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| **Unit 8: Ecology** |

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| **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

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| 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.  A picture containing text, diagram, line  Description automatically generated  A picture containing text, diagram, line  Description automatically generated  (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. |

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| 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.    (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. |

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| 2019 #1 |
| A picture containing text, diagram, screenshot, line  Description automatically generated  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. |

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| 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).  A black text on a white background  Description automatically generated with low confidence  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.  A picture containing text, screenshot, number, font  Description automatically generated  (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.  A picture containing line, diagram, plot  Description automatically generated  (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. |

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| 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.  A picture containing diagram, line, screenshot, design  Description automatically generated  (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.  A picture containing rectangle, line, diagram, screenshot  Description automatically generated |

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| 2018 #5 |
| Chart, bar chart  Description automatically generatedSome 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).  (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 added 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.  Chart, bar chart  Description automatically generated |

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| 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 22ºC, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28ºC, 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 22ºC. A cross between a ZW female and a Z\*Z male is shown in the Punnett square below.  A picture containing line, screenshot, rectangle, square  Description automatically generated  (a) **Predict** the percent of phenotypic males among the F1 offspring of the cross shown in the Punnett square if the offspring are raised at 22ºC.  (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. |

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| 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.  A picture containing text, screenshot, font, line  Description automatically generated  (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.  A picture containing rectangle, square, line, pattern  Description automatically generated |

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| 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.  ‘  A picture containing text, diagram, line, parallel  Description automatically generated  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.  A picture containing text, screenshot, number, font  Description automatically generated  (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. |

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| 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.  A picture containing text, screenshot, number, font  Description automatically generated  (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.  A picture containing line, diagram, design  Description automatically generated |

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| 2016 #2 |
| A picture containing text, diagram, line, font  Description automatically generated  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 infor 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  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 and the genes for metabolism of nutrient II. **Provide** TWO reasons that the population does not grow between hours 5 and 6. |

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| 2016 #3 |
| A picture containing text, diagram, screenshot, sketch  Description automatically generated  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. |

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| 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.  A picture containing text, receipt, line, font  Description automatically generated  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.  A picture containing text, receipt, line, diagram  Description automatically generated |

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| 2016 #8 |
| A picture containing text, diagram, screenshot, sketch  Description automatically generatedResearchers 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. |

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| 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.  A picture containing sketch, drawing, diagram, illustration  Description automatically generated  *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.  A picture containing text, screenshot, line, diagram  Description automatically generated A picture containing text, screenshot, line, diagram  Description automatically generated  *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. |

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| 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.  A picture containing sketch, diagram, drawing, white  Description automatically generated |

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| 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 picture containing text, screenshot, diagram, font  Description automatically generated  (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. |

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| 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. |

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| 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 picture containing diagram, line, text, plot  Description automatically generated  (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. |

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| 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. |

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| 2014 #7 |
| A picture containing text, receipt, line, font  Description automatically generated  (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.  A picture containing text, receipt, screenshot, line  Description automatically generated |

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| 2013 #1 |
| A picture containing circle, diagram, sketch, design  Description automatically generated  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 |  |  |  | |

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| 2013 #4 |
| Matter continuously cycles through an ecosystem. A simplified carbon cycle is depicted below.  A picture containing sketch, diagram, white, drawing  Description automatically generated  (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

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| 2022 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, document  Description automatically generated | 8.6 |
| (b) | A picture containing text, screenshot, font, document  Description automatically generated | 8.6 |
| (c) | A picture containing text, font, line, diagram  Description automatically generated | 8.7 |
| (d) | A picture containing text, font, line, diagram  Description automatically generated | 8.7 |

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| 2021 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | Graphical user interface, text  Description automatically generated | 8.4 |
| (b) | Graphical user interface, text, application  Description automatically generated | 8.7 |
| (c) | Diagram  Description automatically generated | 8.4  8.6 |
| (d) | Text  Description automatically generated | 8.6 |

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| 2019 #1 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with medium confidence | 6.3 |
| (b) | A picture containing text, screenshot, font, algebra  Description automatically generated | 6.3 |
| (c) | A black text on a white background  Description automatically generated with medium confidence | 6.3 |
| (d) | A picture containing text, screenshot, font, line  Description automatically generated | 8.5 |
| (e) | A picture containing text, font, screenshot, line  Description automatically generated | 7.2 |

