Question 4: Conceptual Analysis — 4 points

The common wild oat is native to regions of Europe and Asia but is an invasive species in central California grasslands. In California, the common wild oat has almost completely replaced some species of native bunchgrass. Researchers found that aphids, a type of small insect that often carries plant viruses, have a much higher reproductive rate in grasslands that include the common wild oat than in grasslands composed of only native bunchgrass species. Additionally, the viruses carried by the aphids appear to affect only the native bunchgrasses and not the common wild oat. Native bunchgrasses infected by the virus have much higher death rates than do native bunchgrasses that are not infected.

(a) **Describe** the change in the resilience of an ecosystem when there is a decrease in the number of species. — **1 point**

- (The resilience of the ecosystem) will decrease.

(b) **Explain** how the addition of the common wild oat affects the number of native bunchgrass plants that can be supported by the California grasslands ecosystem. — **1 point**

Accept one of the following:

- (The addition of the wild oat) limits the resources available (to the native plants), resulting in a decrease (in the population size).
- (The addition of the wild oat) enables the aphid population to increase/increases the exposure to viruses, resulting in a decrease (in the population size of the native bunchgrass).

(c) Researchers suggest adding ladybugs, predators of aphids, to the California grasslands. **Predict** the effect of adding ladybugs on the abundance of the native bunchgrass population. — **1 point**

- (The native bunchgrass population) will increase (in abundance).

(d) **Justify** your prediction in part (c). — **1 point**

- (Adding ladybugs) will decrease the number of aphids, which will cause a decrease in the transmission of/infection by plant viruses.

Total for question 4 — **4 points**

Question 3: Scientific Investigation — 4 points

Sand lances of the genus *Ammodytes* are small fish that function as keystone organisms in several coastal ecosystems. These sand lances are prey fish that support organisms at higher trophic levels. Scientists performed experiments to examine how sand lance populations are likely to be affected by the rising temperatures and CO_2 levels associated with climate change.

Sand lance embryos typically develop and mature into adult fish at low temperatures (approximately 5°C) and stable, low CO_2 levels (approximately 400 µatm). Over the course of two years, the scientists measured the survival rate of sand lance embryos allowed to develop and mature in a laboratory at three different temperatures, 5°C, 7°C, and 10°C, with the level of CO_2 maintained at 400 µatm, 1,000 µatm, and 2,100 µatm for each temperature.

(a) **Describe** the effect of increased biodiversity on the resilience of an ecosystem in a changing environment. — **1 point**

- (Ecosystem) resilience/it will be greater (with increased biodiversity).

(b) **Justify** the scientists' selecting 5°C as the lowest temperature and 400 µatm as the lowest CO_2 level in their study of sand lance embryo survival. — **1 point**

Accept one of the following:

- These are the normal/current conditions at which the embryos develop and were used as a basis for comparison.
- These (current) conditions were used as a basis to compare the effects of changes in environmental conditions/increases in temperature and CO_2.

(c) **State** a null hypothesis for the experiment. — **1 point**

Accept one of the following:

- Climate change will have no effect on sand lance (embryo) survival/sand lance development/the size of sand lance populations.
- (Increases in) temperature/CO_2 levels will have no effect on sand lance (embryo) survival/sand lance development /the size of sand lance populations.
- There will be no difference in the sand lance (embryo) survival rates/sand lance development/the size of sand lance populations measured at all/different temperatures and CO_2 levels.

(d) The scientists claim that a reduction in the population size of the *Ammodytes* sand lances will affect the stability of the entire coastal ecosystem. Provide reasoning to **support** the scientists' claim. — **1 point**

Accept one of the following:

- There will be a negative effect on other trophic levels because the sand lance provides food for many other species.
- There will be a negative effect on other trophic levels because there will be reduced energy to transfer (to higher trophic levels).

Total for question 3 — **4 points**

Question 5: Analyze Model or Visual Representation of a Biological Concept or Process — 4 points

The following models represent all the interacting species in two different communities with some of the same species and feeding relationships. These models assume that both communities have the same initial biomass. The models can be used to understand the effects of human activities on the communities.

