# Unit 8: Ecology

| Topic | Learning Objective(s) |
|---|---|
| 8.1 Responses to the Environment | **ENE-3.D** Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment. |
| | **IST-5.A** Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population. |
| 8.2 Energy Flow Through Ecosystems | **ENE-1.M** Describe the strategies organisms use to acquire and use energy |
| | **ENE-1.N** Explain how changes in energy availability affect populations and ecosystems |
| | **ENE-1.O** Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem. |
| 8.3 Population Ecology | **SYI-1.G** Describe factors that influence growth dynamics of populations. |
| 8.4 Effect of Density of Populations | **SYI-1.H** Explain how the density of a population affects and is determined by resource availability in the environment. |
| 8.5 Community Ecology | **ENE-4.A** Describe the structure of a community according to its species composition and diversity |
| | **ENE-4.B** Explain how interactions within and among populations influence community structure. |
| | **ENE-4.C** Explain how community structure is related to energy availability in the environment. |
| 8.6 Biodiversity | **SYI-3.F** Describe the relationship between ecosystem diversity and its resilience to changes in the environment. |
| | **SYI-3.G** Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure. |
| 8.7 Disruptions to Ecosystems | **EVO-1.O** Explain the interaction between the environment and random or preexisting variations in populations. |
| | **SYI-2.A** Explain how invasive species affect ecosystem dynamics. |
| | **SYI-2.B** Describe human activities that lead to changes in ecosystem structure and/or dynamics. |
| | **SYI-2.C** Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics |

# Free Response Practice

| 2022 #5 |
| --- |

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.

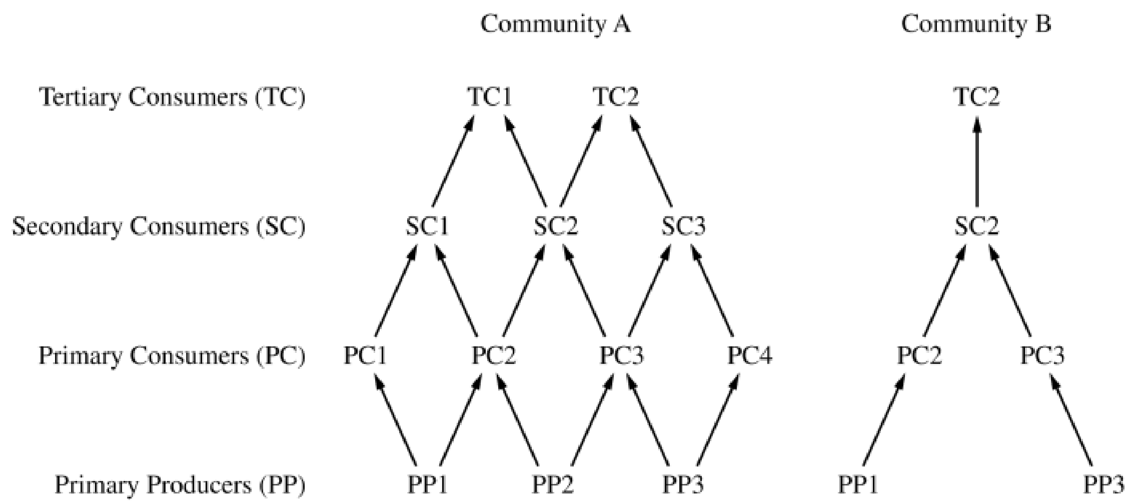


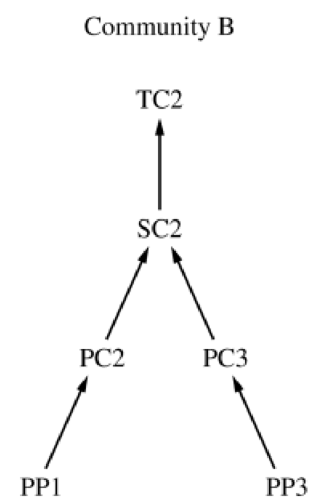

Figure 1. Models of two different communities with some of the same species

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

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

(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.

(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.



# 2021 #5

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 Figure 1A and 1B.

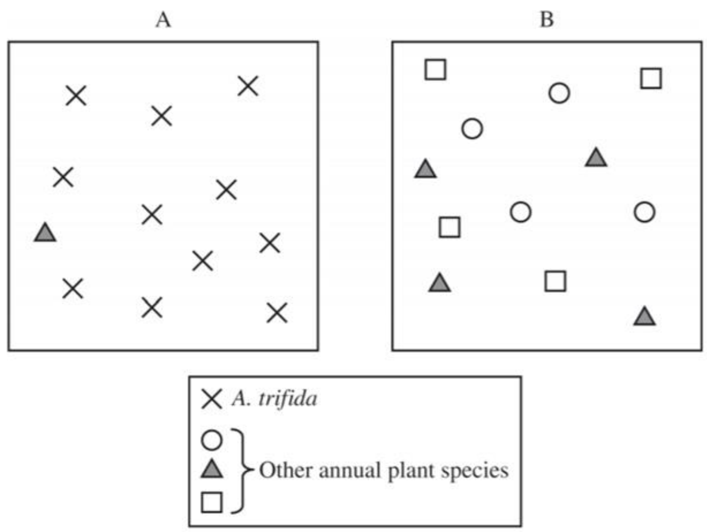



Figure 1. Representations of plant identity and distribution in experimental plots in late summer. Each box represents one typical experimental plot, and each symbol represents 10 individual plants.

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

(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.

(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.

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

## 2019 #1

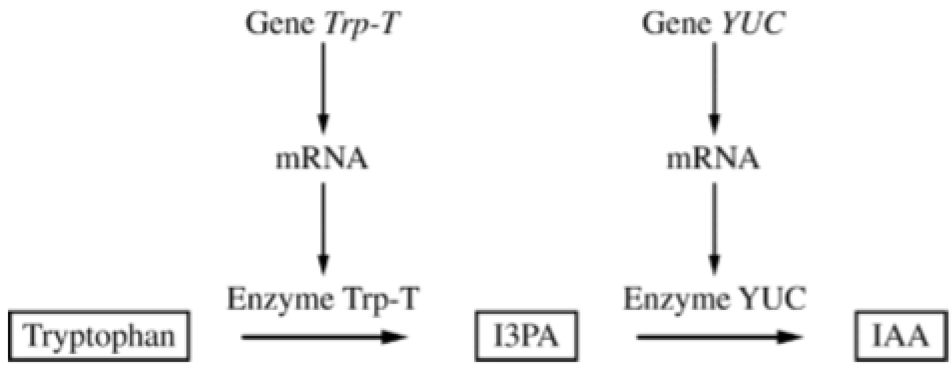



**Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan**

Auxins are plant hormones that coordinate several aspects of root growth and development. Indole-3-acetic acid (IAA) is an auxin that is usually synthesized from the amino acid tryptophan (Figure 1). Gene Trp-T encodes an enzyme that converts tryptophan to indole-3-pyruvic acid (I3PA), which is then converted to IAA by an enzyme encoded by the gene YUC.

(a) **Circle** ONE arrow that represents transcription on the template pathway. **Identify** the molecule that would be absent if enzyme YUC is nonfunctional.

(b) **Predict** how the deletion of one base pair in the fourth codon of the coding region of gene Trp-T would most likely affect the production of IAA. **Justify** your prediction.

(c) **Explain** one feedback mechanism by which a cell could prevent production of too much IAA without limiting I3PA production.

(d) Rhizobacteria are a group of bacteria that live in nodules on plant roots. Rhizobacteria can produce IAA and convert atmospheric nitrogen into forms that can be used by plants. Plants release carbon-containing molecules into the nodules. Based on this information, **identify** the most likely ecological relationship between plants and rhizobacteria. **Describe** ONE advantage to the bacteria of producing IAA.

(e) A researcher removed a plant nodule and identified several "cheater" rhizobacteria that do not produce IAA or fix nitrogen. **Describe** the evolutionary advantage of being a bacterial cheater in a population composed predominantly of non-cheater bacteria. Plants can adjust the amount of carbon-containing molecules released into nodules in response to the amount of nitrogen fixed in the nodule. **Predict** the change in the bacterial population that would cause the plant to reduce the amount of carbon-containing molecules provided to the nodule.

## 2019 #2

A student studying two different aquatic, plant-eating, unicellular protist species (species A and B) designed an experiment to investigate the ecological relationship between the two species (Table 1).

TABLE 1. EXPERIMENTAL TREATMENT GROUPS

| | |
|---|---|
| Group I. | Species A and B are each grown in separate containers. |
| Group II. | Species A and B are grown together in the same container. |

In treatment group I, the student placed 10 individuals of species A into a container with liquid growth medium and 10 individuals of species B into a separate container with an equal amount of the same liquid growth medium. In treatment group II, the student placed 5 individuals of each species into a single container with the liquid growth medium. The student then maintained the containers under the same environmental conditions and recorded the number of individuals in each population at various time points. The results are shown in Table 2.

TABLE 2. NUMBER OF INDIVIDUALS IN EACH PROTIST POPULATION IN BOTH TREATMENT GROUPS

| | Group I. Grown Separately | | Group II. Grown Together | |
|---|---|---|---|---|
| Time (h) | Species A | Species B | Species A | Species B |
| 0 | 10 | 10 | 5 | 5 |
| 10 | 100 | 50 | 45 | 20 |
| 20 | 400 | 200 | 100 | 50 |
| 30 | 1100 | 500 | 250 | 25 |
| 40 | 1400 | 650 | 525 | 20 |
| 50 | 1500 | 700 | 900 | 10 |
| 60 | 1500 | 700 | 1250 | 0 |
| 70 | 1500 | 700 | 1400 | 0 |

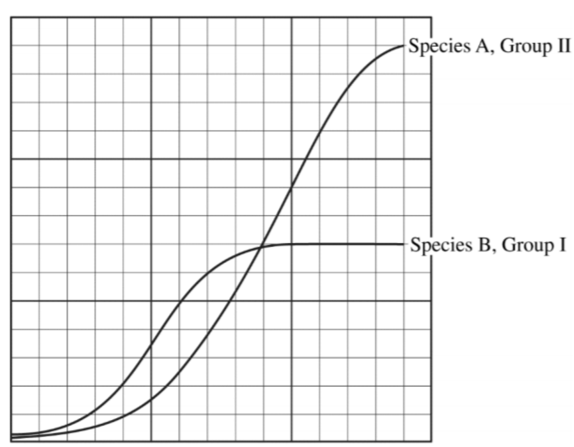
(a) The growth curves for species B in group I and for species A in group II (shaded columns) have been plotted on the template. Use the template to **complete** an appropriately labeled line graph to illustrate the growth of species A in treatment group I and species B in treatment group II (unshaded columns).

