Week 28

AP Biology

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

AP Biology Name: ______________ Score: ________

1. A **stimulus** is…
   - ☐ a change that an organism can detect and react to
   - ☐ a type of cell
   - ☐ a kind of food
   - ☐ a gene
2. Where does the energy in most ecosystems originally come from?
   - ☐ the Sun
   - ☐ the soil
   - ☐ rocks
   - ☐ the wind
3. When resources are unlimited, a population shows **exponential growth**, which means it…
   - ☐ grows faster and faster
   - ☐ stays exactly the same
   - ☐ shrinks steadily
   - ☐ grows in a straight line
4. **Population density** measures…
   - ☐ how many individuals live in a given area
   - ☐ how heavy each individual is
   - ☐ the number of species
   - ☐ the total sunlight
5. A **community** in ecology is…
   - ☐ all the populations of different species living together in an area
   - ☐ a single species
   - ☐ a type of cell
   - ☐ a food molecule
6. An animal moving toward or away from a stimulus is showing a ______.

   ____

7. If a trophic level holds 10000 units of energy, roughly how many pass to the next level (about 10%)?

____

8. **Logistic growth** starts fast, then levels off at the carrying capacity — an S-shaped curve.

☐ True ☐ False

9. A factor like a harsh winter, whose effect does not change with crowding, is density-______.

____

10. The interaction where one species hunts and eats another is called ______.

____

AP Biology

1. **a change that an organism can detect and react to**

   A **stimulus** is a change in the environment (like light or heat) that triggers a **response**.

2. **the Sun**

   Sunlight is captured by **producers** (plants) through photosynthesis, feeding the whole ecosystem.

3. **grows faster and faster**

   Exponential growth speeds up as the population gets bigger — a J-shaped curve.

4. **how many individuals live in a given area**

   Population density is the number of individuals per unit area or volume.

5. **all the populations of different species living together in an area**

   A **community** is all the interacting populations of different species sharing an area.

6. **taxis**

   A **taxis** is a directed movement of an animal toward or away from a stimulus.

7. **1000**

   About **10%** passes up each step, so $10000 \times 0.1 = 1000$ units reach the next level.

8. **True**

   Logistic growth is exponential at first, then flattens as resources run low near carrying capacity.

9. **independent**

   A **density-independent** factor (weather, disaster) affects a population the same at any density.

10. **predation**

    In **predation**, a predator hunts and eats its prey.

8.1 Responses to the Environment

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS innate 先天 • learned 后天 • population 种群

Objective

Build the skills to answer exam questions on **responses to the environment** — behavior.

You must be able to:

- distinguish **innate** 先天 from **learned** 后天 behavior
- explain how behaviors improve survival and reproduction
- give examples (taxis, migration, learned responses)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Innate vs learned

- **Innate behavior** is **inherited** and present from birth (e.g. a spider spinning a web, reflexes).
- **Learned behavior** develops from **experience** (e.g. a rat learning a maze).

■ Behavior aids survival

Behaviors that help an organism find food, avoid predators, or reproduce raise its **fitness**, so they are favored by natural selection.

■ Examples

- **Taxis** — moving toward or away from a stimulus (e.g. moth toward light).
- **Migration** — moving seasonally to better conditions.
- **Learned** — associating a sound with food.

■ A worked judgement

A newly hatched sea turtle heading to the ocean without being taught is **innate**; a dog sitting on command is **learned**.

2 Practice

Now apply the methods above.

2.1 Distinguish innate from learned behavior. [2]

2.2 Give one example of innate behavior. [1]

2.3 How does helpful behavior spread in a population? [1]

3 Exam-style questions

3.1 A behavior present from birth without being taught is [1]

- **A** learned
- **B** innate
- **C** random
- **D** impossible

3.2 Baby sea turtles crawl toward the ocean immediately after hatching.

(a) Classify this behavior. [1]

(b) Explain how such a behavior improves survival and could be favored by selection. [2]

3.3 Explain the difference between innate and learned behavior, giving one example of each. [3]

Solutions

2.1 Innate behavior is inherited/present from birth; learned behavior develops from experience.

2.2 Any one: reflex, web-spinning, sea turtle heading to the ocean.

2.3 Individuals with the helpful behavior survive and reproduce more, passing on the behavior.

3.1 **B** — innate.

3.2 (a) Innate. (b) Reaching the ocean quickly avoids predators on land, so turtles that do it survive and reproduce more, favoring the behavior.

3.3 Innate is inherited and present from birth (e.g. a reflex); learned develops through experience (e.g. a dog trained to sit).

The following information applies to all parts.

1. Molecules known as dinucleoside polyphosphates, a type of nucleotide, are signaling molecules that accumulate in plant cells during dry or stressful conditions.

Part A

Describe the three structural components of a nucleotide.

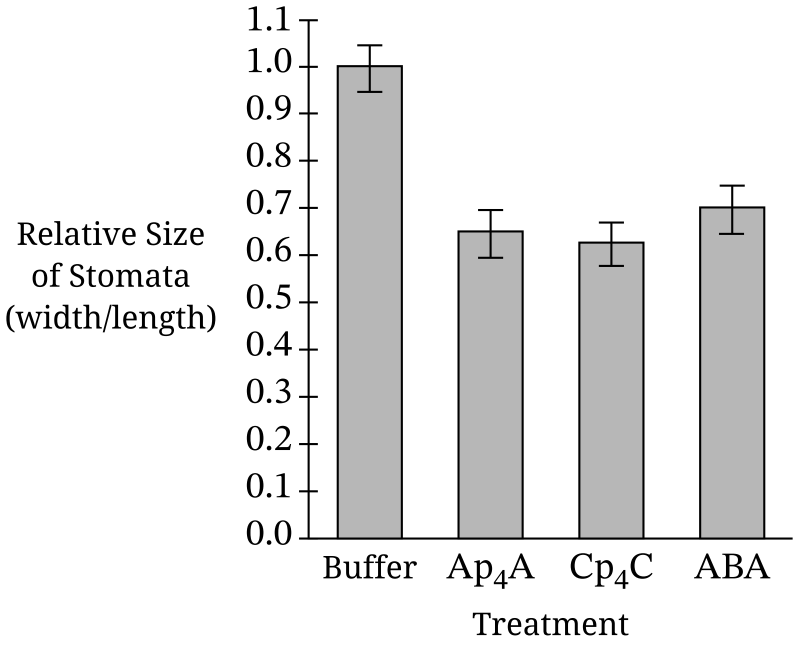
The following information applies to parts B, C, and D.

Stomata are pores on the surface of leaves that open when exposed to light and regulate the flow of carbon dioxide, oxygen, and water vapor in and out of a plant. In response to dry environmental conditions, many plants close their stomata, which reduces water loss.

Scientists hypothesized that the dinucleoside polyphosphates Ap_4A and Cp_4C bind to DORN1 receptors on the plasma membrane of plant cells and initiate signaling cascades that cause stomata to close. The scientists exposed plants to light to open the stomata and then placed samples of the leaves in buffer alone or in buffer containing one of three different compounds: Ap_4A, Cp_4C, or abscisic acid (ABA), a molecule that causes stomata to close.

The scientists measured the size of the stomata in each sample and calculated their sizes relative to the size of the stomata in the sample kept in buffer alone, as shown in Figure 1.

Figure 1. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size (Error Bars Represent $\pm SE_{\bar{x}}$)



Part B

i. **Identify** the dependent variable in the scientists' first experiment.

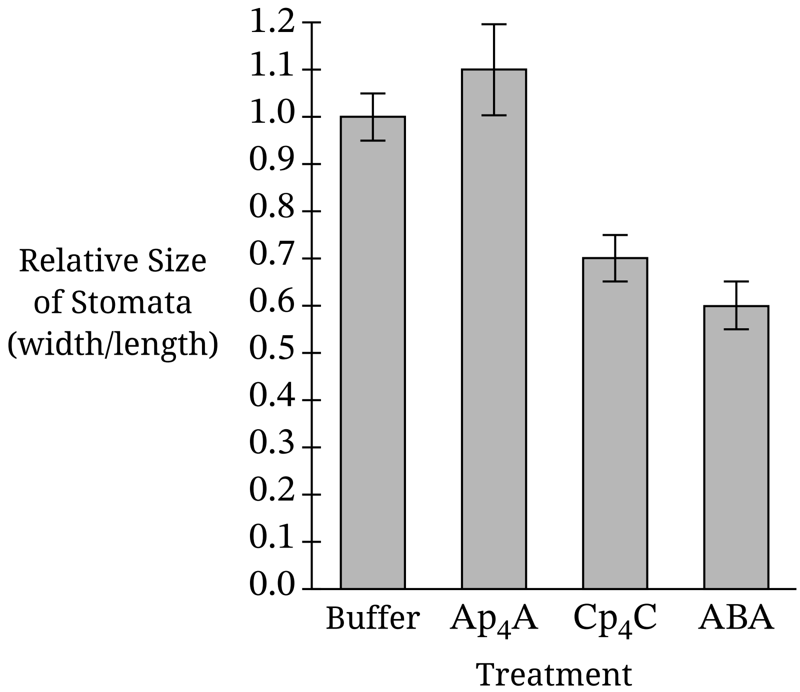
ii. Based on Figure 1, **describe** the relative size of the stomata in the Cp_4C treatment group as compared with the size of the stomata in the group treated with buffer alone.

iii. **Justify** the use of buffer alone as a control in the scientists' experiments.

Part C

In a second experiment, the scientists used plants that were identical to those in the first experiment except that the gene encoding the DORN1 receptor was mutated. The scientists repeated the procedure of the first experiment. Their results are shown in Figure 2.

Figure 2. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size in DORN1 Mutants (Error Bars Represent $\pm SE_{\bar{x}}$)



i. **Justify** the scientists' treating one sample of leaves with ABA in the experiments.

ii. Based on Figure 2, **describe** the difference between the effects of Ap_4A and Cp_4C treatments on the size of stomata in plants with mutated DORN1 receptors.

iii. Activation of DORN1 receptors induces plant cells to produce certain molecules that cause the stomata to close. Based on the data in Figures 1 and 2 for cells treated with Ap_4A, **predict** the relative production of the molecules by DORN1-mutated cells in comparison to the production by nonmutated cells.

Part D

The DORN1 receptor transmits signals that result in an increase in the transcription of genes involved in plant defenses. The scientists then developed DORN1-mutant plants in which the DORN1 receptor lacked most of its intracellular domain.

i. In cells homozygous for this mutation, **predict** the effect of Ap_4A treatment on transcription of the genes involved in plant defenses relative to the effect of Ap_4A on nonmutated cells.

ii. **Justify** your prediction.

AP Biology: **2023**

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

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

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

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

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

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

Write your responses to this question only on the designated pages in the separate Free Response booklet.

