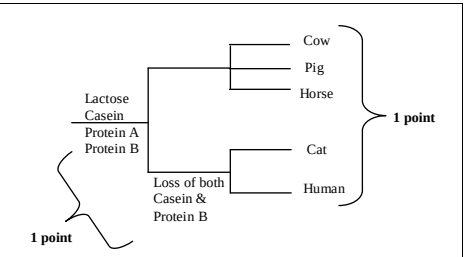
MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+
+ indicates the presence of the character, and – indicates the absence of a character					

(a) Using the data in the table, **construct** a cladogram on the template provided to indicate the most likely evolutionary relationships among the different mammals. **Indicate** on the cladogram where each of the characters most likely arose in the evolutionary process, and **justify** the placement of the characters on the cladogram. (**3 points maximum**; LO 1.18, 1.19)

NOTE: Points are earned in one column only.





Justification (**1 point**)	Justification (**1 point**)
Lactose and Protein A arose in a common ancestor to all 5 animals. Protein B and Casein arose only in the common ancestor to the pig/cow/horse clade/branch.	Lactose, Casein, Protein A, and Protein B arose in a common ancestor to all 5 animals. Protein B and Casein were lost in the common ancestor to the cat/human clade/branch.

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Question 2 (continued)

(b) Describe FOUR steps in the activation of the mother's specific immune response following exposure to a bacterial pathogen. Predict how the mother's immune response would differ upon a second exposure to the same bacterial pathogen a year later. (**5 points maximum**; LO 2.29).

Description (**1 point each; 4 points maximum**)

- Endocytosis of antigen by dendritic cell/macrophage/B-cell
- Degradation of antigen
- Antigen complexed with MHC molecule
- Presentation of antigen on surface of cell
- Recognition of antigen on surface of antigen presenting cell by (helper) T-cell
- Activation of signal transduction mechanism in T-cell
- Activation of (helper) T-cell
- (Helper) T-cells release chemicals that recruit/activate B-cells
- Antigen recognition by B-cell
- Activation of signal transduction mechanism in B-cell
- Activated B-cell or T-cell will clone itself
- Plasma cells/B-cells produce antibodies
- Antibodies recognize antigen
- Antibody binding to antigen is specific
- Memory B cells/memory helper T cells are produced

Prediction (**1 point**)

- Results in more rapid immune response
- Presence of memory cells
- Greater production of antibodies
- Antibodies circulate longer
- Antibodies have a greater affinity for the antigen

(c) **Predict** the most likely consequence for a nursing infant who is exposed to an intestinal bacterial pathogen (e.g., *Salmonella*) to which the mother was exposed three months earlier. **Justify** your prediction. (**2 points maximum**; LO 4.9, 2.40, 2.36)

NOTE: Points are earned in a single row only.

Prediction (**1 point**)	Justification (**1 point**)
Infant will be protected/not get sick	Antibodies are passed to infant *in utero*/via breast milk/infant receives B-cells in breast milk
Infant will become sick/die	Insufficient antibodies were transferred to the offspring/infant exposed to high infecting dose of the pathogen

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Question 3

As part of a new suburban development, a sports complex consisting of athletic fields and buildings is constructed in a formerly wooded area.

(a) **Predict** ONE ecological consequence on the local plant community that is likely to result during the site preparation and construction of the sports complex. **Justify** your prediction. (**2 points maximum**; LO 4.16, 2.21, 4.21)

Predicted consequences on plant community **(1 point)**	Justification of prediction **(1 point)**
Plant death / Loss of plant biomass	• Removing trees/shrubs • Pollution from construction equipment • Fewer individuals for reproduction • Altered habitat, e.g. change in amount of sunlight, obstruction by buildings, isolation of populations
Reduced number of plant species / Loss of biodiversity	• Removal of trees/shrubs • Reduced habitat • Pollution from construction kills local species
Decreased genetic diversity	Reduction in population size / bottleneck
Habitat loss	• Removal of trees/shrubs • Soil loss due to lack of ground cover
Increased success of sun-tolerant plants	Removal of shading trees
Introduction / Immigration of new plant species	Creation of new habitat and landscaped environments

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Question 3 (continued)

(b) To maintain the playing fields, large quantities of water and chemicals are applied regularly to the grass-covered areas. **Predict** ONE effect on the local animal community that might result from regular use and maintenance of the playing fields. **Justify** your prediction. (**2 points maximum**; LO 4.16, 2.21, 4.21)

Predicted consequence on animal community **(1 point)**	Justification of prediction **(1 point)**
Harm / Death to animals	• Exposure to toxic chemicals • Toxic chemicals accumulate through the food chain Persist in the environment • Contaminated groundwater
Emigration Displacement	• Loss of habitat and/or food • Loss of access • Exposure to toxic chemicals
Loss of native animal biodiversity	• Loss of plants on which the animals depend • Loss of habitat
Mutations	Chemicals effect on DNA
Improved conditions for animals	Increased food sources
Immigration of new animal species	Formation of new habitat
Less potable/drinking water for animals	• Increased salinity in water reservoir • Removal of water from reservoir / wells • Contamination of water with chemicals