(b) As shown in the table, the student established treatment group II with 5 individuals of each species. **Provide reasoning** for the reduced initial population sizes.

(c) The student claims that species A and B compete for the same food source. **Provide TWO pieces of evidence** from the data that support the student's claim.

(d) **Predict** TWO factors that will most likely limit the population growth of species A in treatment group I.

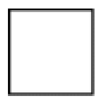
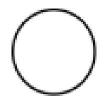
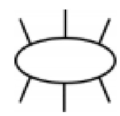
(e) Many protists contain an organelle called a contractile vacuole that pumps water out of the cell. The student repeated the experiment using a growth medium with a lower solute concentration. **Predict** how the activity of the contractile vacuole will change under the new experimental conditions. **Justify** your prediction.



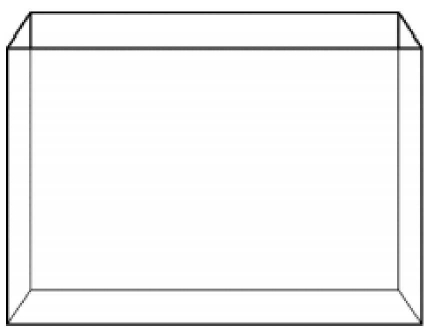
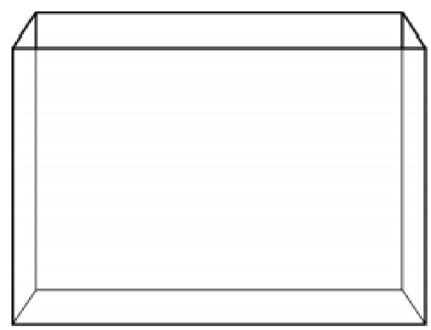
# 2018 #3

Seagrasses are aquatic plants that reproduce sexually. Male seagrass flowers produce sticky pollen that is carried by circulating water to female flowers, resulting in fertilization. A researcher claims that mobile aquatic invertebrates can also transfer pollen from male to female flowers in the absence of circulating water. To investigate this claim, the researcher set up aquariums to model the possible interaction between the invertebrates and seagrasses.

(a) Use the symbols below and the template aquariums to demonstrate the experimental design for testing the researcher's claim that mobile aquatic invertebrates can pollinate seagrass in the absence of circulating water. **Draw** the appropriate symbols in the negative control aquarium AND the experimental aquarium. Do not use an symbol more than once in the same aquarium.

| Male Flower | Female Flower | Invertebrates |
| --- | --- | --- |
|  |  |  |

(b) **Identify** the dependent variable in the experiment. **Predict** the experimental results that would support the researcher's claim that mobile aquatic invertebrates can also transfer pollen from male to female flowers in the absence of circulating water.

| Negative Control Aquarium | Experimental Aquarium |
| --- | --- |
|  |  |

## 2018 #5

Some birds, including great spotted cuckoos, lay their eggs in the nests of other birds, such as reed warblers. The warbler parents raise the unrelated chicks and provide them with food that would otherwise be given to their biological offspring. A researcher conducted an investigation to determine the type of relationship between warblers and cuckoos in an environment without predators. The researcher found that nests containing only warblers were more likely to be successful than nests containing warblers and cuckoos (data not shown). A successful nest is defined as a nest where at least one chick becomes an adult warbler.

In some geographic areas, several species of nest predators are present. Researchers have found that cuckoo chicks, while in the nest, produce a smelly substance that deters nest predators. The substance does not remain in the nest if cuckoo chicks are removed. Figure 1 shows the probability that nest containing only warblers or containing both warblers and cuckoos will be successful in an environment with predators. In a follow-up experiment, the researchers added cuckoos to a nest that contained only warblers (group 1) and removed from a nest containing warblers and cuckoos (group 2).

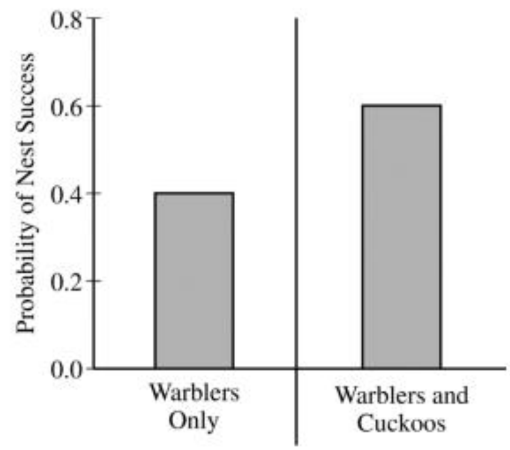


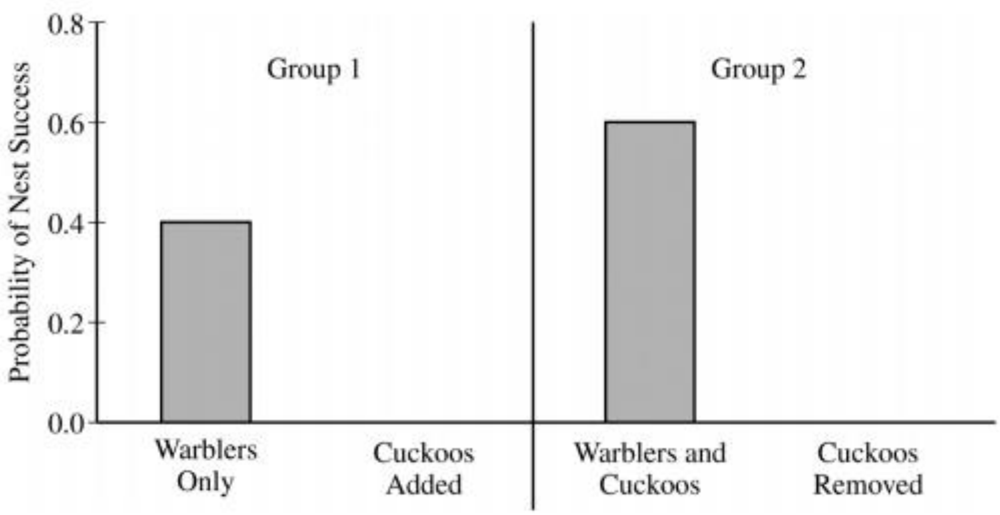

Figure 1. Probability of nest success in an environment with predators

(a) **Describe** the symbiotic relationship that exists between the cuckoo and warbler in an environment without predators.

(b) On the template provided, **draw** bars in the appropriate locations to predict the relative probability of success for the nest in the presence of predators where:

* the cuckoos were <u>added</u> to the nest containing only warblers (group 1)
* the cuckoos were removed from the nest containing warblers and cuckoos (group 2)

(c) **Identify** the symbiotic relationship that exists between the cuckoo and the warbler in the presence of predators.



## 2018 #7

In the tongue sole fish (*Cynoglossis semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

| | Z | W |
|---|---|---|
| Z* | Z* Z | Z* W |
| Z | Z Z | Z W |

(a) **Predict** the percent of phenotypic males among the $F_1$ offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.

(b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, **identify** the genotype of the male parent in the cross. **Describe** ONE fitness cost to the female of mating with this particular male.

## 2017 #1

In flowering plants, pollination is a process that leads to the fertilization of an egg and the production of seeds. Some flowers attract pollinators, such as bees, using visual and chemical cues. When a bee visits a flower, in addition to transferring pollen, the bee can take nectar from the flower and use it to make honey for the colony.

Nectar contains sugar, but certain plants also produce caffeine in the nectar. Caffeine is a bitter-tasting compound that can be toxic to insects at high concentrations. To investigate the role of caffeine in nectar, a group of researchers studied the effect of 0.1 mM caffeine on bee behavior. The results of an experiment to test the effect of caffeine on bees' memory of a nectar source are shown in Table 1.

TABLE 1. EFFECT OF 0.1 mM CAFFEINE ON MEMORY IN BEES

| Treatment | Memory (average probability of revisiting a nectar source $\pm 2SE_{\bar{x}}$) | |
|---|---|---|
| | 10 Minutes | 24 Hours |
| Control | 0.72 ± 0.09 | 0.41 ± 0.07 |
| Caffeine | 0.83 ± 0.07 | 0.78 ± 0.08 |

(a) On the axes provided, **construct** an appropriately labeled graph to illustrate the effect of caffeine on the probability of bees revisiting a nectar source (memory).

(b) Based on the results, **describe** the effect of caffeine on each of the following:

(i) Short-term (10 minute) memory of a nectar source

(ii) Long-term (24 hour) memory of a nectar source

(c) **Design an experiment** using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. **Identify** the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis.

(d) Researchers found that nectar with caffeine tends to have a lower sugar content than nectar without caffeine. Plants use less energy to produce the caffeine in nectar than they do to produce the sugar in nectar. **Propose ONE**

**benefit** to plants that produce nectar with caffeine and a lower sugar content. **Propose ONE cost** to bees that visit the flowers of plants that produce nectar with caffeine and a lower sugar content.