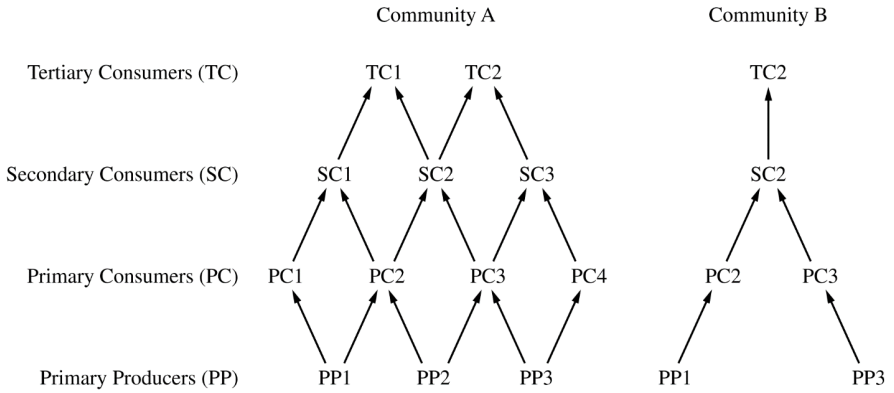


Figure 1. Models of two different communities with some of the same species

(a) **Describe** a characteristic of a community that makes a species invasive in that community but not invasive in a different community. — **1 point**

Accept one of the following:

- There are no/reduced numbers of natural predators of the species in the community where it is invasive.
- There are no/reduced numbers of competitors of the species in the community where it is invasive.
- There are no/reduced numbers of diseases to which the species is susceptible in the community where it is invasive.

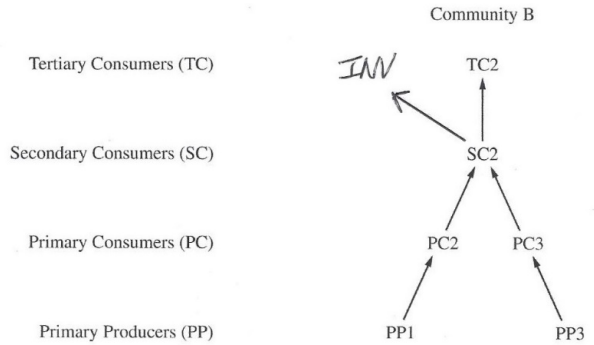
(b) **Explain** why removing species PP1 will have a greater effect on community B than on community A. — **1 point**

Accept one of the following:

- In community B, there will be decreases in PC2, SC2, and TC2 /PC2, SC2, and PC3. In community A, PC2 has alternative food sources.
- With fewer/less diverse primary producers (and primary consumers), there are fewer paths for energy to move through the community.
- With fewer species/fewer feeding interactions/less diversity, community B will be less resilient to future environmental change.

(c) An invasive species (INV) that eats individuals of species SC2 is introduced into community B. Using the template in the space provided for your response, for community B, indicate the feeding relationship for this invasive species by correctly placing **INV** to represent the invasive species and **an arrow** to represent the feeding relationship within community B. — **1 point**

- INV should be added in a position that is horizontally aligned with TC2. An arrow should point from SC2 to INV.



(d) **Explain** how human activities that add toxins to the soil could change a community with many species at each trophic level, such as community A, into a community with few species at each trophic level, such as community B. — **1 point**

Accept one of the following:

- The activities could eliminate primary producers, which reduces species diversity at higher trophic levels.
- The activities could cause biomagnification of the toxins, reducing species diversity at higher trophic levels.

Total for question 5 — **4 points**

Question 5: Analyze a Model or Visual Representation — 4 points

Annual plants complete their life cycle, including germination, seed production, and death, within one year. *Ambrosia trifida* (giant ragweed) is an annual plant that readily colonizes any land that has had a disturbance such as plowing. The plant is considered an invasive species in regions outside of its native range. In a particular region, the seeds of *A. trifida* germinate from early March through the end of the summer, while the seeds of other annual plants require warmer soil temperatures and thus germinate from late April through the end of the summer.

Researchers studied the influence of *A. trifida* on the biodiversity of other annual plant species that grow in the same field. In early spring, the researchers marked off identical plots of land in a field that had been plowed the previous fall and not replanted with new crops. All plants that grew on one half of the plots were left untouched (Figure 1A), while all germinating *A. trifida* seedlings were removed from the other half of the plots throughout the spring and summer (Figure 1B). In late summer, the researchers counted and identified all plants that grew in the plots. The distribution of plants is represented by the symbols in Figures 1A and 1B.