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| 2019 #2 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with medium confidence |  |
| (b) | A black text on a white background  Description automatically generated with medium confidence | 8.3 |
| (c) | A picture containing text, screenshot, font, number  Description automatically generated | 8.4 |
| (d) | A picture containing text, font, screenshot, algebra  Description automatically generated | 8.5 |
| (e) | A picture containing text, screenshot, font, algebra  Description automatically generated | 2.8 |

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| 2018 #3 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing screenshot, text, diagram, line  Description automatically generated | 8.6 |
| (b) | A picture containing text, screenshot, font, line  Description automatically generated | 8.6 |

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| 2018 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with medium confidence | 8.5 |
| (b) | A black text on a white background  Description automatically generated with medium confidence | 8.5 |
| (c) | A black text on a white background  Description automatically generated with medium confidence | 8.5 |

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| 2018 #7 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) |  | 5.4 |
| (b) | A black text on a white background  Description automatically generated with low confidence | 8.1 |

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| 2017 #1 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with medium confidence | 8.1 |
| (b) | A picture containing text, font, screenshot, line  Description automatically generated | 8.1 |
| (c) | A picture containing text, font, screenshot, line  Description automatically generated | 8.1 |
| (d) | A picture containing text, font, screenshot, algebra  Description automatically generated | 8.1 |

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| 2017 #2 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, number  Description automatically generated | 3.7 |
| (b) | A picture containing text, screenshot, font, number  Description automatically generated | OOS |
| (c) | A picture containing text, font, line, number  Description automatically generated | 8.5 |

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| 2017 #4 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, line, diagram, font  Description automatically generated | 8.2  8.5 |
| (b) | A picture containing text, screenshot, font, line  Description automatically generated | 8.6 |

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| 2016 #2 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A white background with black text  Description automatically generated with low confidence | 8.3 |
| (b) |  | 8.3 |
| (c) | A picture containing text, screenshot, font  Description automatically generated | 8.3 |
| (d) | A picture containing text, screenshot, font, line  Description automatically generated | 8.1 |

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| 2016 #3 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, font, screenshot, algebra  Description automatically generated | 3.7 |
| (b) | A black text on a white background  Description automatically generated with medium confidence | 3.7 |
| (c) |  | 7.1  8.2 |

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| 2016 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
|  | A picture containing text, screenshot, font, number  Description automatically generated | 8.5 |

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| 2016 #8 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with medium confidence | 8.1 |
| (b) | A picture containing text, screenshot, font, algebra  Description automatically generated | 8.1 |

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| 2015 #1 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, line  Description automatically generated | OOS |
| (b) | A black text on a white background  Description automatically generated with low confidence | 8.1 |
| (c) | A picture containing text, screenshot, font, algebra  Description automatically generated |  |
| (d) | A picture containing text, screenshot, font, line  Description automatically generated |  |
| (e) | A picture containing text, font, line, number  Description automatically generated | 7.1 |

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| 2015 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with low confidence | 8.1 |
| (b) | A black text on a white background  Description automatically generated with low confidence | 8.1 |

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| 2015 #6 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A black text on a white background  Description automatically generated with low confidence | 8.3 |
| (b) | A picture containing text, screenshot, font, line  Description automatically generated | 8.3  8.7 |
| (c) | A picture containing text, font, screenshot, line  Description automatically generated | 8.4 |

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| 2014 #3 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, number  Description automatically generated | 8.6  8.7 |
| (b) | A picture containing text, screenshot, receipt, font  Description automatically generated | 8.6  8.7 |

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| 2014 #4 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) |  | 7.1 |
| (b) |  | 8.1 |
| (c) | A picture containing text, screenshot, font, line  Description automatically generated | 7.5 |

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| 2014 #5 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
|  | A picture containing text, screenshot, font, number  Description automatically generated | 6.8  7.3  8.7 |

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| 2014 #7 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, number  Description automatically generated | 8.1 |
| (b) | A graph of body temperature  Description automatically generated with low confidence | 8.1 |

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| 2013 #1 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) |  | 8.1 |
| (b) | A picture containing text, screenshot, font, number  Description automatically generated | 8.1 |
| (c) | A picture containing text, screenshot, number, font  Description automatically generated | 8.1 |
| (d) | A picture containing text, screenshot, font, line  Description automatically generated | 8.1 |
| (e) |  | 8.1 |

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| 2013 #4 | | |
| **Part** | **Scoring Guidelines** | **Topic** |
| (a) | A picture containing text, screenshot, font, number  Description automatically generated | 3.5  3.6 |
| (b) | A picture containing text, font, screenshot, algebra  Description automatically generated | 8.2 |