## 2017 #2

Fires frequently occur in some ecosystems and can destroy all above-ground vegetation. Many species of plants in these ecosystems respond to compounds in smoke that regulate seed germination after a major fire. Karrikins (KAR) and trimethylbutenolides (TMB) are water-soluble compounds found in smoke that are deposited in the soil as a result of a fire. KAR and TMB bind to receptor proteins in a seed. In a study on the effects of smoke on seeds, researchers recorded the timing and percent of seed germination in the presence of various combinations of KAR and TMB. The results are shown in Figure 1.

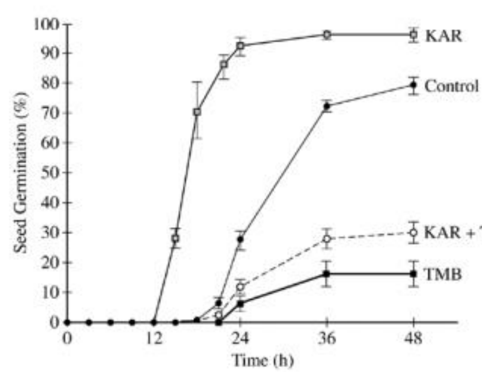



Figure 1. The effect of karrikins (KAR) and trimethylbutenolides (TMB) on seed germination in *Lactuca* plants. Error bars represent $\pm 2SE_{\overline{X}}$.

In a second investigation into the effect of available water on seed germination after a fire, researchers treated seeds with KAR or TMB. The treated seeds were then divided into two treatment groups. One group received a water rinse and the other group received no water rinse. The seeds were then incubated along with a group of control seeds that were not treated. The results are shown in the table.

EFFECT OF CHEMICAL TREATMENT AND WATER RINSE ON GERMINATION

| Treatment Group | Chemical Treatment | | Water | Germination Result |
|---|---|---|---|---|
| | KAR | TMB | | |
| 1 (control) | – | – | – | Control result |
| 2 | + | – | – | Different from control |
| 3 | – | + | – | Different from control |
| 4 (control) | – | – | + | Control result |
| 5 | + | – | + | Different from control |
| 6 | – | + | + | Same as control |

(a) The researchers made the following claims about the effect of KAR and the effect of TMB on seed germination relative to the control treatment.

- KAR alone affects the timing of seed germination
- KAR alone affects the percentage of seeds that germinate
- TMB alone affects the timing of seed germination
- TMB alone affects the percentage of seeds that germinate

**Provide support** using data from Figure 1 for each of the researchers' claims.

(b) **Make a claim** about the effect of rinsing on the binding of KAR to the receptor in the seed and about the effect of rinsing on the binding of TMB to the receptor in the seed. Identify the appropriate treatment groups and results from the table that, when compared with the controls, **provide support** for each claim.

(c) There is intense competition by plants to successfully colonize areas that have been recently cleared by a fire. **Describe** ONE advantage of KAR regulation and ONE advantage of TMB regulation to plants that live in an ecosystem with regular fires.

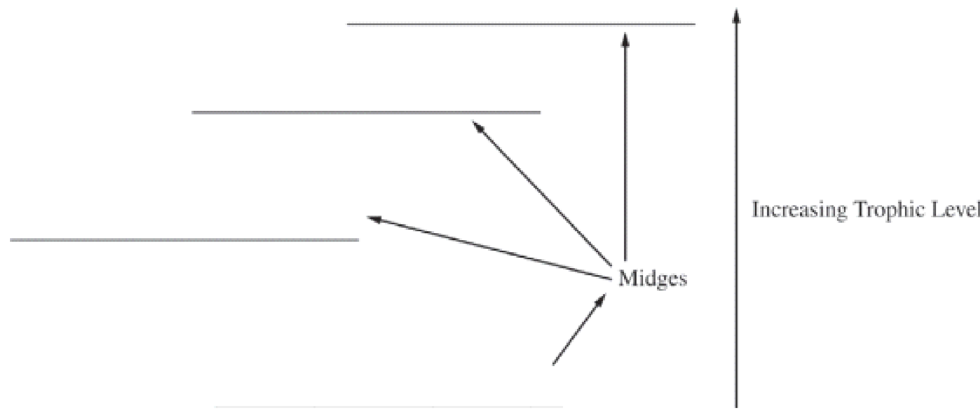
## 2017 #4

The table below shows how much each organism in an aquatic ecosystem relies on various food sources. The rows represent the organisms in the ecosystem, and the columns represent the food source. The percentages indicate the proportional dietary composition of each organism. High percentages indicate strong dependence of an organism on a food source.

DIETARY COMPOSITION OF ORGANISMS IN AN AQUATIC ECOSYSTEM

| Organism | Food Source (% of diet) | | | | |
|---|---|---|---|---|---|
| | Algae | Stoneflies | Midges | Hellgrammites | Caddisflies |
| Algae | | | | | |
| Stoneflies | | | 90 | | 10 |
| Midges | 100 | | | | |
| Hellgrammites | | 20 | 10 | | 70 |
| Caddisflies | 70 | | 30 | | |

(a) Based on the food sources indicated in the data table, **construct** a food web in the template below. Write the organism names on the appropriate lines AND draw the arrows necessary to indicate the energy flow between organisms in the ecosystem.




## 2016 #2

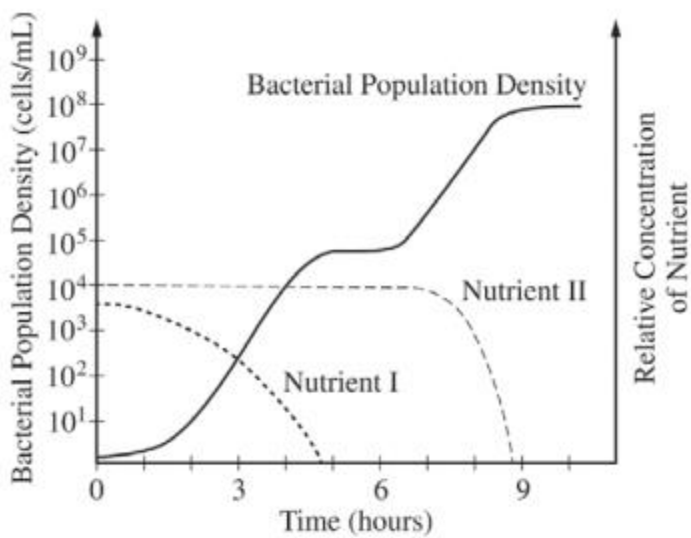



**Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)**

Bacteria can be cultured in media with a carefully controlled nutrient composition. The graph above shows the growth of a bacterial population in a medium with limiting amounts of two nutrients, I and II.

(a) **Estimate** the maximum population density in $\frac{cells}{mL}$ for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.

(b) Using the data, **calculate** the growth rate in $\frac{cells}{mL x hour}$ of the bacterial population between hours 2 and 4.

(c) **Identify** the preferred nutrient source of the bacteria in the culture over the course of the experiment. Use the graph to **justify** your response. **Propose** ONE advantage of the nutrient preference for an individual bacterium.

(d) **Describe** how nutrient I most likely regulates the genes for metabolism of nutrient I <u>and</u> the genes for metabolism of nutrient II. **Provide** TWO reasons that the population does not grow between hours 5 and 6.

## 2016 #3

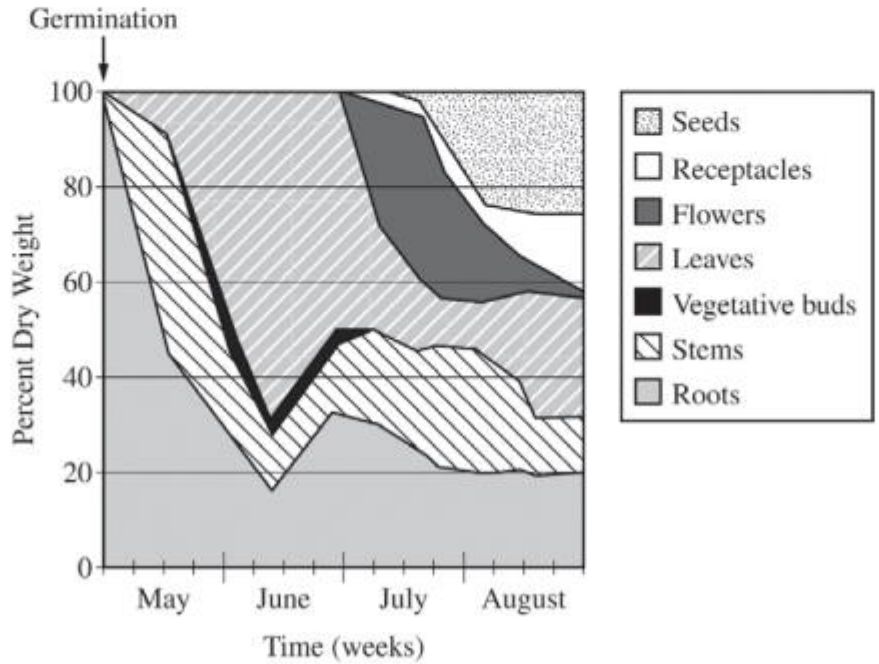



**Figure 1. Percent dry weight of different plant structures during the growing season for an annual plant**

The graph above illustrates the percent dry weight of different parts of a particular annual plant (plants that live less than one year) from early May to late August. The percent dry weight can be used to estimate the amount of energy a plant uses to produce its leaves, vegetative buds, stems, roots, and reproductive parts (seeds, receptacles, and flowers).

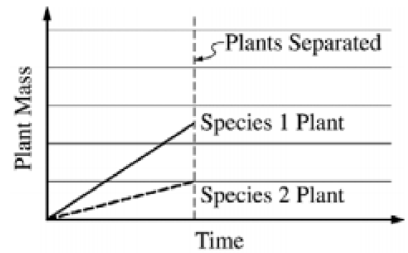
(a) **Identify** the direct source of energy used for plant growth during the first week of May, and **identify** the part of the plant that grew the most during the same period.