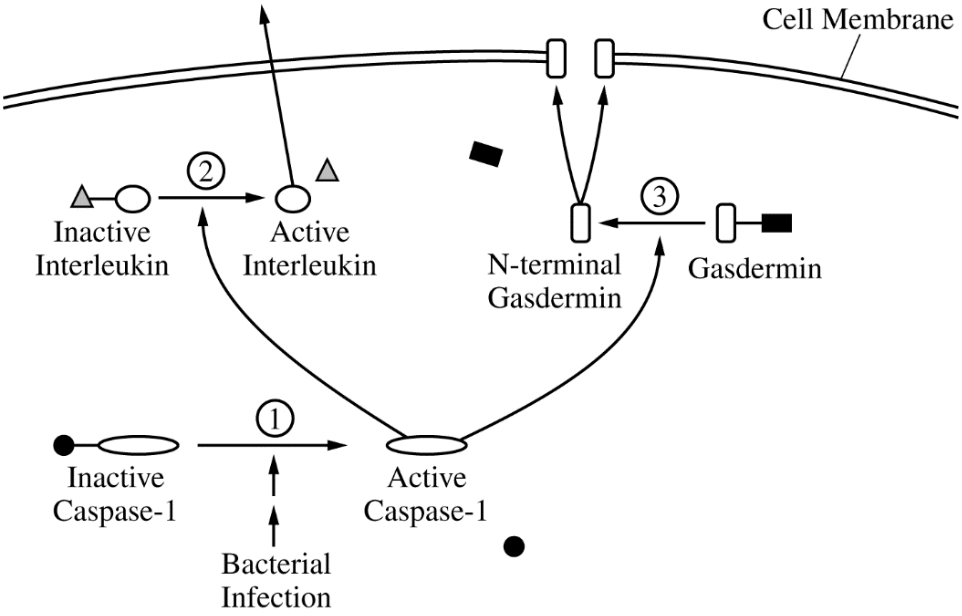


Figure 1. Cellular response to infection by pathogenic bacteria

2. Some pathogenic bacteria enter cells, replicate, and spread to other cells, causing illness in the host organism. Host cells respond to these infections in a number of ways, one of which involves activating particular enzymatic pathways (Figure 1). Cells normally produce a steady supply of inactive caspase-1 protein. In response to intracellular pathogens, the inactive caspase-1 is cleaved and forms an active caspase-1 (step 1). Active caspase-1 can cleave two other proteins. When caspase-1 cleaves an inactive interleukin (step 2), the active portion of the interleukin is released from the cell. An interleukin is a signaling molecule that can activate the immune response. When caspase-1 cleaves gasdermin (step 3), the N-terminal portions of several gasdermin proteins associate in the cell membrane to form large, nonspecific pores.

   Researchers created the model in Figure 1 using data from cell fractionation studies. In the experiments, various parts of the cell were separated into fractions by mechanical and chemical methods. Specific proteins known to be located in different parts of the cell were used as markers to determine the location of other proteins. The table below shows the presence of known proteins in specific cellular fractions.

CELL FRACTIONS CONTAINING DIFFERENT CELLULAR PROTEINS

	Aconitase (Krebs cycle protein)	DNA polymerase	GAPDH (glycolytic protein)	Sodium-potassium pump	NF-κB (Immune response protein)
Whole cell sample	+	+	+	+	+
Fraction 1	+				
Fraction 2		+			+
Fraction 3			+		+
Fraction 4				+	
					+ = presence of protein

(a) **Describe** the effect of inhibiting step 3 on the formation of pores AND on the release of interleukin from the cell.

(b) **Make a claim** about how cleaving inactive caspase-1 results in activation of caspase-1. A student claims that preinfection production of inactive precursors shortens the response time of a cell to a bacterial infection. **Provide ONE reason** to support the student's claim.

(c) A student claims that the NF-κB protein is located in the cytoplasm until the protein is needed for transcription. **Justify** the student's claim with evidence. **Identify TWO** fractions where N-terminal gasdermin would be found in cells infected with pathogenic bacteria.

(d) **Describe** the most likely effect of gasdermin pore formation on water balance in the cell in a hypotonic environment.

(e) **Explain** how gasdermin pore formation AND interleukin release contribute to an organism's defense against a bacterial pathogen.

AP Biology: **2017**

BIOLOGY

Section II

8 Questions

Total Time—90 minutes

Reading Period—10 minutes

Writing Period—80 minutes

Directions: Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. You are advised to spend the 10-minute reading period planning your answers. You may begin writing your responses before the reading period is over. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

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

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) 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:

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

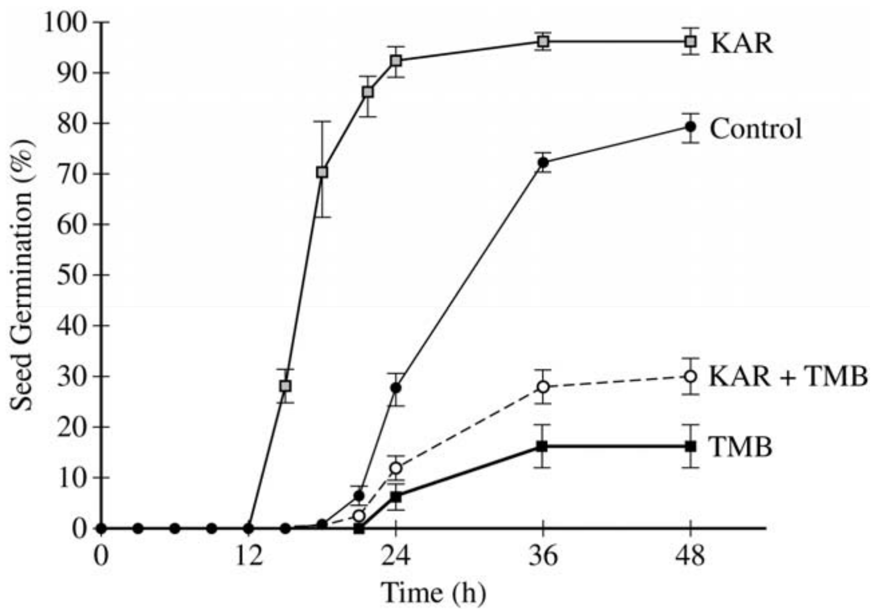


Figure 1. The effect of karrikins (KAR) and trimethylbutenolides (TMB) on seed germination in *Lactuca* plants. Error bars represent $\pm 2SE_{\bar{X}}$.

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.

   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 <u>and</u> about the effect of rinsing on the binding of TMB to the receptor in the seed. Identify the appropriate treatment groups <u>and</u> 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 <u>and</u> ONE advantage of TMB regulation to plants that live in an ecosystem with regular fires.

BIOLOGY

Section II

8 Questions

Planning Time—10 minutes

Writing Time—80 minutes

Directions: Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

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.

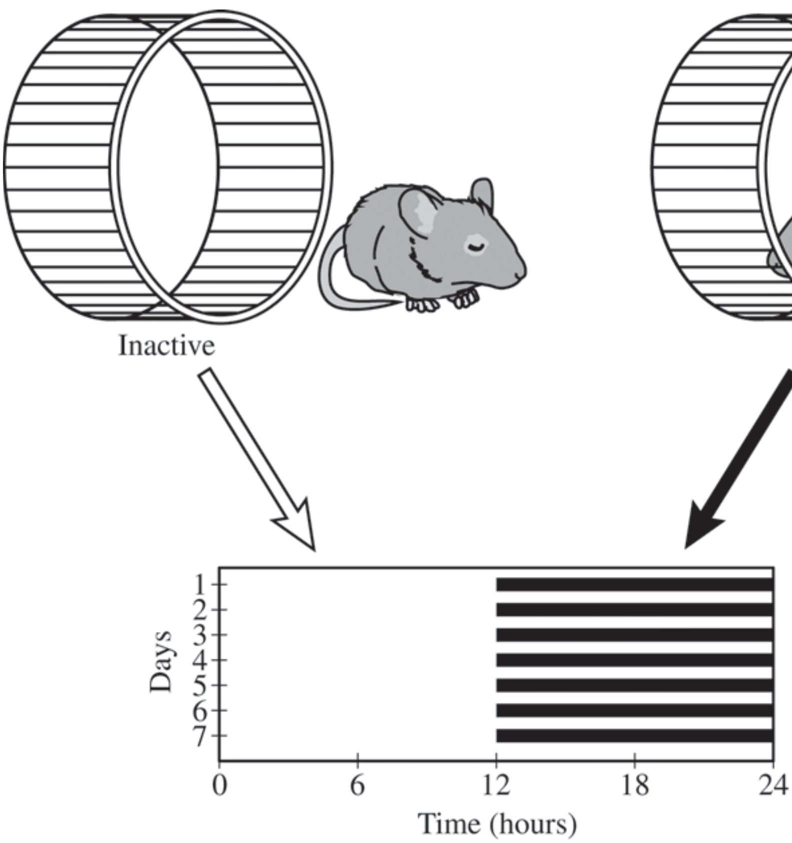


Figure 1. Strategy for recording mouse activity data. When a mouse is active on the running wheel, the activity is recorded as a dark horizontal line on an actogram. When the mouse is inactive, no dark line is recorded.

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.

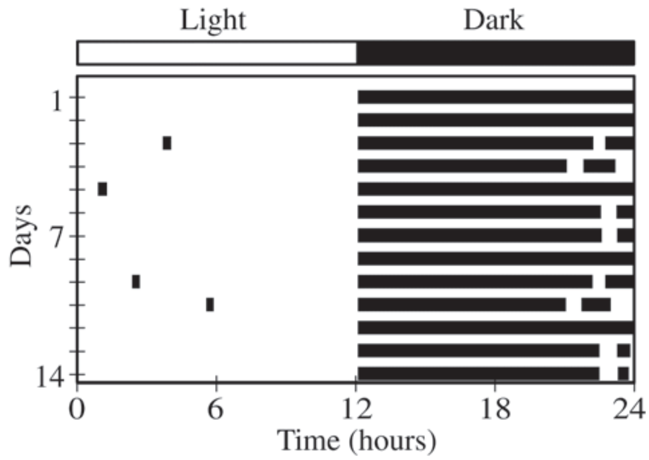


Figure 2. Actogram of mouse activity under L12:D12 conditions. Each row represents a 24-hour period, and the dark horizontal lines represent activity on the running wheel.

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.

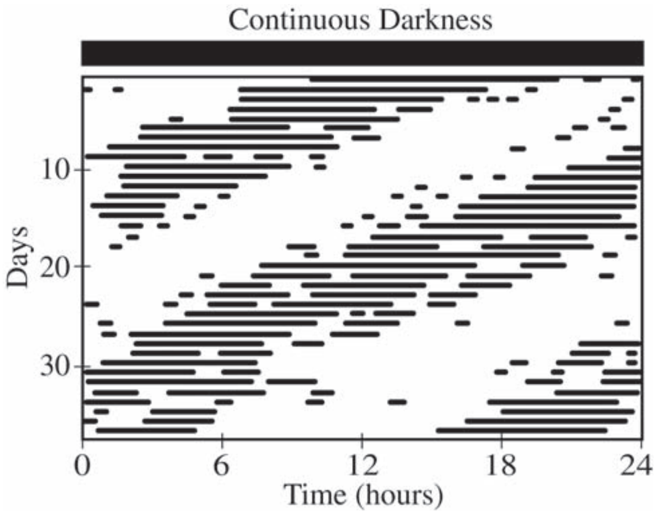


Figure 3. Actogram of mouse activity under DD conditions. Each row represents a 24-hour period, and the dark horizontal lines represent activity on the running wheel.

(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.