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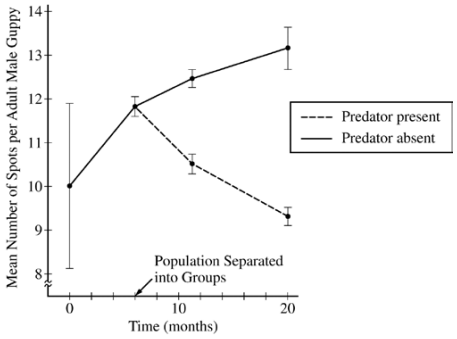
Question 4

Adult male guppies (*Poecilia reticulata*) exhibit genetically determined spots, while juvenile and adult female guppies lack spots. In a study of selection, male and female guppies from genetically diverse populations were collected from different mountain streams and placed together in an isolated environment containing no predators.

The study population was maintained for several generations in the isolated area before being separated into two groups. One group was moved to an artificial pond containing a fish predator, while a second group was moved to an artificial pond containing no predators. The two groups went through several generations in their new environments. At different times during the experiment, the mean number of spots per adult male guppy was determined as shown in the figure below. Vertical bars in the figure represent two standard errors of the mean (SEM).



(a) **Describe** the change in genetic variation in the population between 0 and 6 months and **provide** reasoning for your description based on the means and SEM.
(**2 points maximum**; LO 1.2, 2.24, 4.12, 4.26)

Describe change (**1 point**)	Provide reasoning (**1 point**)
Genetic variation is decreasing	SEM gets smaller

(b) **Propose** ONE type of mating behavior that could have resulted in the observed change in the number of spots per adult male guppy between 6 and 20 months in the absence of the predator.
(**1 point**; LO 1.2, 1.5, 2.40, 3.26, 3.40)

- Sexual selection for individuals with more spots
- Random mating behavior resulted in increased number of spots by chance

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Question 4 (continued)

(c) **Propose** an evolutionary mechanism that explains the change in average number of spots between 6 and 20 months in the presence of the predator.
(**1 point**; LO 1.2, 3.26, 4.19)

- Directional selection against individuals with large numbers of spots
- Directional selection for individuals with fewer spots
- Natural selection used in context
- Genetic drift resulted in several generations of decreased numbers of spots

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Question 5

Genetically modified crops have been developed that produce a protein that makes the plants resistant to insect pests. Other genetic modifications make the crops more resistant to chemicals that kill plants (herbicides).

(a) **Describe** TWO potential biological risks of large-scale cultivation and use of such genetically modified plants. (**2 points maximum**)

(b) For each of the risks you described in part (a), **propose** a practical approach for reducing the risk. (**2 points maximum**; LO 4.21, 2.23)

Description of risk (**1 point each; 2 points maximum**)	Proposed mitigation* + (**1 point each box; 2 points maximum**)
Unknown human/other animal health risk due to consuming GM proteins	• Testing/labeling product packaging • Isolate animals from crops
Disruption within food chain	• Intersperse GM plants with non-GM plants in culture • Provide alternative food source
Developed resistance in pest species	• Increased use of effective pesticides • Introduce pest predators • Further engineer the GMO to produce more resistance protein • Rotate GM and non-GM crops
Spread of genetic modifications to non-GM plants	• Contain pollen of GM plants • Disable the ability of GM plants to produce viable seeds
GM plants out-compete native species	• Contain/isolate GM plants • Disable GM plants' ability to produce viable seeds
Reduced numbers of pollinators	Contain/isolate GM plants
Loss of biodiversity	Intersperse GM plants with non-GM plants in culture
Use of herbicides harms non-target species	• Rotate GM and non-GM crops • Use organic/alternative herbicides
Invasive disease wiping out the monoculture	Intersperse GM plants with non-GM plants in culture

* Proposed mitigation of non-use of GM plants is acceptable for any described risk above.

+Mitigation must be practical for the risk given.

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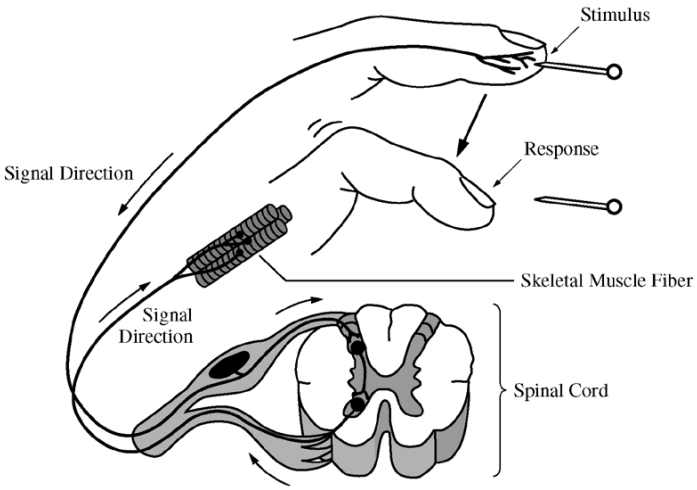
Question 6



Cross Section of Spinal Cord and Skeletal Muscle Fiber

Information processing involves complex neural pathways that require a certain amount of time between recognition of a stimulus and the resulting response. For some types of stimuli, a reflex arc replaces the typical stimulus-response pathway. A representation of a reflex arc is shown in the figure above.