(b) Based on the data on the graph, **estimate** the percent of the total energy that the plant has allocated to the growth of leaves on the first day of July.

(c) Compared with perennials (plants that live more than two years), annual plants often allocate a much greater percentage of their total energy to growth of their reproductive parts in any given year. **Propose** ONE evolutionary advantage of the energy allocation strategy in annual plants compared with that in perennial plants.

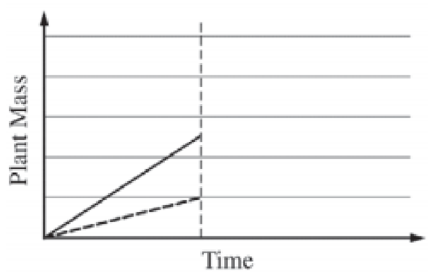
## 2016 #5

The graph below shows the mass of plants from two different species over time. The plants grew while attached to each other. The plants were separated at the time indicated by the vertical line in the graph.

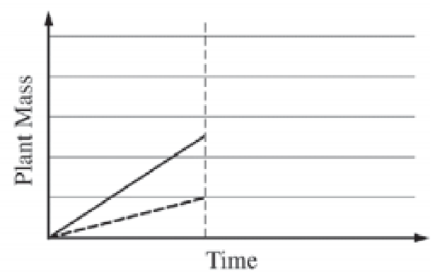



Using template 1, **graph** the predicted shape of the plant-mass lines after separation of the two plants if the plants were in an obligate mutualistic relationship. On template 2, **graph** the predicted shape of the plant-mass lines if the species 2 plant was a parasite of the species 1 plant. **Justify** each of your predictions.

TEMPLATE 1: OBLIGATE MUTUALISM




TEMPLATE 2: PARASITISM




## 2016 #8

Researchers conducted a study to investigate the effect of exercise on the release of prolactin into the blood. The researchers measured the concentration of prolactin in the blood of eight adult males before (T = 0 hour) and after one hour (T = 1 hour) of vigorous exercise. As a control, the researchers measured the concentration of blood prolactin in the same group of individuals at the same times of day one week later, but without having them exercise. The results are shown in Figure 1.

(a) **Justify** the use of the without-exercise treatment as the control in the study design.

(b) Using evidence from the specific treatments, **describe** whether prolactin release changes after exercise. **Justify** your answer.

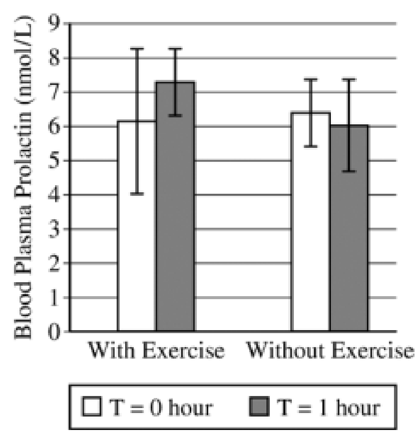



Figure 1. Effect of exercise on blood prolactin levels in adult males. The data represent the mean $\pm 2SE_{\bar{x}}$.

## 2015 #1

Many species have circadian rhythms that exhibit an approximately 24-hour cycle. Circadian rhythms are controlled by both genetics and environmental conditions, including light. Researchers investigated the effect of light on mouse behavior by using a running wheel with a motion sensor to record activity on actograms, as shown in Figure 1.

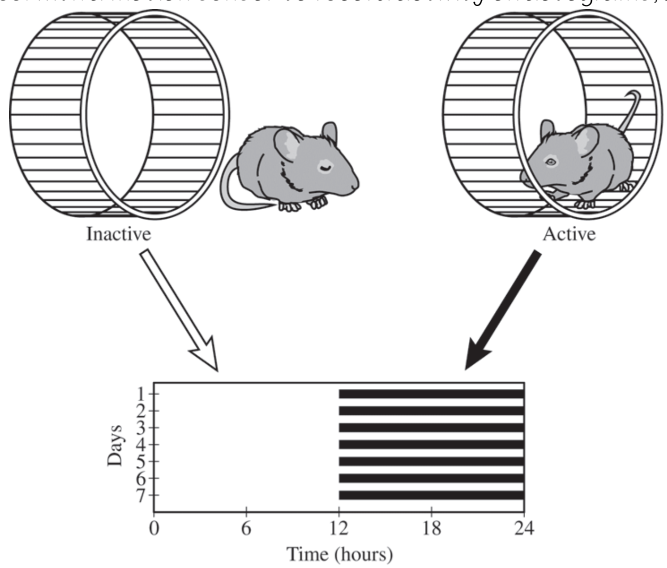



*Figure 1. Strategy for recording mouse activity data. When a mouse is active on the running wheel, the activity is recorded as a dark horizontal line on an actogram. When the mouse is inactive, no dark line is recorded.*

For the investigation, adult male mice were individually housed in cages in a soundproof room at 25°C. Each mouse was provided with adequate food, water, bedding material, and a running wheel. The mice were exposed to daily periods of 12 hours of light (L) and 12 hours of dark (D) (L12:D12) for 14 days, and their activity was continuously monitored. The activity data are shown in Figure 2.

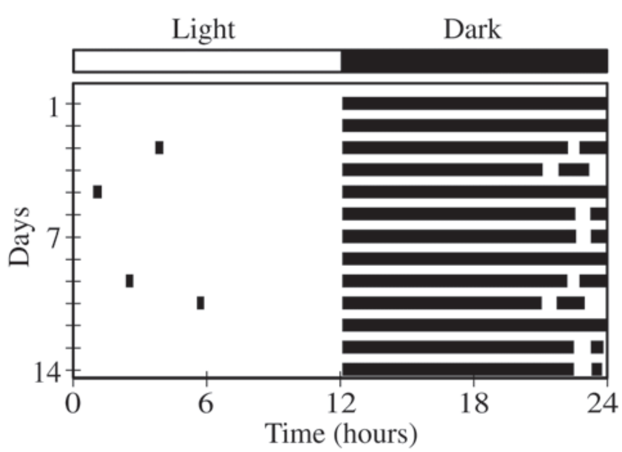



*Figure 2. Actogram of mouse activity under L12:D12 conditions. Each row represents a 24-hour period, and the dark horizontal lines represent activity on the running wheel.*

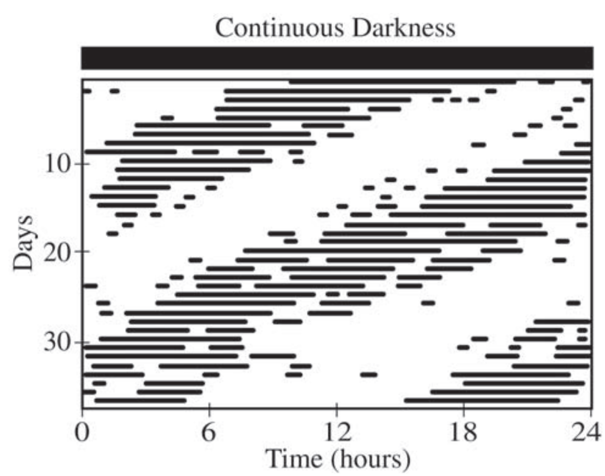



*Figure 3. Actogram of mouse activity under DD conditions. Each row represents a 24-hour period, and the dark horizontal lines represent activity on the running wheel.*

After 14 days in L12:D12, the mice were placed in continuous darkness (DD), and their activity on the running wheel was recorded as before. The activity data under DD conditions are shown in Figure 3.

*NOTE: Part (a) IS OUT OF SCOPE FOR THE EXAM*

(a) The nervous system plays a role in coordinating the observed activity pattern of the mice in response to light-dark stimuli. **Describe** ONE role of each of the following anatomical structures in responding to light-dark stimuli.

- A photoreceptor in the retina of the eye
- The brain
- A motor neuron

(b) Based on an analysis of the data in Figure 2, **describe** the activity pattern of the mice during the light and dark periods of the L12:D12 cycle.

(c) The researchers claim that the genetically controlled circadian rhythm in the mice does not follow a 24-hour cycle. **Describe** ONE difference between the daily pattern of activity under L12:D12 conditions (Figure 2) and under DD conditions (Figure 3), and use the data to **support** the researchers' claim.

(d) To investigate the claim that exposure to light overrides the genetically controlled circadian rhythm, the researchers plan to repeat the experiment with mutant mice lacking a gene that controls the circadian rhythm. **Predict** the observed activity pattern of the mutant mice under L12:D12 conditions and under DD conditions that would support the claim that light overrides the genetically controlled circadian rhythm.

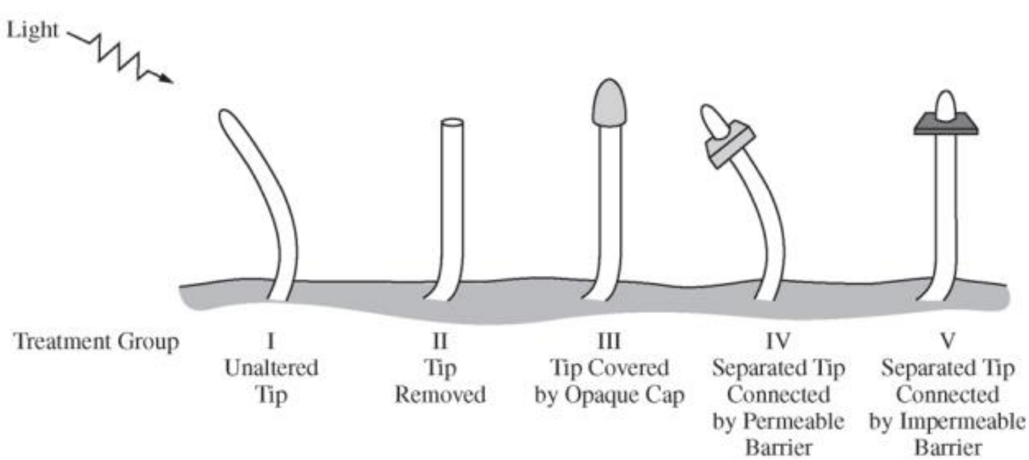
(e) In nature, mice are potential prey for some predatory birds that hunt during the day. **Describe** TWO features of a model that represents how the predator-prey relationship between the birds and the mice may have resulted in the evolution of the observed activity pattern of the mice.