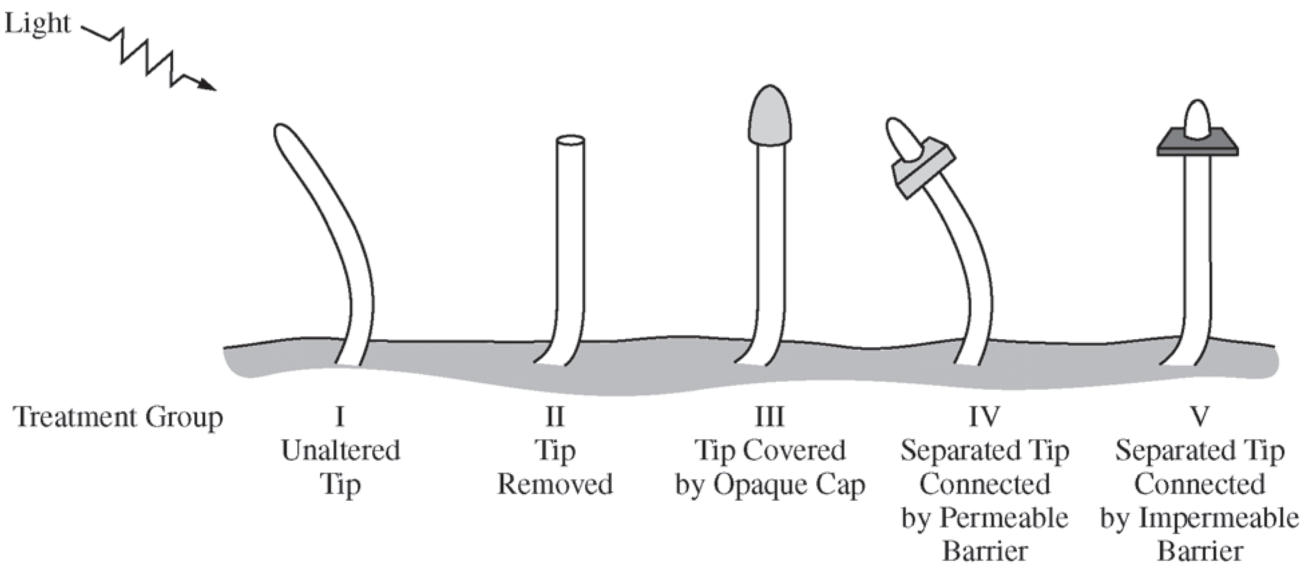
(d) To investigate the claim that exposure to light overrides the genetically controlled circadian rhythm, the researchers plan to repeat the experiment with mutant mice lacking a gene that controls the circadian rhythm. **Predict** the observed activity pattern of the mutant mice under L12:D12 conditions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

4. Both mitosis and meiosis are forms of cell division that produce daughter cells containing genetic information from the parent cell.

   (a) **Describe** TWO events that are common to both mitosis and meiosis that ensure the resulting daughter cells inherit the appropriate number of chromosomes.

   (b) The genetic composition of daughter cells produced by mitosis differs from that of the daughter cells produced by meiosis. **Describe** TWO features of the cell division processes that lead to these differences.



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 above.

   (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.

7. Smell perception in mammals involves the interactions of airborne odorant molecules from the environment with receptor proteins on the olfactory neurons in the nasal cavity. The binding of odorant molecules to the receptor proteins triggers action potentials in the olfactory neurons and results in transmission of information to the brain. Mammalian genomes typically have approximately 1,000 functional odorant-receptor genes, each encoding a unique odorant receptor.

   (a) **Describe** how the signal is transmitted across the synapse from an activated olfactory sensory neuron to the interneuron that transmits the information to the brain.

   (b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your answer.

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8. An individual has lost the ability to activate B cells and mount a humoral immune response.

   (a) **Propose** ONE direct consequence of the loss of B-cell activity on the individual's humoral immune response to the initial exposure to a bacterial pathogen.

   (b) **Propose** ONE direct consequence of the loss of B-cell activity on the speed of the individual's humoral immune response to a second exposure to the bacterial pathogen.

   (c) **Describe** ONE characteristic of the individual's immune response to the bacterial pathogen that is not affected by the loss of B cells.

STOP

END OF EXAM

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

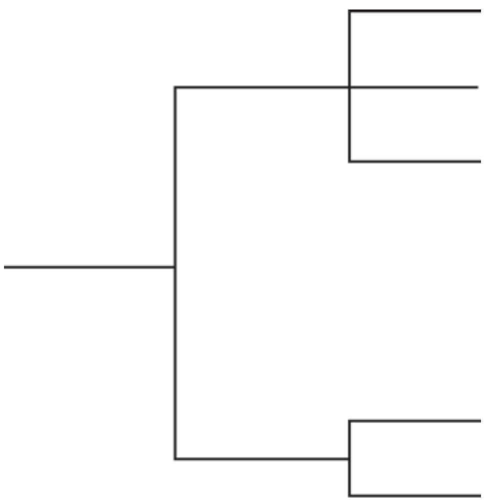
MILK COMPONENTS IN DIFFERENT MAMMALS

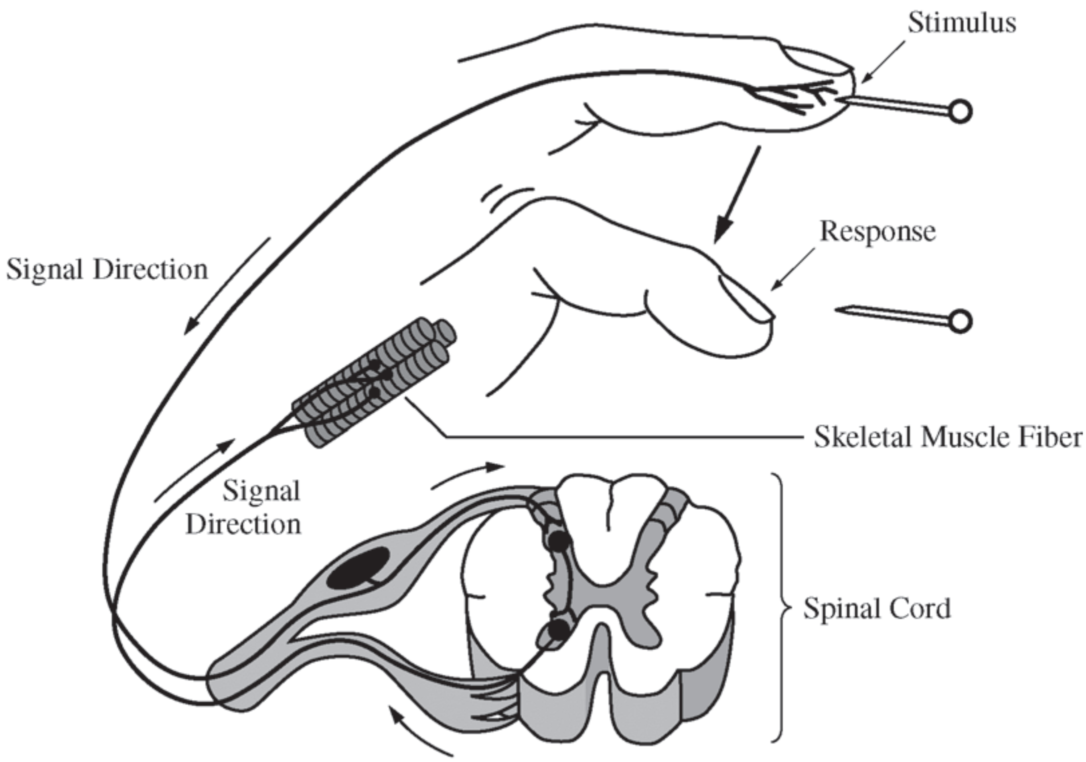
Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+
+ indicates the presence of the character, and – indicates the absence of the character					

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

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

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

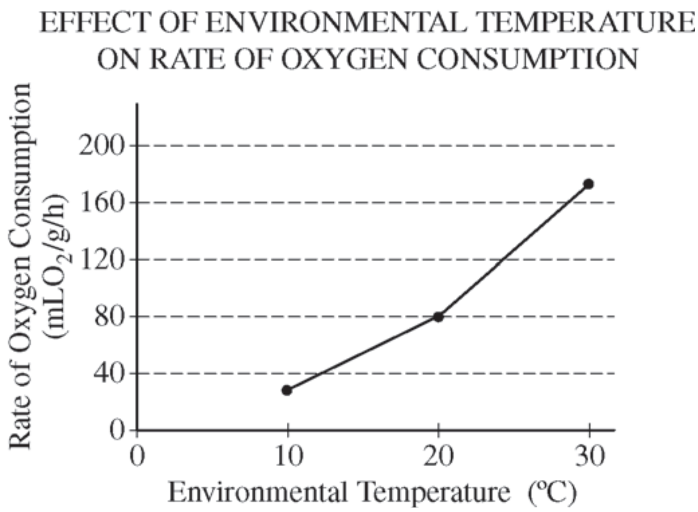




Cross Section of Spinal Cord and Skeletal Muscle Fiber

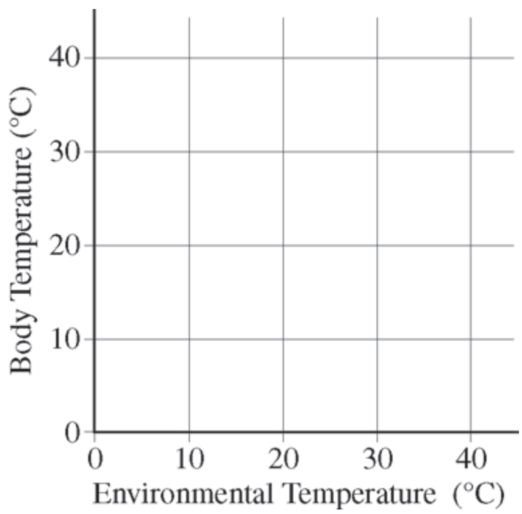
6. Information processing involves complex neural pathways that require a certain amount of time between recognition of a stimulus and the resulting response. For some types of stimuli, a reflex arc replaces the typical stimulus-response pathway. A representation of a reflex arc is shown in the figure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

   Based on the figure, **describe** TWO ways that the reflex arc differs from typical stimulus-response transmission pathways. **Provide** reasoning to support the claim that reflex arcs help organisms avoid serious injury.



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.



8.2 Energy Flow Through Ecosystems

Name: ______________ Class: _________ Date: ___________ **Total: 10 marks**

KEY WORDS trophic level 营养级 • consumers 消费者 • food chain 食物链 • producers 生产者 • energy pyramid 能

Objective

Build the skills to answer exam questions on **energy flow through ecosystems**.

You must be able to:

- describe **trophic levels** 营养级 and the **10% rule**
- draw/read an **energy pyramid** 能量金字塔
- explain why food chains are short

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Trophic levels

Energy flows from **producers** (make their own food) to **primary consumers** (herbivores), to **secondary** and **tertiary consumers** (carnivores). Each is a **trophic level**.

■ The 10% rule

Only about **10%** of the energy at one trophic level passes to the next. The other ~90% is lost as **heat** and used for life processes.

■ A worked calculation

If producers store 10 000 kJ: primary consumers get ~1000 kJ; secondary ~100 kJ; tertiary ~10 kJ.

■ Why food chains are short

Because so much energy is lost at each step, there is **too little** energy left to support many levels — so food chains rarely exceed 4-5 links.

2 Practice

Now apply the methods above.

2.1 What percentage of energy passes to the next trophic level? [1]

2.2 Where does the "lost" energy go? [1]

2.3 If producers have 8000 kJ, how much reaches primary consumers? [1]

3 Exam-style questions

3.1 Roughly how much energy passes from one trophic level to the next? [1]

- **A** 1%
- **B** 10%
- **C** 50%
- **D** 90%

3.2 An ecosystem's producers store 20 000 kJ.

(a) Estimate the energy reaching the secondary consumers. [3]

(b) Explain why so little energy reaches the top level. [1]

3.3 Explain why food chains rarely have more than four or five trophic levels. [2]

Solutions

2.1 About 10%.

2.2 Lost as heat (and used in life processes).

2.3 About 800 kJ.

3.1 **B** — 10%.

3.2 (a) Primary consumers: 2000 kJ; secondary consumers: 200 kJ. (b) About 90% of the energy is lost at each transfer, so very little remains after several steps.