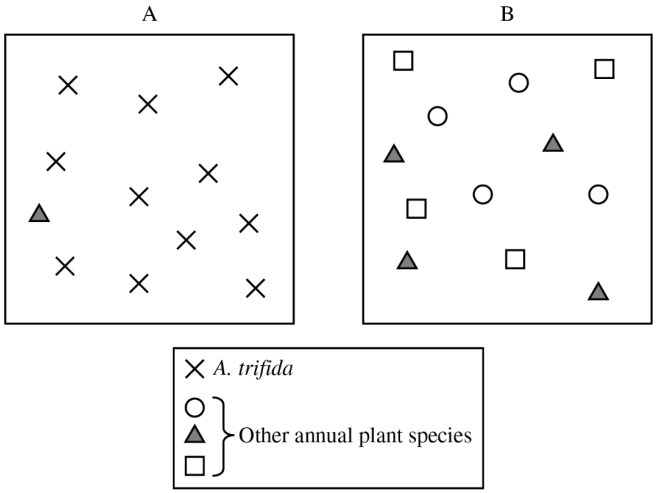


Figure 1. Representations of plant identity and distribution in experimental plots in late summer. Each box represents one typical experimental plot, and each symbol represents 10 individual plants.

(a) **Describe** a cause of logistic growth of the ragweed population. **1 point**

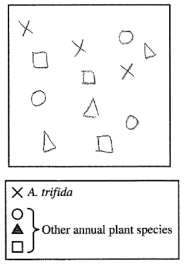
Accept one of the following:

- A factor that becomes limiting would cause the population size to stabilize.
- Space/sunlight/herbivory/phosphorus/nitrogen/other density-dependent factor becomes limiting, and the population stabilizes.

(b) Based on the representation in Figure 1, **explain** why the scientists claim that plot B would be more resilient than plot A in response to a sudden environmental change. **1 point**

- (Plot B is more resilient) because it has much greater (species) diversity than plot A does.

(c) In a third group of plots, the researchers removed all seedlings of all plants that germinated before June 1. All plants that germinated after June 1 were left untouched. Using the template in the space provided for your response and the symbols shown in Figure 1, **represent** the expected plant species that would be found in this third group of plots three months later. Draw no more than 12 symbols. Assume all other environmental conditions are the same as for the initial study described. **1 point**



- All four species, including *A. trifida*, must be added to the template.

(d) **Explain** how an invasive species such as ragweed affects ecosystem biodiversity, as illustrated in Figure 1. **1 point**

- The explanation requires a process or relationship - and must state that biodiversity decreases.
- Examples of appropriate responses include:
  - There are no predators of the invasive species, so its population grows faster and reduces biodiversity.
  - The invasive species germinates earlier, uses up resources, and reduces biodiversity.
  - The invasive species outcompetes other species and reduces biodiversity.

Total for question 5 — 4 points

AP® Biology
2014 Scoring Guidelines

2014 SCORING GUIDELINES

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)

2014 SCORING GUIDELINES

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

SCORING GUIDELINES

Question 2

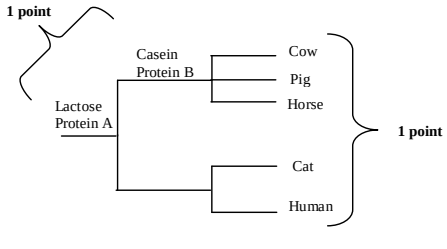
Mammalian milk contains antibodies that are produced by the mother's immune system and passed to offspring during feeding. Mammalian milk also contains a sugar (lactose) and may contain proteins (protein A, protein B, and casein), as indicated in the table.

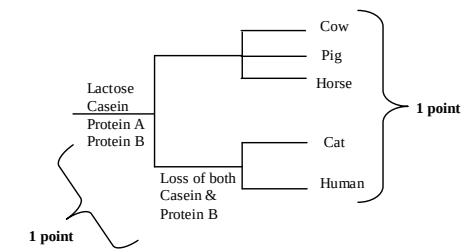
MILK COMPONENTS IN DIFFERENT MAMMALS

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					

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.