## 2015 #5

Phototropism in plants is a response in which a plant shoot grows toward a light source. The results of five different experimental treatments from classic investigations of phototropism are shown below.

(a) **Give support** for the claim that the cells located in the tip of the plant shoot detect the light by comparing the results from treatment group I with the results from treatment group II and treatment group III.

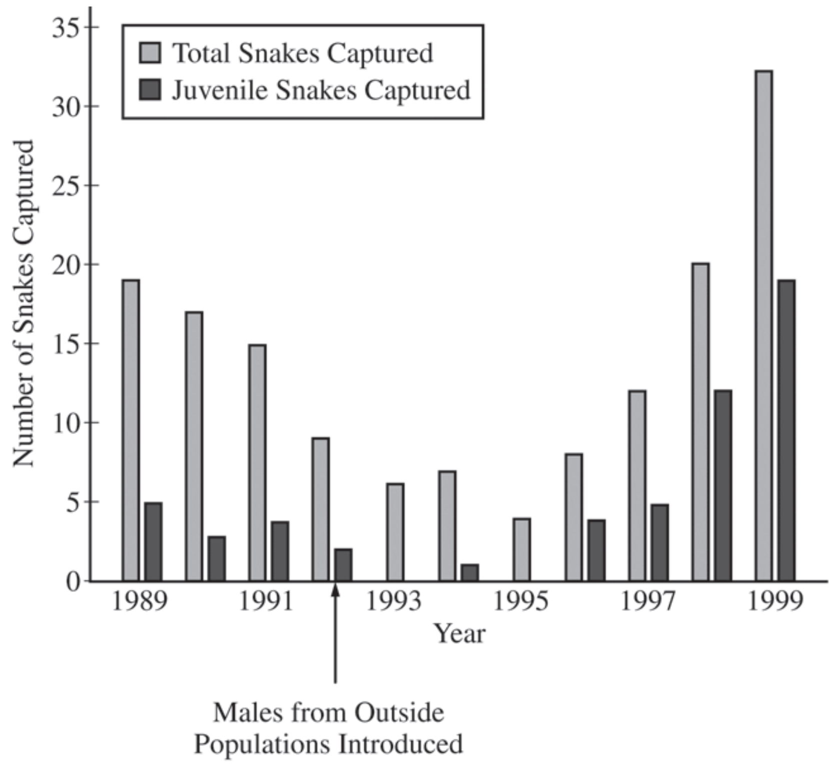
(b) In treatment groups IV and V, the tips of the plants are removed and placed back onto the shoot on either a permeable or impermeable barrier. Using the results from treatment groups IV and V, **describe** TWO additional characteristics of the phototropism response.



## 2015 #6

In an attempt to rescue a small isolated population of snakes from decline, a few male snakes from several larger populations of the same species were introduced into the population in 1992. The snakes reproduce sexually, and there are abundant resources in the environment.

The figure below shows the results of a study of the snake population both before and after the introduction of the outside males. In the study, the numbers of captured snakes indicate the overall population size.




(a) **Describe** ONE characteristic of the original population that may have led to the population's decline in size between 1989 and 1993.

(b) **Propose** ONE reason that the introduction of the outside males rescued the snake population from decline.

(c) **Describe** how the data support the statement that there are abundant resources in the environment.

## 2014 #3

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

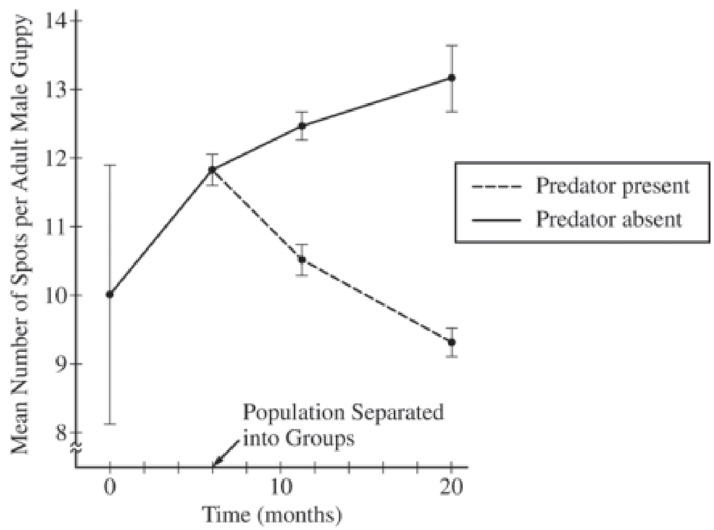
(a) **Predict** ONE ecological consequence on the local plant community that is likely to result during the site preparation and construction of the sports complex. **Justify** your predication.

(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.

## 2014 #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 population 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 artifical 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.

(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.

(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.

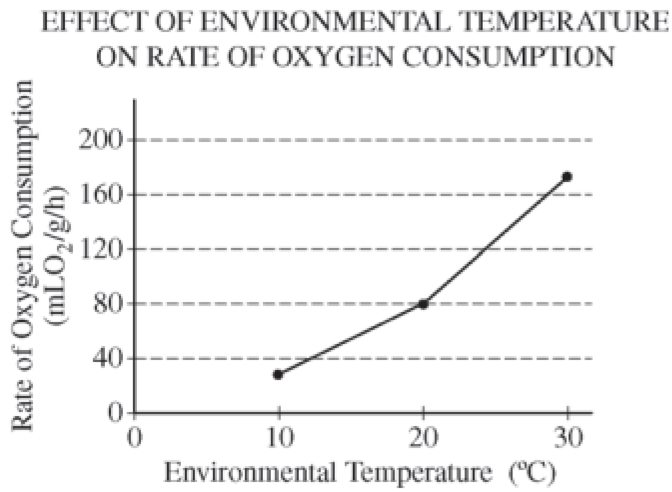
## 2014 #5

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

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

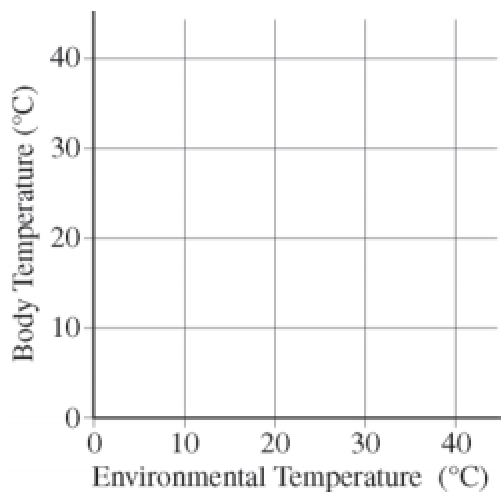
(b) For each of the risks you described in part (a), **propose** a practical approach for reducing the risk.

## 2014 #7

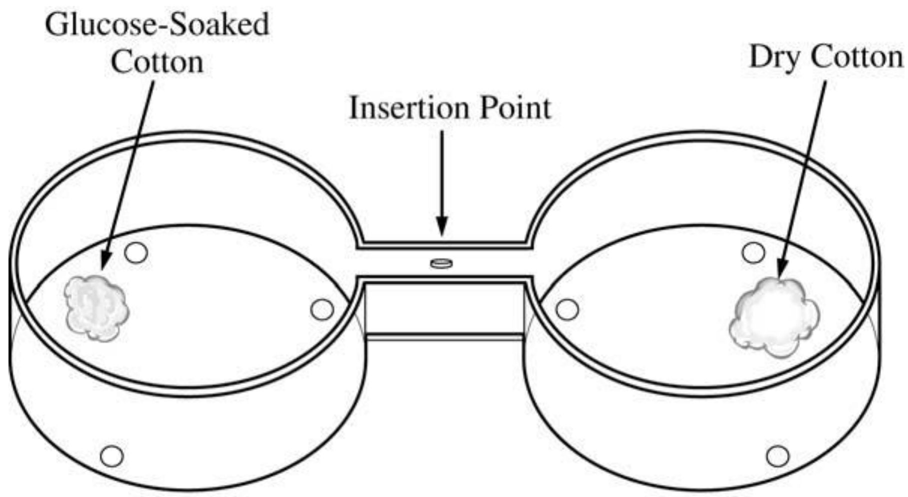



(a) Based on the graph, **describe** a specific method of thermoregulation used by the species of animal. **Provide** support for your answer using the data.

(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.



## 2013 #1




Choice Chamber

In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10% glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

(a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction.

(b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment.

- Experimental control
- Environmental factors

(c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

| Time (minutes) | Position in Chamber | | |
|---|---|---|---|
| | End with Ripe Banana | Middle | End with Unripe Banana |
| 1 | 21 | 18 | 21 |
| 10 | 45 | 3 | 12 |

**Perform** a chi-square test on the data for the 10-minute time point in the banana experiment. Specify the null hypothesis that you are testing and **enter** the values from your calculations in the table below.

(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber.