3.3 So much energy is lost (~90%) at each level that after a few levels there is too little left to support another, limiting chain length.

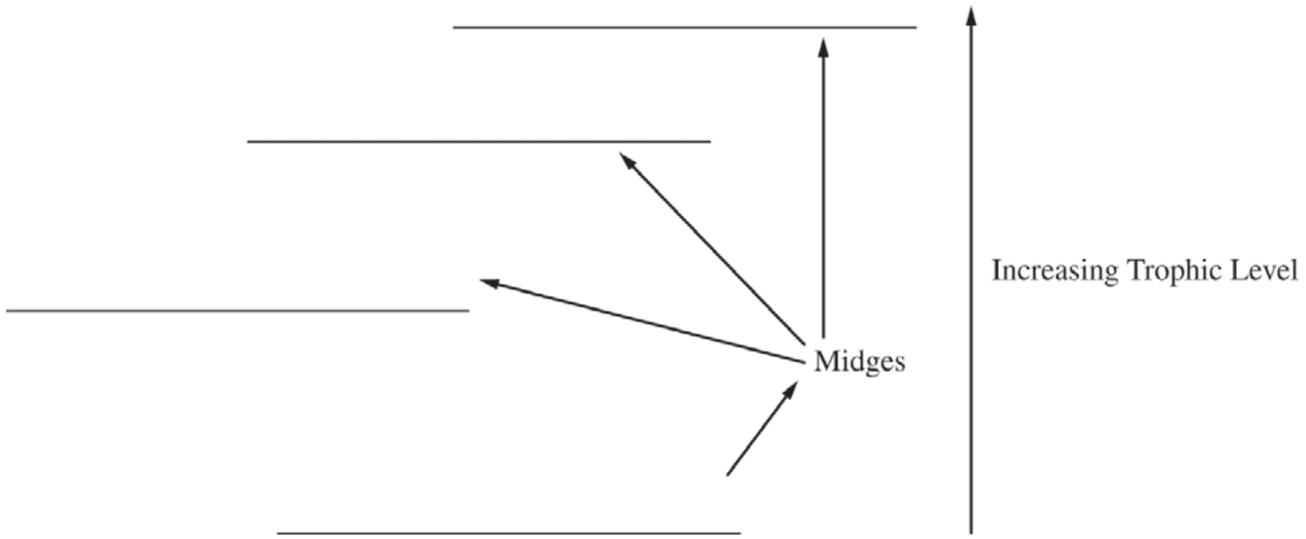
DIETARY COMPOSITION OF ORGANISMS IN AN AQUATIC ECOSYSTEM

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

4. The table above 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) 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.

   (b) In an effort to control the number of midges, an area within the ecosystem was sprayed with the fungus *Metarhizium anisopliae*, which significantly decreased the midge population. Based on the data in the table, **predict** whether the spraying of the fungus will have the greatest short-term impact on the population of the stoneflies, the caddisflies, or the hellgrammites. **Justify** your prediction.



8.3 Population Ecology

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS population 种群 • logistic 逻辑斯蒂 • logistic growth 逻辑斯蒂增长 • carrying capacity 环境容纳量 • exponential 指数

Objective

Build the skills to answer exam questions on **population ecology** — growth models.

You must be able to:

- distinguish **exponential** 指数 from **logistic** 逻辑斯蒂 growth
- explain **carrying capacity** 环境容纳量 K
- read a growth curve

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Exponential growth

With unlimited resources, a population grows **exponentially** — a **J-shaped** curve that keeps steepening. Rare in nature except briefly (e.g. new habitat).

■ Logistic growth

With limited resources, growth **slows** as the population rises, leveling off at the **carrying capacity** K — an **S-shaped** curve.

■ Carrying capacity

K is the **maximum** population the environment can support long-term. Near K, births ≈ deaths and growth stops.

■ A worked reading

An S-curve that flattens at 500 individuals has a carrying capacity of 500. Growth is fastest in the middle of the curve, not at the top.

2 Practice

Now apply the methods above.

2.1 What shape is an exponential growth curve? [1]

2.2 What does carrying capacity mean? [1]

2.3 What shape is a logistic growth curve? [1]

3 Exam-style questions

3.1 Logistic growth levels off at the [1]

- **A** origin
- **B** carrying capacity
- **C** exponential phase
- **D** zero point

3.2 A population grows and then levels off at 1200 individuals.

(a) State the carrying capacity. [1]

(b) Explain why growth slows as the population approaches this value. [2]

3.3 Explain the difference between exponential and logistic growth in terms of resources. [2]

Solutions

2.1 J-shaped.

2.2 The maximum population the environment can support long-term.

2.3 S-shaped.

3.1 **B** — the carrying capacity.

3.2 (a) 1200. (b) As the population grows, resources (food, space) become limited and competition rises, so births fall and deaths rise, slowing growth toward K.

3.3 Exponential growth assumes unlimited resources, so it keeps accelerating; logistic growth accounts for limited resources, so it slows and levels off at the carrying capacity.

3. Buffelgrass, an invasive grass species in southwestern desert ecosystems, is threatening the saguaro cactus, a keystone species in these ecosystems. Buffelgrass is drought-tolerant and can survive wildfires. However, the dry buffelgrass also acts as fuel for wildfires, causing the fires to be more severe. Older saguaro cacti can survive wildfires; however, many of the young cacti cannot.

Scientists conducted an experiment to determine whether they could control the abundance of the buffelgrass population. The scientists identified several native grass species that, when grown with buffelgrass, might reduce the abundance of buffelgrass. They grew buffelgrass in the presence of several different native grass species in greenhouses, in either nondrought (watered every 3 days) or drought (watered every 9 days) conditions. After twelve weeks, they measured the height and dry weight of the buffelgrass in each treatment group.

A. **Describe** the effect that removing a keystone species will have on an ecosystem.

B. **Identify** a control group the scientists should include in their experiment.

C. **State** the null hypothesis of the experiment in which buffelgrass is grown in the presence of native grass species.

D. Scientists have found that the population growth rates of native grasses are much slower than the population growth rate of buffelgrass following a wildfire. The scientists claim that wildfires will therefore increase the abundance of buffelgrass plants in the ecosystem. Based on the information given, **justify** the scientists' claim.

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 Figures 1A and 1B.

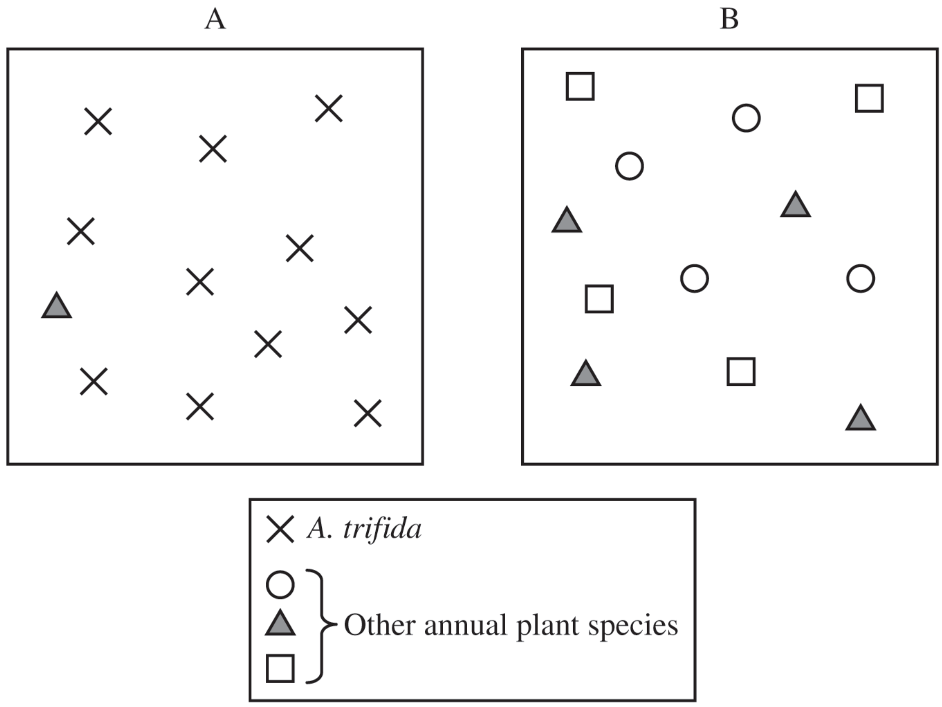


Figure 1. Representations of plant identity and distribution in experimental plots in late summer. Each box represents one typical experimental plot, and each symbol represents 10 individual plants.

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

(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.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

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

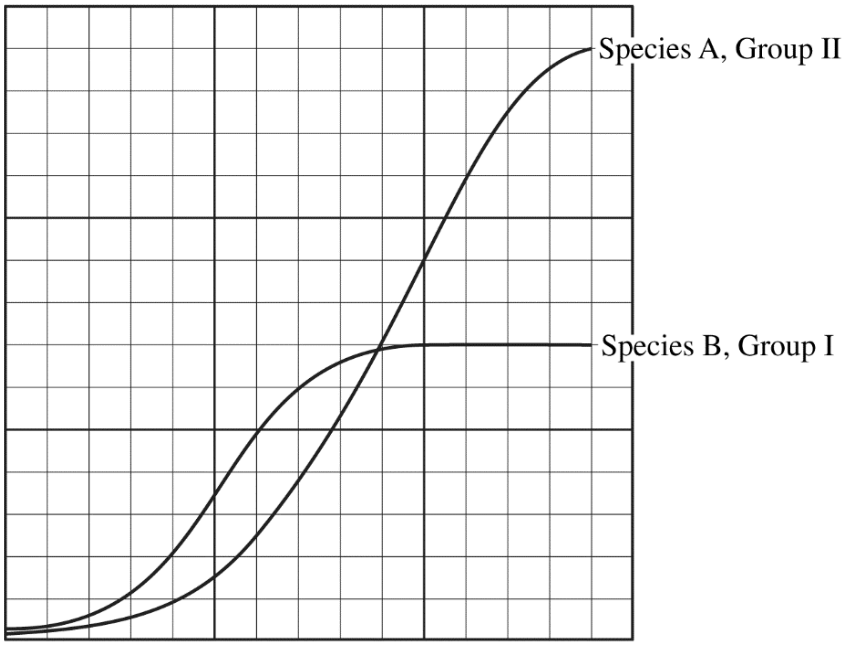
(a) The growth curves for species B in group I and for species A in group II (shaded columns) have been plotted on the template. Use the template to **complete** an appropriately labeled line graph to illustrate the growth of species A in treatment group I and species B in treatment group II (unshaded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


Species A, Group II
Species B, Group I

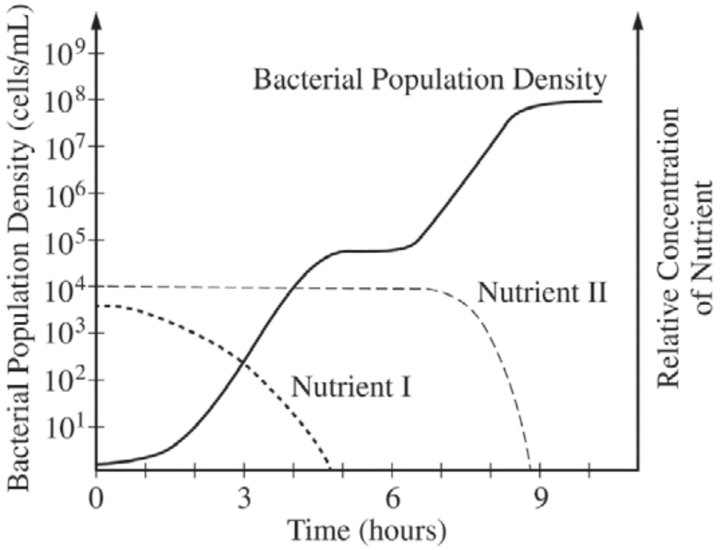


Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

2. 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 $\frac{\text{cells}}{\text{mL}}$ for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.