SCORING GUIDELINES

Question 2 (continued)

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

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

SCORING GUIDELINES

Question

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

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

SCORING GUIDELINES

Question 3 (continued)

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**; 6, 2.21, 4.21)

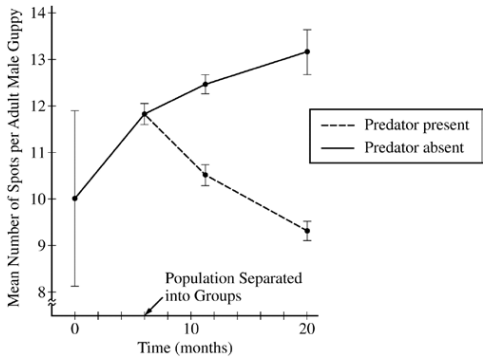
Predicted consequence on animal community **(1 point)**	Justification of prediction **(1 point)**
Harm ath to animals	• Exposure to toxic chemicals • Toxic chemicals accumulate through the food chain Persist in the environment • Contaminated groundwater
Emigration Displacement	• Loss of habitat and/or 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

2014 SCORING GUIDELINES

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

2014 SCORING GUIDELINES

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

CORING GUIDELINES

Question

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).

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

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)

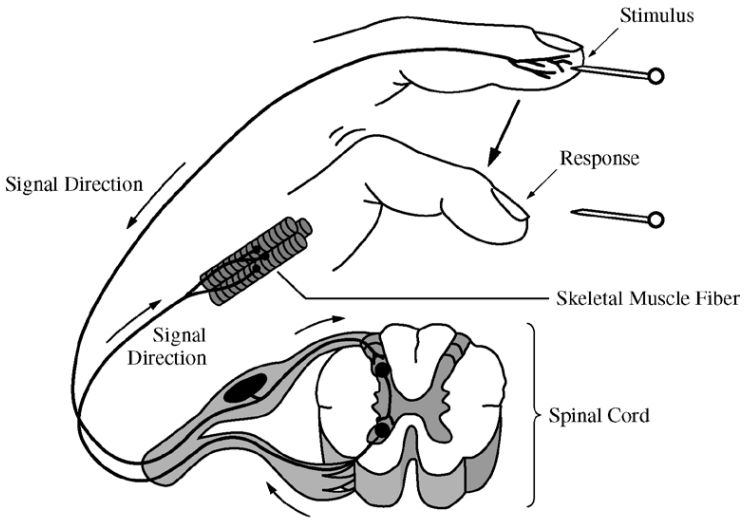
Description of risk . **point each; 2 points maximum**)	Proposed mitigation* + (**1 point each box; 2 points maximum**)
Unknown human/other animal health risk due to consuming GM proteins	• Testing/labeling product packaging • Isolate animals from crops
Disruption within food chain	• Intersperse GM plants 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
read 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
f herbicides harms non-target species	• Rotate GM and non-GM crops • Use organic/alternative herbicides
ıvasive 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.

2014 SCORING GUIDELINES

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**)

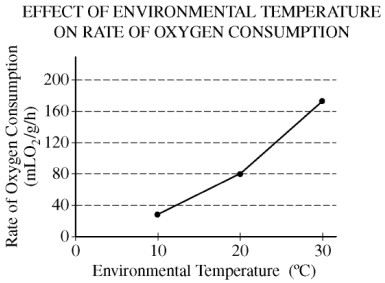
- Quicker response time
- No integration with brain / does not reach brain before response occurs
- Fewer neurons / synapses involved in reflex arc / shorter distance for signal to travel
- Involuntary / no conscious control / no processing by brain

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

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

SCORING GUIDELINES

Question



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)

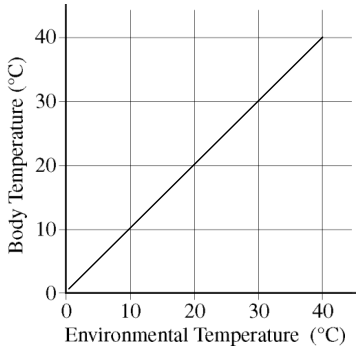
NOTE: students may only earn points within one row.

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 rat 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

CORING GUIDELINES

Question 7 (continued)

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

2014 SCORING GUIDELINES

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