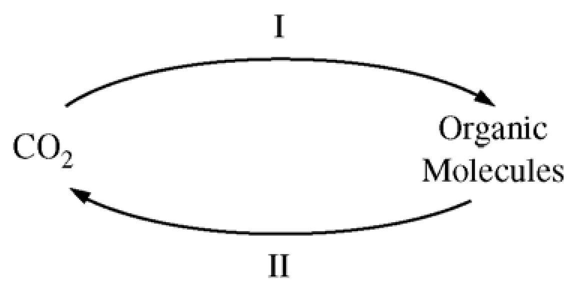
PART (C): CHI-SQUARE CALCULATIONS

Null Hypothesis:

| | Observed (o) | Expected (e) | $(o-e)^2/e$ |
|---|---|---|---|
| End with ripe banana | | | |
| Middle | | | |
| End with unripe banana | | | |
| Total | | | |

## 2013 #4

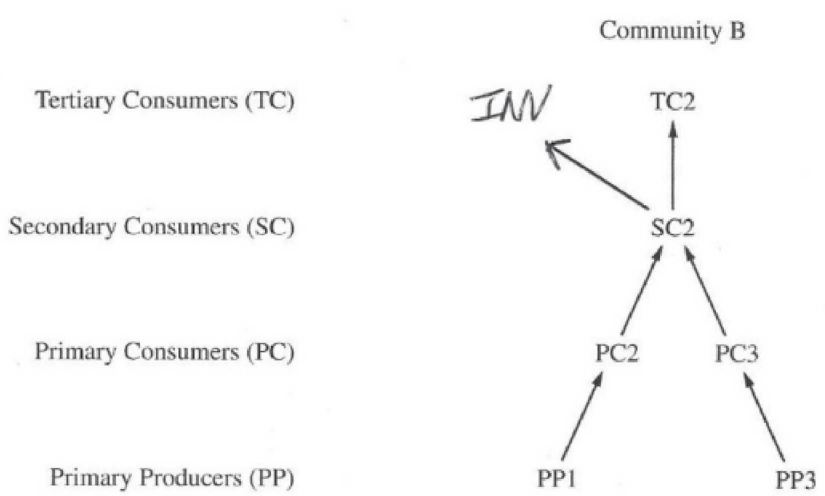
Matter continuously cycles through an ecosystem. A simplified carbon cycle is depicted below.



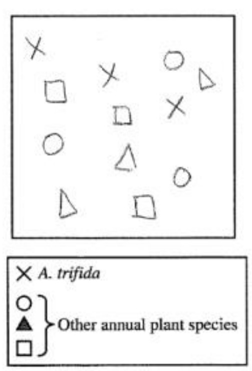

(a) **Identify** the key metabolic process for step I and the key metabolic process for step II, and briefly **explain** how each process promotes movement of carbon through the cycle. For each process, your explanation should focus on the role of energy in the movement of carbon.

(b) **Identify** an organism that carries out both processes.

# Free Response Scoring Guidelines

<table>
<tr><th colspan="3">2022 #5</th></tr>
<tr><th>Part</th><th>Scoring Guidelines</th><th>Topic</th></tr>
<tr><td>(a)</td><td>Describe a characteristic of a community that makes a species invasive in that community but not invasive in a different community.<br>Accept one of the following:<br>• There are no/reduced numbers of natural predators of the species in the community where it is invasive.<br>• There are no/reduced numbers of competitors of the species in the community where it is invasive.<br>• There are no/reduced numbers of diseases to which the species is susceptible in the community where it is invasive.</td><td>8.6</td></tr>
<tr><td>(b)</td><td>Explain why removing species PP1 will have a greater effect on community B than on community A.<br>Accept one of the following:<br>• In community B, there will be decreases in PC2, SC2, and TC2 /PC2, SC2, and PC3. In community A, PC2 has alternative food sources.<br>• With fewer/less diverse primary producers (and primary consumers), there are fewer paths for energy to move through the community.<br>• With fewer species/fewer feeding interactions/less diversity, community B will be less resilient to future environmental change.</td><td>8.6</td></tr>
<tr><td>(c)</td><td>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.<br>• INV should be added in a position that is horizontally aligned with TC2. An arrow should point from SC2 to INV.<br><br></td><td>8.7</td></tr>
</table>

| | | |
|---|---|---|
| (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.<br>Accept one of the following:<br>• The activities could eliminate primary producers, which reduces species diversity at higher trophic levels.<br>• The activities could cause biomagnification of the toxins, reducing species diversity at higher trophic levels. | 8.7 |

| 2021 #5 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| (a) | **Describe** a cause of logistic growth of the ragweed population.<br>Accept one of the following:<br>• A factor that becomes limiting would cause the population size to stabilize.<br>• Space/sunlight/herbivory/phosphorus/nitrogen/other density-dependent factor becomes limiting, and the population stabilizes. | 8.4 |
| (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.<br>• (Plot B is more resilient) because it has much greater (species) diversity than plot A does. | 8.7 |
| (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 <u>no more than 12</u> symbols. Assume all other environmental conditions are the same as for the initial study described.<br><br><br>• All four species, including *A. trifida*, must be added to the template. | 8.4<br>8.6 |

| | | |
|---|---|---|
| (d) | **Explain** how an invasive species such as ragweed affects ecosystem biodiversity, as illustrated in Figure 1.<br>• The explanation requires a process or relationship - and must state that biodiversity decreases.<br>• Examples of appropriate responses include:<br>  ○ There are no predators of the invasive species, so its population grows faster and reduces biodiversity.<br>  ○ The invasive species germinates earlier, uses up resources, and reduces biodiversity.<br>  ○ The invasive species outcompetes other species and reduces biodiversity. | 8.6 |

| 2019 #1 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| (a) | **Circle (1 point)**<br>• Circle around either arrow pointing from a gene (*Trp-T* or *YUC*) to mRNA<br>**Identification (1 point)**<br>• IAA | 6.3 |
| (b) | **Prediction (1 point)**<br>• Reduction in IAA production OR No production of IAA<br>**Justification (1 point)**<br>• The mutation will result in the translation of an inactive/nonfunctional Trp-T enzyme.<br>• The mutation will result in no translation of the Trp-T enzyme.<br>• The mutation will result in no/reduced production of I3PA. | 6.3 |
| (c) | **Explanation (2 points)**<br>• Negative feedback/feedback inhibition/increasing amounts of IAA inhibits the pathway.<br>• Production of YUC enzyme is inhibited OR YUC enzyme activity is inhibited. | 6.3 |
| (d) | **Identification (1 point)**<br>• Mutualism<br>**Description (1 point)**<br>• Increases habitat/number of nodules for the rhizobacteria.<br>• The bacteria receive carbon/carbon-containing molecules (as a result of increased plant growth). | 8.5 |
| (e) | **Description (1 point)**<br>• Cheaters/bacteria that benefit without producing IAA/fixing nitrogen have more energy for reproduction.<br>**Prediction (1 point)**<br>• Decrease in the nitrogen-fixing/noncheater bacteria<br>• Decrease in the amount of nitrogen fixed (by bacteria) | 7.2 |

| 2019 #2 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| (a) | **Completion (3 points)**<br>• Correctly plotted lines for remaining two treatments<br>• Correctly labeled axes including units<br>• Correctly labeled data lines | |
| (b) | **Reasoning (1 point)**<br>• Reduced initial population sizes keep the total number of organisms the same in all containers.<br>• Reduced initial population sizes serve as a control for population density. | 8.3 |

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (c) | **Evidence (1 point per row; 2 points max.)** | 8.4 |

| Comparison of Groups | Evidence |
|---|---|
| I-A to II-A | • Growth rate is faster in I/slower in II |
| I-A to II-A | • Grows to a higher population density in I/lower population density in II |
| I-B to II-B | • Growth rate is faster in I/slower in II |
| I-B to II-B | • Grows to a higher population density in I/lower population density in II/ II dies out/II goes to zero |

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (d) | **Prediction (2 points)** | 8.5 |

Acceptable factors include:

- Food
- Space
- Metabolic waste
- Dissolved oxygen

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (e) | **Prediction (1 point)** | 2.8 |

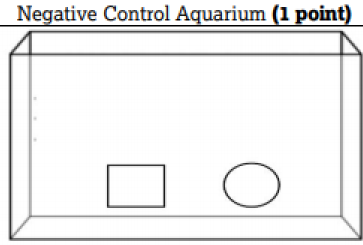
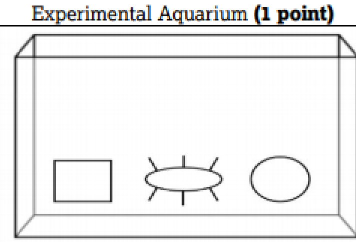
- The contractile vacuole will be more active.

**Justification (1 point)**

- The environment is hypotonic with respect to the cell.
- The cell is hypertonic with respect to environment.
- Water has entered the cell (which could cause lysis).
- The cell has lower water potential than the environment/the environment has higher water potential than the cell.

## 2018 #3

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Drawing (2 points)** | 8.6 |

| Negative Control Aquarium **(1 point)** | Experimental Aquarium **(1 point)** |
|---|---|
|  |  |

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (b) | | 8.6 |

| **Identification (1 point maximum)** | **Prediction (1 point maximum)** |
|---|---|
| Number/presence of pollen grains on female flowers OR pollination | More pollen grains transferred/pollination seen in experimental aquarium |
| Number/presence of fertilized plants/flowers OR fertilization | More fertilized plants/flowers/fertilization seen in experimental aquarium |
| Number/presence of seed/fruit/offspring produced OR reproduction | More seeds/fruits/offspring produced/reproduction in experimental aquarium |

## 2018 #5

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Description (1 point)**<br>• Cuckoos are parasites (of the warbler).<br>• The cuckoo benefits from the relationship, and the warbler is harmed by the relationship. | 8.5 |
| (b) | **Graph (2 points)**<br>• Cuckoo added (group 1): Bar must be HIGHER than the “Warblers Only” bar.<br>• Cuckoo removed (group 2): Bar must be LOWER than the “Warblers and Cuckoos” bar. | 8.5 |

| | | |
|---|---|---|
| (c) | **Identification (1 point)**<br>• Mutualism<br>• Both organisms benefit | 8.5 |

## 2018 #7

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Prediction (1 point)**<br>75% | 5.4 |
| (b) | **Identification (1 point)**<br>$Z^* W$<br><br>**Description (1 point)**<br>• Fewer offspring will develop/survive.<br>• 1/4 of the offspring are predicted to die.<br>• Some of her offspring will have the $Z^*$ chromosome/all of her male offspring will have a $Z^*$ chromosome. | 8.1 |