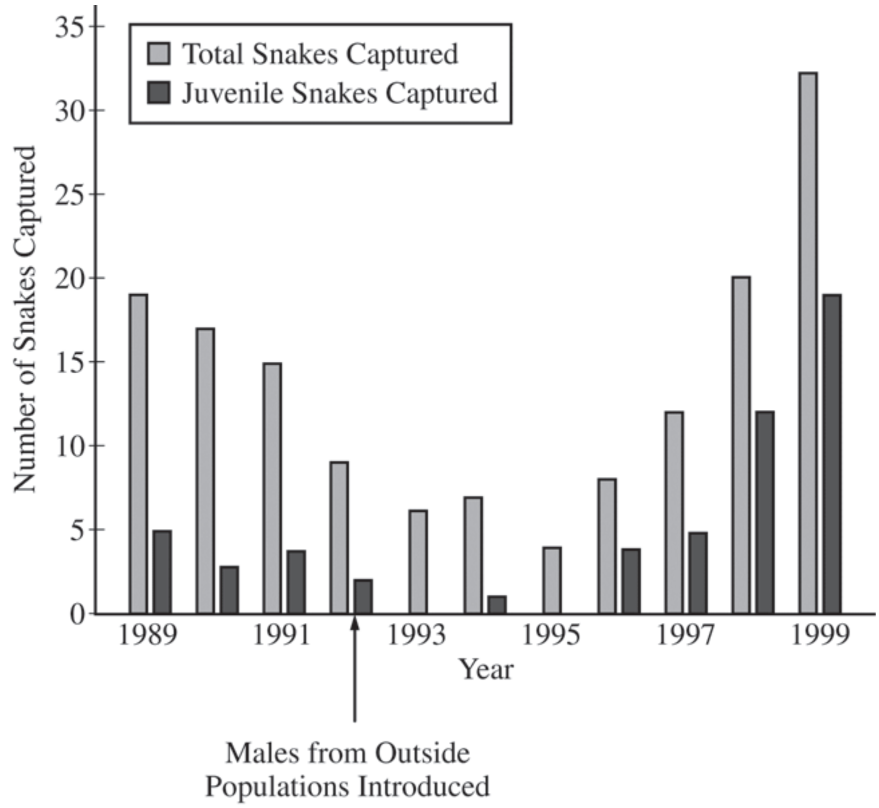
   (b) Using the data, **calculate** the growth rate in $\frac{\text{cells}}{\text{mL}\times\text{hour}}$ of the bacterial population between hours 2 and 4.

   (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.

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.

BIOLOGY
Section II
8 Questions
Planning Time—10 minutes
Writing Time—80 minutes

Directions: Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

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

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

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

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

(a) On the axes provided, **create** an appropriately labeled graph to illustrate the sample means of the three populations to within 95% confidence (i.e., sample mean ± 2 SEM).

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

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

8.4 Effect of Density on Populations

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS density-dependent 密度制约 • density-independent 非密度制约 • competition 竞争 • predation 捕食 • population 种群

Objective

Build the skills to answer exam questions on **density-dependent and density-independent factors**.

You must be able to:

- distinguish **density-dependent** 密度制约 from **density-independent** 非密度制约 factors
- give examples of each
- predict which limits a population

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Density-dependent factors

These have a **stronger effect** as the population gets **denser**: competition for food, disease spread, predation, and waste build-up. They help regulate the population toward carrying capacity.

Density-independent factors

These affect the population **regardless** of its size: weather, natural disasters (fire, flood), and temperature. A storm kills the same fraction whether the population is large or small.

A worked identification

Disease spreading faster in a crowded population = **density-dependent**. A drought killing many plants regardless of number = **density-independent**.

Why the distinction matters

Density-dependent factors **regulate** populations around K; density-independent factors can cause sudden crashes unrelated to density.

2 Practice

Now apply the methods above.

2.1 Give one density-dependent factor. [1]

2.2 Give one density-independent factor. [1]

2.3 Which type of factor helps regulate a population near carrying capacity? [1]

3 Exam-style questions

3.1 A disease that spreads faster in a crowded population is a [1]

- **A** density-independent factor
- **B** density-dependent factor
- **C** carrying capacity
- **D** producer

3.2 A sudden flood kills many organisms in a population.

(a) Classify this factor. [1]

(b) Explain why its effect does not depend on population density. [2]

3.3 Explain how density-dependent factors help keep a population near its carrying capacity. [2]

Solutions

2.1 Any one: competition, disease, predation, waste build-up.

2.2 Any one: weather, natural disaster, temperature.

2.3 Density-dependent factors.

3.1 **B** — a density-dependent factor.

3.2 (a) Density-independent. (b) A flood affects the same proportion of organisms whether the population is large or small — its effect does not change with density.

3.3 As density rises, competition, disease, and predation increase, raising deaths and lowering births; this pushes the population back down toward the carrying capacity.

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

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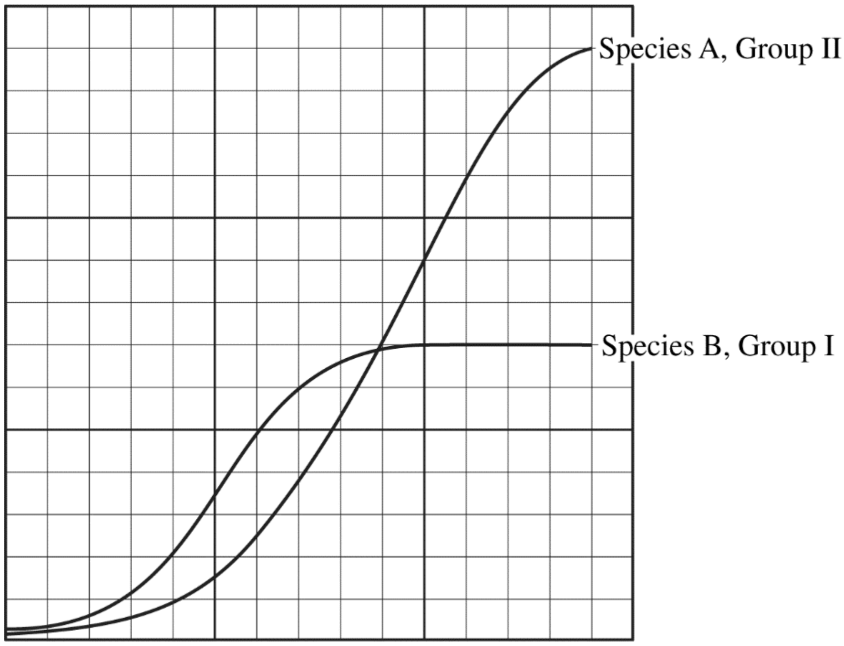
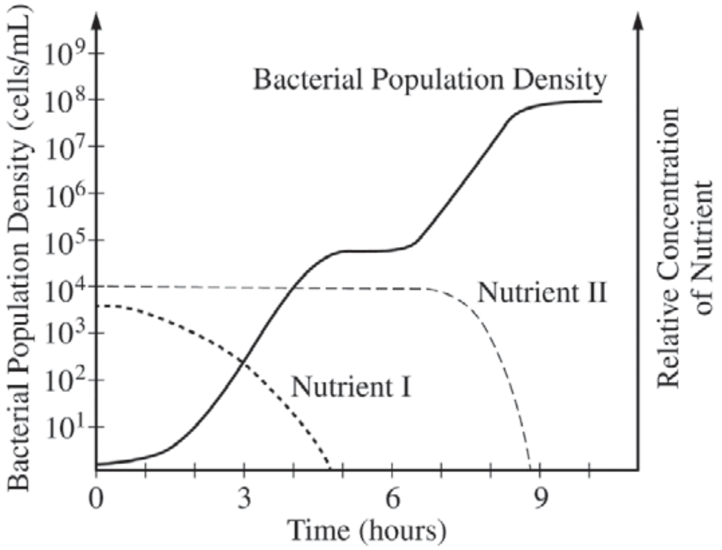
(b) As shown in the table, the student established treatment group II with 5 individuals of each species. **Provide reasoning** for the reduced initial population sizes.

(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.


Species A, Group II
Species B, Group I



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2. 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 $\frac{\text{cells}}{\text{mL}}$ for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.

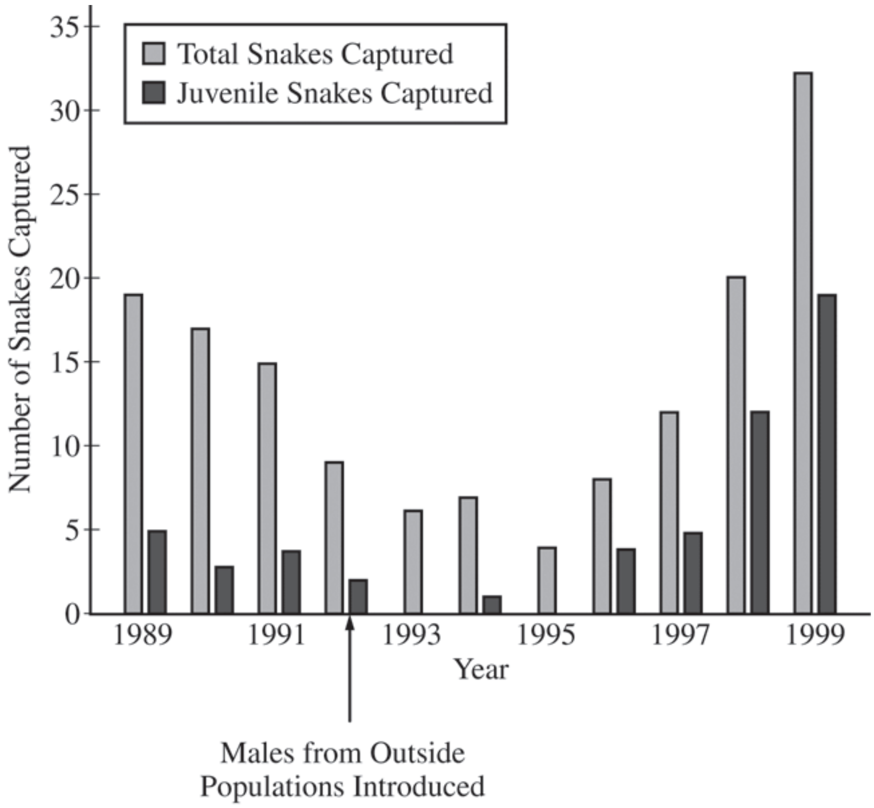
(b) Using the data, **calculate** the growth rate in $\frac{\text{cells}}{\text{mL} \times \text{hour}}$ of the bacterial population between hours 2 and 4.

(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.

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.

AP BIOLOGY • EXERCISE SHEET

8.5 Community Ecology

Name: ______________ Class: __________ Date: ____________ **Total: 9 marks**

KEY WORDS community 群落 • predation 捕食 • competition 竞争 • symbiosis 共生

Objective

Build the skills to answer exam questions on **community ecology** — species interactions.