Based on the figure, **describe** TWO ways that the reflex arc differs from typical stimulus-response transmission pathways. **Provide** reasoning to support the claim that reflex arcs help organisms avoid serious injury. (**3 points maximum**; LO 2.38, 3.44, 3.45, 4.10)

Description of difference (**1 point each**; **2 points maximum**)

- Quicker response time
- No integration with brain / does not reach brain before response occurs
- Fewer neurons / synapses involved in reflex arc / shorter distance for signal to travel
- Involuntary / no conscious control / no processing by brain

Reasoning to support claim **(1 point maximum)**

- Quicker response to a threat
- Response is innate (automatic response) rather than learned / predetermined neuron pathway / hardwired

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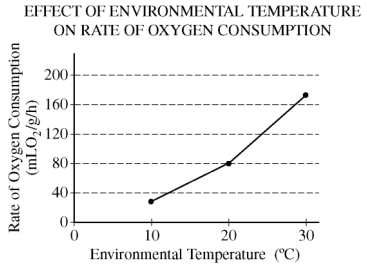
Question 7



(a) Based on the graph, **describe** a specific method of thermoregulation used by the species of animal. **Provide** support for your answer using the data. (**2 points maximum**; LO 2.21, 2.24, 2.27)

NOTE: students may only earn points within one row.

Describe method (**1 point**)	Support (**1 point**)
This species is an ectotherm/incapable of endoregulation	• Increased metabolic rate/O_2 consumption rate/respiration rate with increased temperature • Decreased metabolic rate/O_2 consumption rate/respiration rate with decreased temperature • If the animal were endothermic, O_2 consumption rate/respiration rate/metabolic rate would increase with decreasing temperature
Behavior to adjust body temperature, i.e.,seeking shade, basking in the sun, burrowing in mud, evaporative cooling	• Increased metabolic rate/O_2 consumption rate/respiration rate with increased temperature • Decreased metabolic rate/O_2 consumption rate/respiration rate with decreased temperature • This species is ectothermic/incapable of endoregulation

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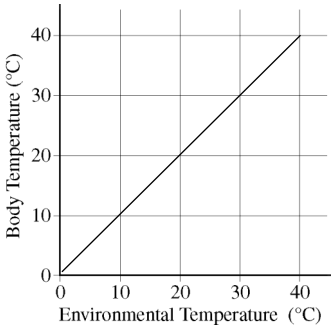
Question 7 (continued)

(b) On the labeled axis provided below, **draw** a line to indicate the most likely relationship between body temperature and environmental temperature in the species. (**1 point**; LO 2.22)



- Line/curve with positive slope

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Question 8

A research team has genetically engineered a strain of fruit flies to eliminate errors during DNA replication. The team claims that this will eliminate genetic variation in the engineered flies. A second research team claims that eliminating errors during DNA replication will not entirely eliminate genetic variation in the engineered flies. (**3 points maximum**)

(a) **Provide** ONE piece of evidence that would indicate new genetic variation has occurred in the engineered flies. (**1 point**; LO 1.10)

Piece of evidence
- New phenotypes
- Different DNA sequence
- New genotypes
- Chromosomal differences
- Different mRNA sequence
- Protein with different amino acid sequence

(b) **Describe** ONE mechanism that could lead to genetic variation in the engineered strain of flies. (**1 point**; LO 3.28)

Describe mechanism
- Sexual reproduction produces offspring with new combinations of alleles/traits
- Meiosis produces new combinations of alleles/traits
- Crossing over produces new combinations of alleles/traits
- Independent assortment produces new combinations of alleles/traits
- Random fertilization produces new combinations of alleles/traits
- Immigration/gene flow introduces new alleles/gene sequences
- Viral infection inserts DNA into genome
- Nondisjunction causes anomaly in chromosome number
- Chromosomal rearrangements (e.g., large deletions, duplications, translocations, inversions, transposons, etc.) inactivate genes or result in multiple copies of genes
- Radiation or chemicals or mutagens induce mutations/changes in DNA

(c) **Describe** how genetic variation in a population contributes to the process of evolution in the population. (**1 point**; LO 1.25)

Description
- Genetic variation is the basis of phenotypic variation that can be acted upon by natural selection
- Without genetic variation, there is no phenotypic variation on which natural selection can act

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