## 2017 #1

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Construct graph (3 points)**<br>• Correctly plotted means on a bar graph/modified bar graph<br>• Appropriate labels, units, and scaling<br>• Correctly plotted error bars | 8.1 |
| (b) | **Description (2 points)**<br>Short-term: Caffeine does not affect short-term memory/memory at 10 minutes.<br>Long-term: Caffeine improves/increases the long-term memory/memory at 24 hours. | 8.1 |
| (c) | **Identification (3 points; 1 point per row)**<br>Null hypothesis: Increasing caffeine concentration has no effect (on the number of floral visits by bees).<br>Control: (Nectar/flowers with) no caffeine<br>Predicted results:<br>• The number of floral visits by bees is different at increasing caffeine concentrations.<br>• The number of floral visits by bees is different than the control. | 8.1 |
| (d) | **Proposed plant benefit (1 point)**<br>• More pollen is transferred/more visits by pollinators.<br>• Plants store energy/have more energy available for other uses.<br><br>**Proposed bee cost (1 point)**<br>• (Individual) bees visit more flowers.<br>• (Individual) bees use more energy.<br>• The colony/bees may produce less honey<br>• The colony/bees may produce lower quality honey/honey that provides less energy. | 8.1 |

## 2017 #2

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Provide support** using data from Figure 1 for each of the researchers' claims. **(4 points)** | 3.7 |

| Claim | Support (1 point each row; 4 points maximum) |
|---|---|
| KAR affects timing | • germination starts earlier/sooner/faster/quicker |
| KAR affects percentage | • higher percentage of seeds germinate in the presence of only KAR |
| TMB affects timing | • germination starts later/slower |
| TMB affects percentage | • lower percentage of seeds germinate in presence of only TMB |

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (b) | (see table below) | 005 |

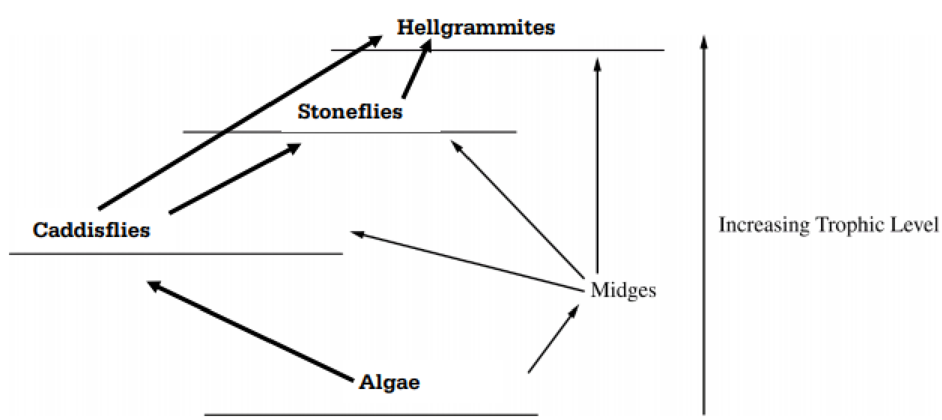
<table>
<tr><th>Claim (2 points maximum; 1 point for KAR; 1 for TMB )</th><th colspan="5">Support (2 points maximum; 1 point for KAR; 1 for TMB)</th></tr>
<tr><td rowspan="2">• KAR remains (bound after rinsing)<br>• Rinsing does not affect KAR (binding)</td><td>KAR with no rinse</td><td>KAR with rinse</td><td rowspan="2">different than</td><td colspan="2">Controls</td></tr>
<tr><td>Group 2</td><td>Group 5</td><td>Group 1</td><td>Group 4</td></tr>
<tr><td rowspan="4">• TMB does not remain (bound)<br>• Rinsing affects TMB (binding)</td><td colspan="2">TMB with no rinse</td><td rowspan="2">different than</td><td colspan="2">Control</td></tr>
<tr><td colspan="2">Group 3</td><td colspan="2">Group 1</td></tr>
<tr><td colspan="2">TMB with rinse</td><td rowspan="2">same as</td><td colspan="2">Control</td></tr>
<tr><td colspan="2">Group 6</td><td colspan="2">Group 4</td></tr>
</table>

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (c) | (see table below) | 8.5 |

<table>
<tr><th colspan="2">Description (1 point per row; 2 points maximum)</th></tr>
<tr><td>Advantage of KAR regulation</td><td>• Germination occurs at times of increased resources availability.<br>• Plants with KAR regulation can outcompete other plants (without KAR regulation).<br>• Germination occurs when fewer competitors are present/land is barren.</td></tr>
<tr><td>Advantage of TMB regulation</td><td>• Plants with TMB regulation do not germinate/can maintain seed dormancy until (enough) water is available.<br>• Plants with TMB regulation do not germinate in a dry environment.</td></tr>
</table>

## 2017 #4

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Construction of food web (2 points maximum)**<br>• All four organisms placed on the appropriate lines<br>• All four arrows correctly drawn between organisms | 8.2<br>8.5 |




| Part | Scoring Guidelines | Topic |
|---|---|---|
| (b) | **Prediction (1 point)**<br>• Stoneflies<br><br>**Justification (1 point)**<br>• Stoneflies have a higher dependence on the midges than do the hellgrammites and caddisflies.<br>• Midges are 90 percent of the stonefly diet, while 30 percent of the caddisfly and 10 percent of the hellgrammite diet are midges. | 8.6 |

## 2016 #2

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | **Estimate (1 point)**<br>• $10^8$<br><br>**Description (1 point)**<br>• When both nutrients are depleted | 8.3 |

| | | |
|---|---|---|
| (b) | **Calculation (1 point)**<br>• 4,995 | 8.3 |
| (c) | **Identification (1 point)**<br>• Nutrient I is the preferred nutrient.<br><br>**Justification (1 point)**<br>• When both nutrients are present in the growth medium, only nutrient I is used.<br>• Nutrient II is only used after nutrient I is depleted.<br><br>**Proposed advantage (1 point)**<br>• Do not spend energy making enzymes/proteins that the cell doesn't need.<br>• Do not have to express all metabolic genes at once.<br>• The preferred nutrient provides more energy. | 8.3 |
| (d) | **Description (2 points)**<br>• Nutrient I promotes expression of genes required for metabolism of nutrient I.<br>• Nutrient I represses expression of genes required for metabolism of nutrient II.<br><br>**Reasoning (2 points)**<br>• Nutrient I is depleted from the growth medium OR neither nutrient is being consumed.<br>• Takes time to produce proteins/enzymes required to metabolize nutrient II. | 8.1 |

| 2016 #3 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| (a) | **Identify direct source of energy (1 point)**<br>• Seed<br>• Stored organic nutrients/carbohydrates<br><br>**Identify plant part (1 point)**<br>• Roots | 3.7 |
| (b) | **Identification (1 point)**<br>• Any value between 45-55 percent | 3.7 |
| (c) | **Proposed advantage (1 point)**<br>• Increased chance of reproduction before the plants die.<br>• If the plants do not use the strategy, they decrease the likelihood they will ever reproduce. | 7.1<br>8.2 |

| 2016 #5 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| | (see table below) | 8.5 |

| | **Graph characteristics (1 point each graph; 2 points maximum)** | **Justification (1 point each box; 2 points maximum)** |
|---|---|---|
| **Obligate Mutualism** | Both of the growth curves level off or decline. | • Each species depends on the other for survival.<br>• Without the relationship, both species are harmed. |
| **Parasitism** | Species 1 continues to increase while species 2 levels off or declines. | • The parasite requires an association with the host to survive but harms the host.<br>• Without the relationship, the parasite cannot survive while the host continues to grow. |

| 2016 #8 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |

<table>
<tr><td>(a)</td><td>Justification (1 point)<ul><li>Attribute changes in the concentration of blood prolactin to exercise only</li><li>Rule out normal fluctuations in prolactin release/levels</li></ul></td><td>8.1</td></tr>
<tr><td>(b)</td><td>Determination (1 point)<ul><li>Exercise does not affect prolactin release</li></ul>Justification (1 point)<ul><li>The T=1 hour with-exercise mean and the T=1 hour without-exercise mean are within $\pm 2SE_{\bar{x}}$.</li><li>The $\pm 2SE_{\bar{x}}$ error bars for the T=1 hour with-exercise time point and the T=1 hour time without-exercise point overlap.</li><li>The $\pm 2SE_{\bar{x}}$ error bars for the T=0 and T=1 hour with-exercise time points overlap.</li><li>The T=0 hour with-exercise mean and the T=1 hour with exercise-mean are within $\pm 2SE_{\bar{x}}$.</li></ul></td><td>8.1</td></tr>
</table>