You must be able to:

- describe **competition 竞争**, **predation 捕食**, and **symbiosis 共生** (mutualism, commensalism, parasitism)
- give the +/− effect on each partner
- identify an interaction from a description

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The main interactions

- **Competition** (−/−) — both species are harmed as they use the same limited resource.
- **Predation** (+/−) — the predator benefits, the prey is harmed.
- **Mutualism** (+/+) — both benefit.
- **Commensalism** (+/0) — one benefits, the other is unaffected.
- **Parasitism** (+/−) — the parasite benefits, the host is harmed.

■ Reading effects

Assign a +, −, or 0 to each partner. For example, a bee and a flower: bee gets nectar (+), flower gets pollinated (+) → **mutualism**.

■ A worked identification

A tick feeding on a dog: tick benefits (+), dog harmed (−) → **parasitism**.

■ Competitive exclusion

Two species competing for exactly the same niche cannot coexist indefinitely — one outcompetes the other (competitive exclusion).

2 Practice

Now apply the methods above.

2.1 State the effect (+/−) on each partner in predation. [1]

2.2 Name the interaction where both species benefit. [1]

2.3 Classify a tick feeding on a dog. [1]

3 Exam-style questions

3.1 An interaction that benefits one species and harms the other is [1]

- **A** mutualism
- **B** commensalism
- **C** parasitism
- **D** competition

3.2 A bird eats insects stirred up by a grazing buffalo; the buffalo is unaffected.

(a) Name the interaction. [1]

(b) State the effect on each partner. [2]

3.3 Explain why two species competing for exactly the same resources cannot coexist indefinitely. [2]

Solutions

2.1 Predator +, prey −.

2.2 Mutualism.

2.3 Parasitism.

3.1 **C** — parasitism (or predation) benefits one and harms the other.

3.2 (a) Commensalism. (b) The bird benefits (+); the buffalo is unaffected (0).

3.3 One species will use the shared resource slightly more efficiently and outcompete the other, which declines or is excluded (competitive exclusion).

3. Buffelgrass, an invasive grass species in southwestern desert ecosystems, is threatening the saguaro cactus, a keystone species in these ecosystems. Buffelgrass is drought-tolerant and can survive wildfires. However, the dry buffelgrass also acts as fuel for wildfires, causing the fires to be more severe. Older saguaro cacti can survive wildfires; however, many of the young cacti cannot.

Scientists conducted an experiment to determine whether they could control the abundance of the buffelgrass population. The scientists identified several native grass species that, when grown with buffelgrass, might reduce the abundance of buffelgrass. They grew buffelgrass in the presence of several different native grass species in greenhouses, in either nondrought (watered every 3 days) or drought (watered every 9 days) conditions. After twelve weeks, they measured the height and dry weight of the buffelgrass in each treatment group.

A. **Describe** the effect that removing a keystone species will have on an ecosystem.

B. **Identify** a control group the scientists should include in their experiment.

C. **State** the null hypothesis of the experiment in which buffelgrass is grown in the presence of native grass species.

D. Scientists have found that the population growth rates of native grasses are much slower than the population growth rate of buffelgrass following a wildfire. The scientists claim that wildfires will therefore increase the abundance of buffelgrass plants in the ecosystem. Based on the information given, **justify** the scientists' claim.

4. Twenty million years ago the Caribbean Sea and Pacific Ocean were connected, and water flowed freely between the two bodies of water. Many of the same marine species were found in both areas. Over millions of years, the land referred to as the Isthmus of Panama formed, eventually closing off the connection between the Caribbean Sea and Pacific Ocean and creating two separate bodies of water. The ecology of these two marine habitats was dramatically altered by this land formation. The warmer Caribbean water could no longer flow west, so the Pacific water cooled and became more nutrient-rich, while the Caribbean water became warmer.

A. **Describe** the genetic evidence that evolution is occurring in a population.

B. **Explain** how the isolation of marine species by the formation of a land barrier can lead to divergent evolution of those species.

The formation of the Isthmus of Panama connected two continents, North America and South America. Many North American land animal species migrated to South America after the formation of the isthmus and occupied similar niches as South American species.

C. **Predict** the effect the formation of the isthmus had on resource availability for South American species.

D. **Justify** your prediction in part C.

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

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

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

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

(d) **Justify** your prediction in part (c).

Write your responses to this question only on the designated pages in the separate Free Response booklet.

If there are multiple parts to this question, write the part letter with your response.

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

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

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

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

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

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

Write your responses to this question only on the designated pages in the separate Free Response booklet.

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.

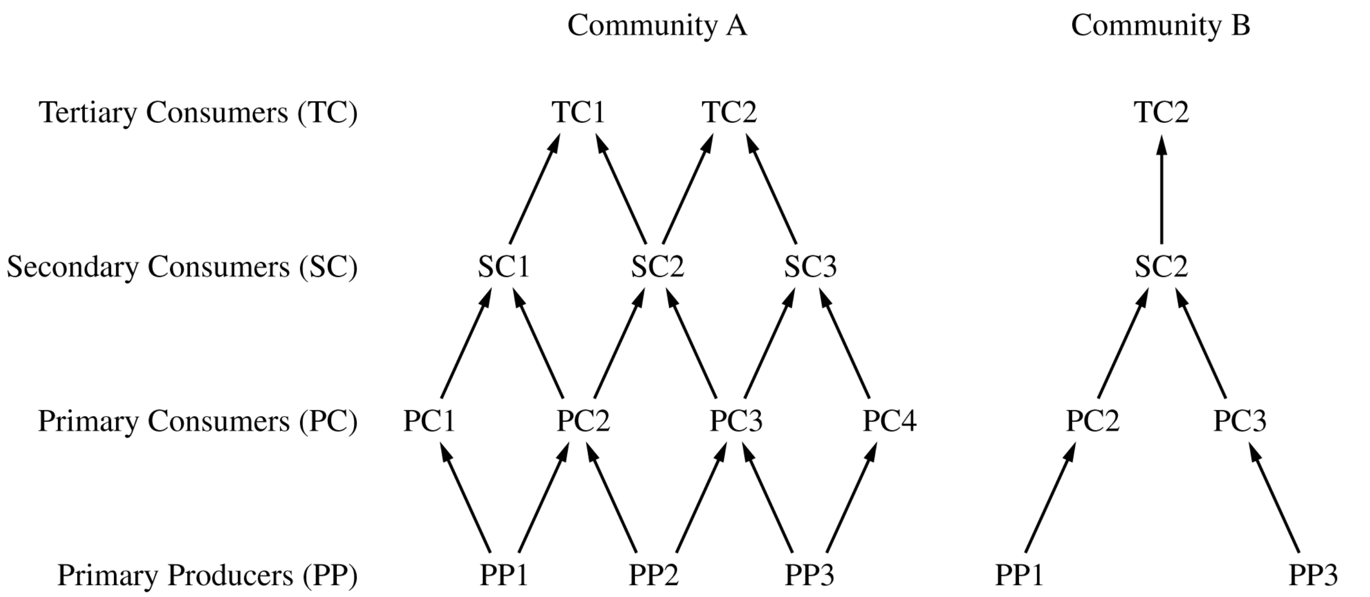


Figure 1. Models of two different communities with some of the same species

(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.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

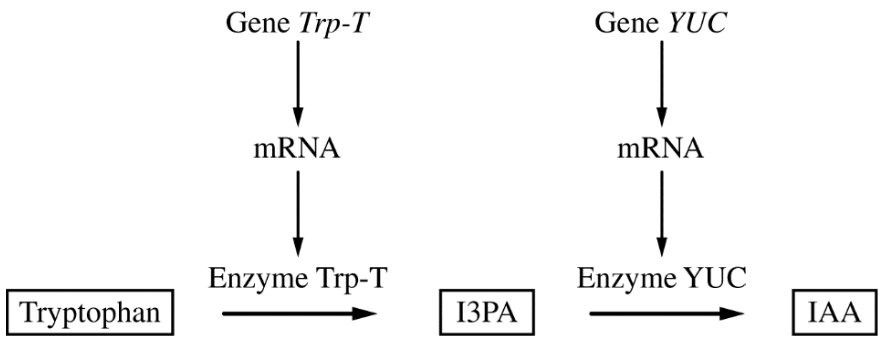


Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

1. 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 noncheater 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.

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

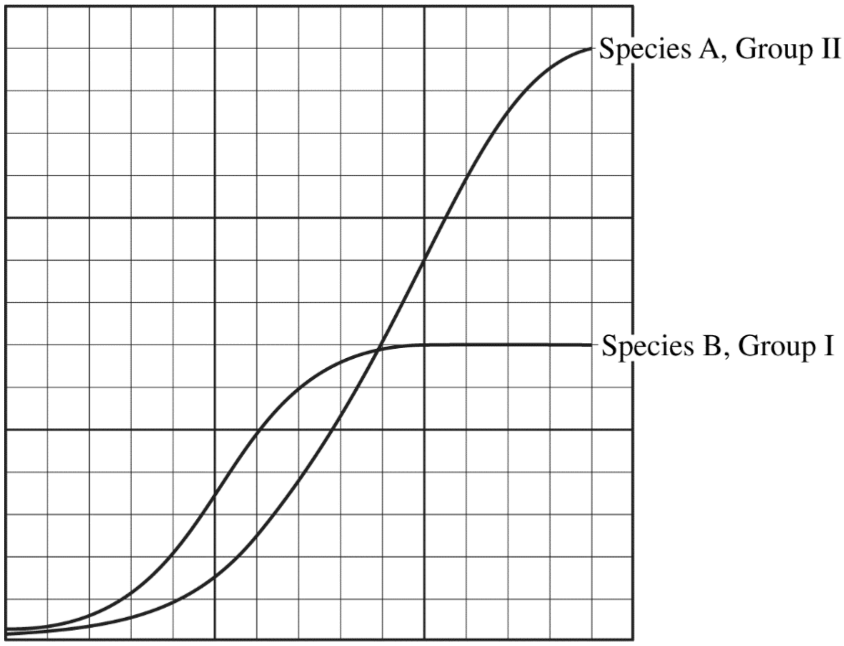
(a) The growth curves for species B in group I and for species A in group II (shaded columns) have been plotted on the template. Use the template to **complete** an appropriately labeled line graph to illustrate the growth of species A in treatment group I and species B in treatment group II (unshaded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

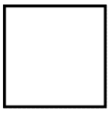
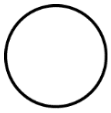
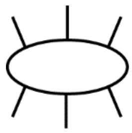
(d) **Predict** TWO factors that will most likely limit the population growth of species A in treatment group I.

(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.