<table>
<tr><th colspan="3">2015 #1</th></tr>
<tr><th>Part</th><th>Scoring Guidelines</th><th>Topic</th></tr>
<tr><td>(a)</td><td><table><tr><th></th><th>Descriptions (1 point per box; 3 points maximum)</th></tr><tr><td>Photoreceptor</td><td>Detects light/dark stimulus and initiates/transmits signal</td></tr><tr><td>Brain</td><td>Integrates/processes/coordinates information</td></tr><tr><td>Motor neuron</td><td>Transmits signal from brain to an effector</td></tr></table></td><td>005</td></tr>
<tr><td>(b)</td><td>Description (1 point)<ul><li>Active during dark phase AND inactive during light phase</li><li>Active ONLY during the dark period</li><li>Inactive ONLY during the light period</li></ul></td><td>8.1</td></tr>
<tr><td>(c)</td><td>Description (1 point)<ul><li>Active period begins a little earlier each day</li><li>Active/inactive period is shorter than 12 hours each day</li><li>Daily circadian rhythm is less than 24 hours</li><li>Pattern of activity shifts each day</li></ul>Support (1 point)<ul><li>Without light, active/inactive periods are determined only by the genetically controlled circadian rhythm.</li><li>If it were a 24-hour circadian rhythm, the pattern of activity in DD would be the same as the pattern of activity in L12:D12.</li></ul></td><td></td></tr>
<tr><td>(d)</td><td><table><tr><th>Conditions</th><th>Predicted Activity Pattern (1 point per box; 2 points maximum)</th></tr><tr><td>Mutant under L12:D12</td><td>Normal rhythm/rhythm similar to wild-type mouse under L12:D12 (Figure 2)</td></tr><tr><td>Mutant under DD</td><td><ul><li>Random activity throughout the 24 hour period</li><li>No pattern/rhythm</li><li>Constantly active/constantly inactive</li></ul></td></tr></table></td><td></td></tr>
<tr><td>(e)</td><td><table><tr><th></th><th>Description (1 point per box; 2 points maximum)</th></tr><tr><td>Selective Advantage</td><td><ul><li>Selection for individuals active at night</li><li>Selection against individuals active during the day</li><li>Day-active variants susceptible to predation</li><li>Night-active variants able to avoid predation</li></ul></td></tr><tr><td>Reproductive Success</td><td><ul><li>Mice selected for produce more offspring</li><li>Mice selected against produce fewer offspring</li></ul></td></tr></table></td><td>7.1</td></tr>
</table>

<table>
<tr><th colspan="3">2015 #5</th></tr>
<tr><th>Part</th><th>Scoring Guidelines</th><th>Topic</th></tr>
<tr><td>(a)</td><td>Support (2 points maximum)<ul><li>In treatment II the tip is removed and the plant no longer bends toward light.</li><li>In treatment III the cap blocks the light to the tip and the plant no longer bends toward light.</li></ul></td><td>8.1</td></tr>
</table>

| | | |
|---|---|---|
| (b) | **Description (2 points maximum)**<br>• Tip produces a substance/signal/hormone (auxin) in response to light causing the plants to bend<br>• Substance must diffuse from the tip causing the plants to bend | 8.1 |

| 2015 #6 | | |
|---|---|---|
| Part | Scoring Guidelines | Topic |
| (a) | **Description (1 point)**<br>• Lacked genetic diversity/variation<br>• Was an aged/post-reproductive population/not enough young snakes<br>• Had unfavorable sex ratio/too few males<br>• Possessed a harmful mutation/disease | 8.3 |
| (b) | **Proposal (1 point)**<br>• Increased genetic diversity in the population<br>• Increased reproductive success<br>• Established beneficial sex ratio/sufficient proportion of males for reproduction<br>• Introduced resistance to disease that was affecting the original population | 8.3<br>8.7 |
| (c) | **Description (1 point)**<br>• Population can/does grow<br>• If resources are limited population would not grow | 8.4 |

## 2014 #3

Part (a) — Scoring Guidelines — Topic 8.6, 8.7

| Predicted consequences on plant community **(1 point)** | Justification of prediction **(1 point)** |
|---|---|
| Plant death / Loss of plant biomass | • Removing trees/shrubs<br>• Pollution from construction equipment<br>• Fewer individuals for reproduction<br>• 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<br>• Reduced habitat<br>• Pollution from construction kills local species |
| Decreased genetic diversity | Reduction in population size / bottleneck |
| Habitat loss | • Removal of trees/shrubs<br>• 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 |

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (b) | | 8.6 8.7 |

| Predicted consequence on animal community **(1 point)** | Justification of prediction **(1 point)** |
|---|---|
| Harm / Death to animals | • Exposure to toxic chemicals<br>• Toxic chemicals accumulate through the food chain Persist in the environment<br>• Contaminated groundwater |
| Emigration<br>Displacement | • Loss of habitat and/or food<br>• Loss of access<br>• Exposure to toxic chemicals |
| Loss of native animal biodiversity | • Loss of plants on which the animals depend<br>• 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<br>• Removal of water from reservoir / wells<br>• Contamination of water with chemicals |

## 2014 #4

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | Describe change (**1 point**): Genetic variation is decreasing<br>Provide reasoning (**1 point**): SEM gets smaller | 7.1 |
| (b) | • Sexual selection for individuals with more spots<br>• Random mating behavior resulted in increased number of spots by chance | 8.1 |
| (c) | • Directional selection against individuals with large numbers of spots<br>• Directional selection for individuals with fewer spots<br>• Natural selection used in context<br>• Genetic drift resulted in several generations of decreased numbers of spots | 7.5 |

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

## 2014 #5

| Part | Scoring Guidelines | Topic |
|---|---|---|
| | | 6.8 7.3 8.7 |

| 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<br>• Isolate animals from crops |
| Disruption within food chain | • Intersperse GM plants with non-GM plants in culture<br>• Provide alternative food source |
| Developed resistance in pest species | • Increased use of effective pesticides<br>• Introduce pest predators<br>• Further engineer the GMO to produce more resistance protein<br>• Rotate GM and non-GM crops |
| Spread of genetic modifications to non-GM plants | • Contain pollen of GM plants<br>• Disable the ability of GM plants to produce viable seeds |
| GM plants out-compete native species | • Contain/isolate GM plants<br>• 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<br>• Use organic/alternative herbicides |
| Invasive disease wiping out the monoculture | Intersperse GM plants with non-GM plants in culture |

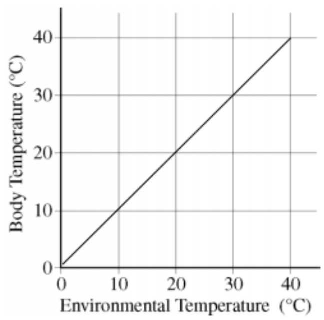
* Proposed mitigation of non-use of GM plants is acceptable for any described risk above.
+Mitigation must be practical for the risk given.

## 2014 #7

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | See table below | 8.1 |

| 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<br>• Decreased metabolic rate/$O_2$ consumption rate/respiration rate with decreased temperature<br>• 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<br>• Decreased metabolic rate/$O_2$ consumption rate/respiration rate with decreased temperature<br>• This species is ectothermic/incapable of endoregulation |

**(b)** — Topic 8.1




- Line/curve with positive slope

## 2013 #1

| Part | Scoring Guidelines | Topic |
|---|---|---|
| (a) | • 1 point for predicting the location of the flies in the choice chamber<br>• 1 point for justifying the prediction | 8.1 |
| (b) | See tables below | 8.1 |

| | Proposed Improvement (includes but not limited to) (**1 point maximum**) | Explanation (**1 point maximum**) |
|---|---|---|
| Experimental control | Replace the dry cotton ball with a water-soaked cotton ball. | Ensures that glucose is the attractant |
| | Constant light or temperature or duration of experiment or time of day, etc. | Other variables must be held constant |

| | Proposed Improvement (includes but not limited to) (**1 point maximum**) | Explanation (**1 point maximum**) |
|---|---|---|
| Environmental factors | • Use different concentrations of glucose<br>• Use different temperature(s)<br>• Use different light levels<br>• Use a different choice chamber (size/shape)<br>• Vary duration of the experiment<br>• Vary time of day when experiment is performed | Attributes movement of flies only to glucose preference |

<table>
<tr><td>(c)</td><td>

PART (c): CHI-SQUARE CALCULATION

<table>
<tr><td colspan="4">Null Hypothesis: (1 point)<br>The flies will be evenly distributed across the three different parts of the choice chamber.</td></tr>
<tr><td></td><td>Observed (o)</td><td>Expected (e)*<br>(1 point)</td><td>$(o - e)^2/e$</td></tr>
<tr><td>End with ripe banana</td><td>45</td><td>20</td><td>31.25</td></tr>
<tr><td>Middle</td><td>3</td><td>20</td><td>14.45</td></tr>
<tr><td>End with unripe banana</td><td>12</td><td>20</td><td>3.2</td></tr>
<tr><td>Total</td><td>60</td><td>60</td><td>48.9</td></tr>
<tr><td colspan="4">*Expected values must be those predicted by the null hypothesis provided in the student response, add up to 60, and include no cells equal to 0.</td></tr>
</table>

</td><td>8.1</td></tr>
<tr><td>(d)</td><td>

- Correct explanation with justification of why the stated null hypothesis is rejected or not rejected. Response must clarify each of the following:
  - degrees of freedom (df) = 2 and p = 0.05 (critical value = 5.99)<br>OR<br>degrees of freedom (df) = 2 and p = 0.01 (critical value = 9.21)
  - how the calculated test statistic compares to the selected critical value
  - whether the null hypothesis should be rejected

</td><td>8.1</td></tr>
<tr><td>(e)</td><td>

- Stimulus → Response
- Input →(possible integration) →Output

</td><td>8.1</td></tr>
</table>

<table>
<tr><th colspan="3">2013 #4</th></tr>
<tr><th>Part</th><th>Scoring Guidelines</th><th>Topic</th></tr>
<tr><td>(a)</td><td>

Identification: **1 point maximum**

<table>
<tr><td>I = photosynthesis / Calvin cycle<br>AND<br>II = (cellular) respiration / citric acid cycle / Krebs cycle</td></tr>
</table>

Explanation: **1 point each row; 2 points maximum**

<table>
<tr><td>Process</td><td>Carbon Input</td><td>Role of Energy in the Movement of Carbon</td><td>Carbon Output</td></tr>
<tr><td>Photosynthesis</td><td>$CO_2$ is fixed</td><td>Uses (light) energy OR ATP from light reactions</td><td>Organic molecules</td></tr>
<tr><td>(Cellular) Respiration</td><td>Organic molecules are hydrolyzed / broken down</td><td>Uses energy for cellular processes such as growth and /or ATP production</td><td>$CO_2$</td></tr>
</table>

</td><td>3.5<br>3.6</td></tr>
<tr><td>(b)</td><td>

- Plant
- Algae
- Photosynthetic protist (e.g., Euglena)
- Cyanobacterium
- $CO_2$ fixing bacterium
- Lichen (not fungus)

</td><td>8.2</td></tr>
</table>