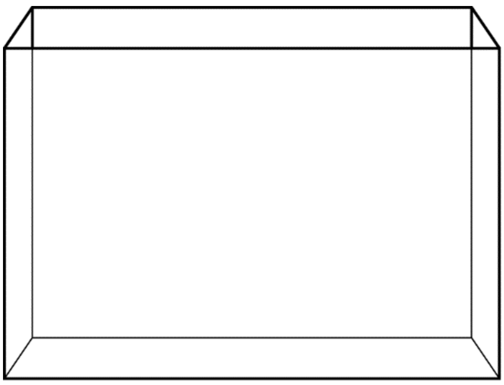
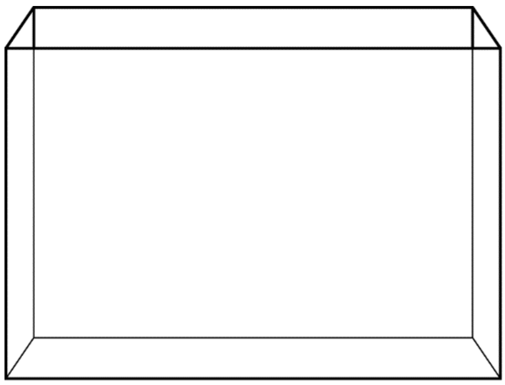

Species A, Group II
Species B, Group I

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 interactions 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 any 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
	

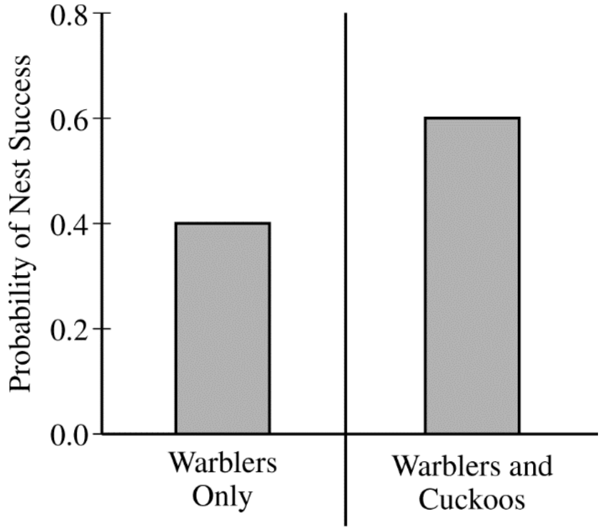


Figure 1. Probability of nest success in an environment with predators

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.

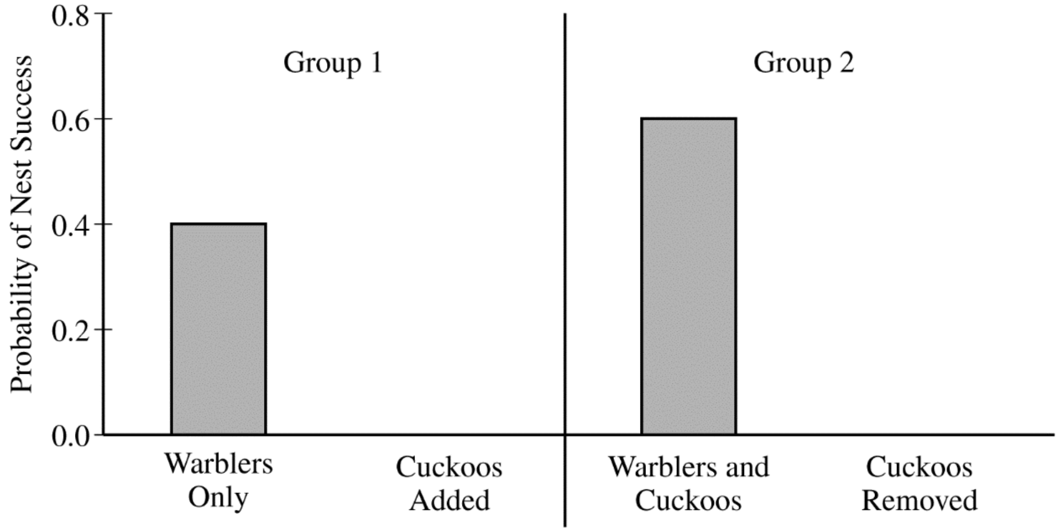
   In some geographic areas, several species of nest predators are present. Researchers have found that cuckoo chicks, while in the nest, produce a smelly substance that deters nest predators. The substance does not remain in the nest if cuckoo chicks are removed. Figure 1 shows the probability that nests 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 cuckoos 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 <u>added</u> to the nest containing only warblers (group 1)
   - the cuckoos were <u>removed</u> 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.



BIOLOGY

Section II

8 Questions

Total Time—90 minutes

Reading Period—10 minutes

Writing Period—80 minutes

Directions: Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. You are advised to spend the 10-minute reading period planning your answers. You may begin writing your responses before the reading period is over. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

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

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) 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:

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

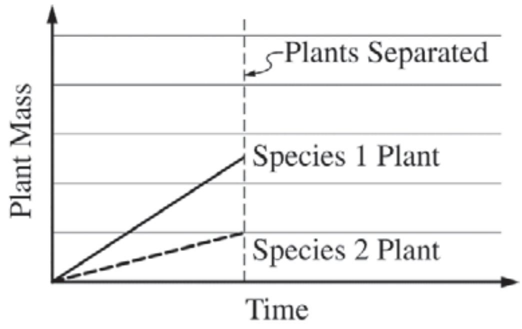
(d) Researchers found that nectar with caffeine tends to have a lower sugar content than nectar without caffeine. Plants use less energy to produce the caffeine in nectar than they do to produce the sugar in nectar. **Propose ONE benefit** to plants that produce nectar with caffeine and a lower sugar content. **Propose ONE cost** to bees that visit the flowers of plants that produce nectar with caffeine and a lower sugar content.

7. Many species of bacteria grow in the mouths of animals and can form biofilms on teeth (plaque). Within plaque, the outer layers contain high levels of oxygen and the layers closest to the tooth contain low levels of oxygen. The surface of the tooth is covered in a hard layer of enamel, which can be dissolved under acidic conditions. When the enamel breaks down, the bacteria in plaque can extract nutrients from the tooth and cause cavities.

   Certain types of bacteria (e.g., *Streptococcus mutans*) thrive in the innermost anaerobic layers of the plaque and are associated with cavities. Other types of bacteria (*Streptococcus sanguinis*) compete with *S. mutans* but are unable to thrive in acidic environments.

   (a) **Identify** the biochemical pathway *S. mutans* uses for metabolizing sugar and **describe** how the pathway contributes to the low pH in the inner layers of plaque.

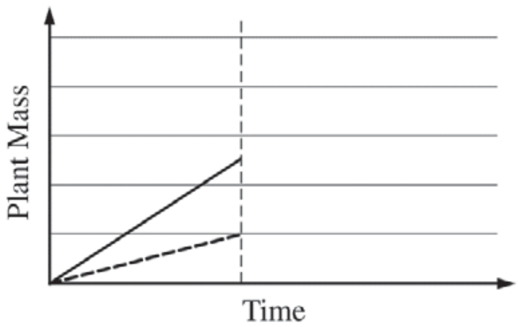
   (b) Normal tooth brushing effectively removes much of the plaque from the flat surfaces of teeth but cannot reach the surfaces between teeth. Many commercial toothpastes contain alkaline components, which raise the pH of the mouth. **Predict** how the population sizes of *S. mutans* AND *S. sanguinis* in the bacterial community in the plaque between the teeth are likely to change when these toothpastes are used.



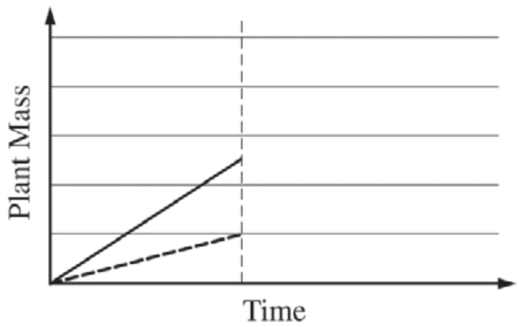
5. The graph above shows the mass of plants from two different species over time. The plants grew while attached to each other. The plants were separated at the time indicated by the vertical line in the graph.

   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



8.6 Biodiversity

Name: ______________ Class: __________ Date: ____________ **Total: 9 marks**

KEY WORDS biodiversity 生物多样性 • resilient 有韧性 • ecosystems 生态系统

Objective

Build the skills to answer exam questions on **biodiversity**.

You must be able to:

- explain why **biodiversity 生物多样性** makes ecosystems resilient
- link diversity to stability and ecosystem services
- describe threats to biodiversity

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Diversity builds resilience

An ecosystem with **high biodiversity** has more species filling more roles, so it is more **resilient** — better able to recover from disturbances (disease, weather).

■ Why diversity helps

If one species is lost, others can fill a similar role, keeping the ecosystem functioning. Low-diversity systems are more easily disrupted by a single loss.

■ Ecosystem services

Diverse ecosystems provide **services**: clean water, pollination, climate regulation, and food. Losing species can reduce these services.

■ Threats

Biodiversity is reduced by **habitat loss**, **pollution**, **invasive species**, **overharvesting**, and **climate change**.

2 Practice

Now apply the methods above.

2.1 Why is a high-biodiversity ecosystem more resilient? [1]

2.2 Give one ecosystem service provided by diverse ecosystems. [1]

2.3 State one threat to biodiversity. [1]

3 Exam-style questions

3.1 An ecosystem with high biodiversity is generally [1]

- **A** less stable
- **B** more resilient to disturbance
- **C** unable to recover
- **D** identical to a monoculture

3.2 A disease removes one species from an ecosystem.

(a) Explain why a diverse ecosystem is more likely to keep functioning. [2]

(b) State one human activity that reduces biodiversity. [1]

3.3 Explain how the loss of biodiversity could reduce the ecosystem services humans rely on. [2]

Solutions

2.1 More species fill more roles, so it can recover better from disturbances.

2.2 Any one: clean water, pollination, climate regulation, food.

2.3 Any one: habitat loss, pollution, invasive species, overharvesting, climate change.

3.1 B — more resilient to disturbance.

3.2 (a) In a diverse ecosystem, other species can fill the lost species' role, so the ecosystem keeps functioning. (b) Any one: habitat destruction, pollution, overharvesting.

3.3 Many services (pollination, water purification, food) depend on particular species; losing them removes those functions, reducing the services people rely on.

The following information applies to all parts.

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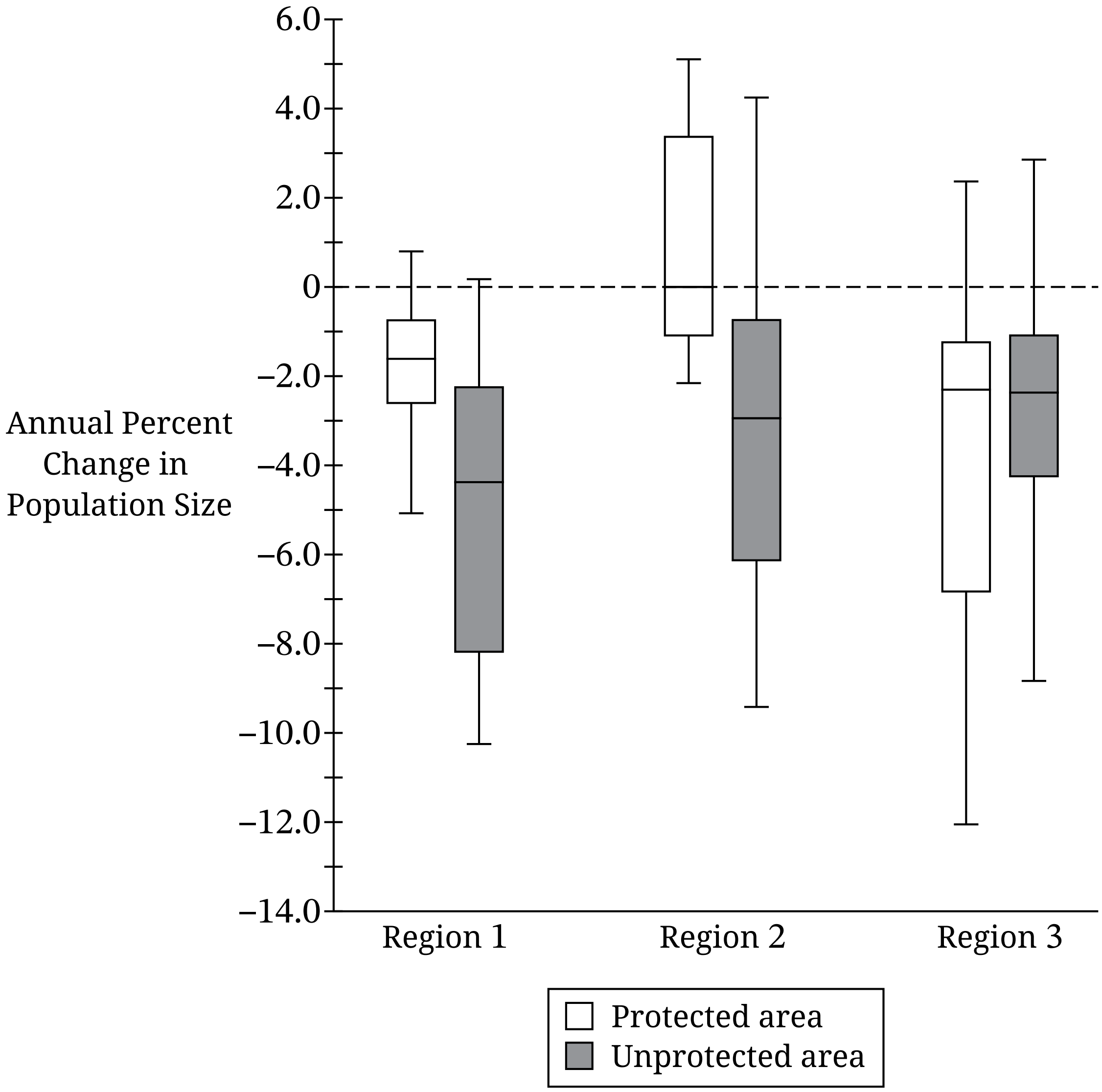
6. Many raptors in Africa are top predators and keystone species in their ecosystems. Raptor population sizes have been declining in recent years.

Scientists studied the relationship between the conversion of the raptors’ natural habitat into farmland and the population sizes of raptors in those regions. They compiled raptor population size data from three different regions of Africa: Region 1, Region 2, and Region 3. In each of the regions, the scientists compared the annual percent change in the raptor population size in areas that were protected from farming (protected) with the annual percent change in areas where farming occurred (unprotected). Their results are shown in the box and whisker plot.

type of bird

Median Annual Percent Change in the Population Size of Raptors in Protected and Unprotected Areas



Part A

Based on the box and whisker plot, **identify** the median annual percent change in population size in the unprotected area of Region 2.

Part B

Based on the box and whisker plot, **identify** the region and area that experienced the greatest median annual percent change in population size.

Part C

Researchers hypothesize that if farming is eliminated in Region 2, there will no longer be a decline in the raptor population size. Based on the data in the box and whisker plot, **evaluate** the researchers' hypothesis.

Part D

Based on the information provided, **explain** why ecosystem resilience in unprotected areas may decline over time.

STOP

END OF EXAM

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

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

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

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

   (d) **Justify** your prediction in part (c).

Write your responses to this question only on the designated pages in the separate Free Response booklet.

If there are multiple parts to this question, write the part letter with your response.

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

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

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

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

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

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

Write your responses to this question only on the designated pages in the separate Free Response booklet.

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.

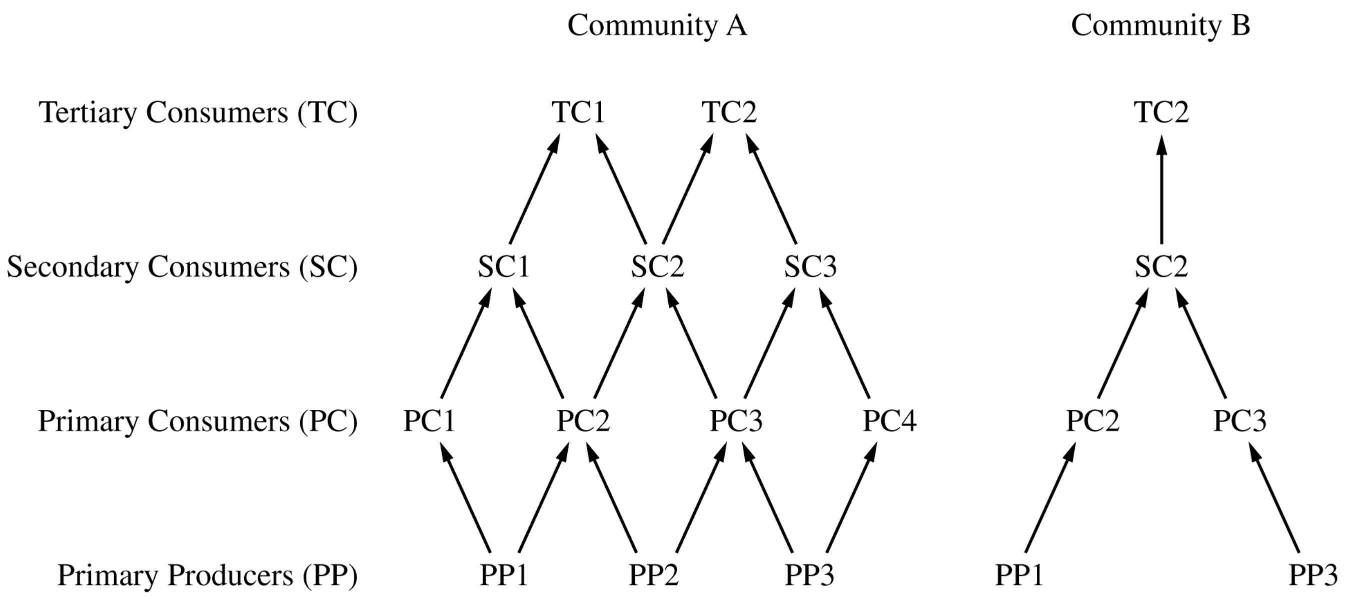


Figure 1. Models of two different communities with some of the same species

(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.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

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 Figures 1A and 1B.

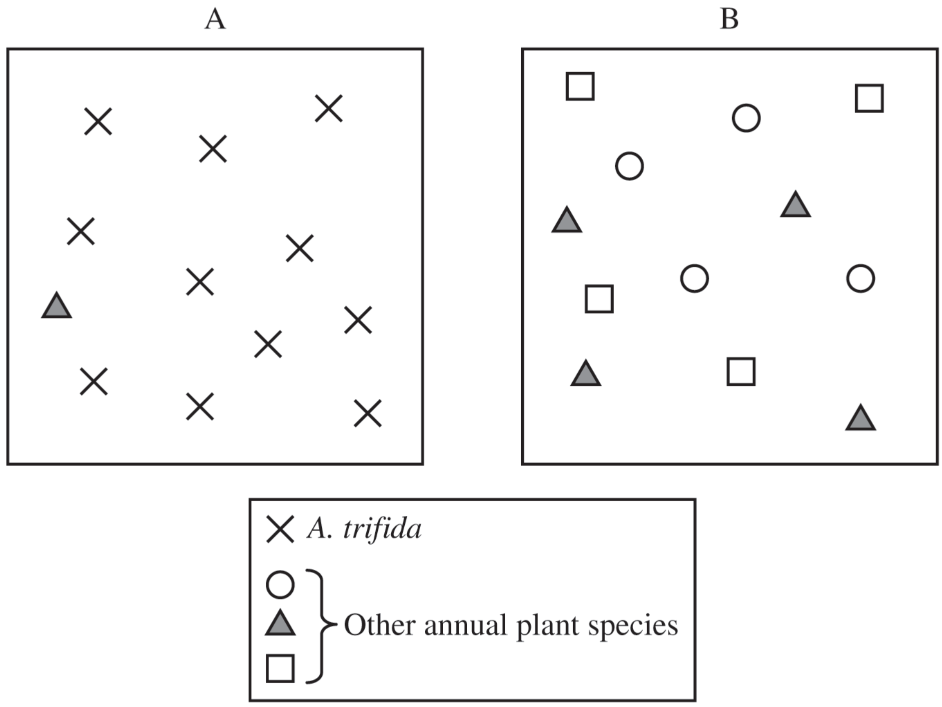


Figure 1. Representations of plant identity and distribution in experimental plots in late summer. Each box represents one typical experimental plot, and each symbol represents 10 individual plants.

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

(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.

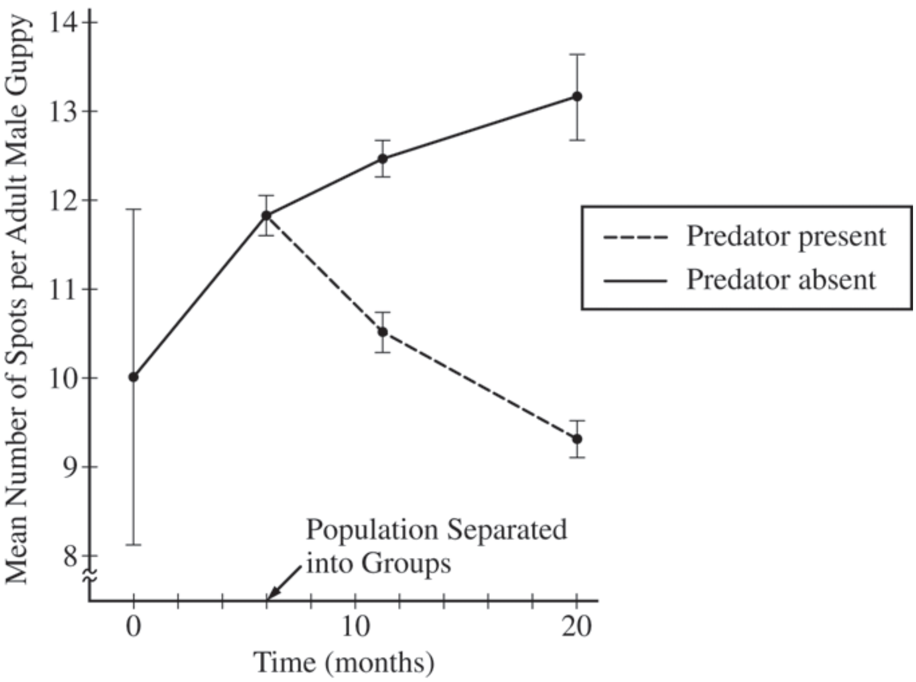
(c) In a third group of plots, the researchers removed all seedlings of all plants that germinated before June 1. All plants that germinated after June 1 were left untouched. Using the template in the space provided for your response and the symbols shown in Figure 1, **represent** the expected plant 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.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

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

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



   (a) **Describe** the change in genetic variation in the population between 0 and 6 months and **provide** reasoning for your description based on the means and SEM.

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

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

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

AP BIOLOGY • EXERCISE SHEET

8.7 Disruptions in Ecosystems

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS invasive species 入侵物种 • ecosystems 生态系统 • keystone species 关键种 • population 种群 • community 群落

Objective

Build the skills to answer exam questions on **disruptions in ecosystems**.

You must be able to:

- describe how **invasive species 入侵物种**, **human activity**, and **natural events** disrupt ecosystems
- explain knock-on effects through food webs
- link disruptions to changes in populations and diversity

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Sources of disruption

- **Invasive species** — a non-native species with no natural predators can outcompete or prey on natives.
- **Human activity** — habitat destruction, pollution, and climate change.
- **Natural events** — fires, floods, and volcanic eruptions.

■ Knock-on effects

Because species are connected in **food webs**, removing or adding one species has **knock-on effects** on many others — a change ripples through the community.

■ A worked example

An invasive predator with no natural enemies multiplies and eats native prey; the prey decline, and species that depended on that prey are also affected.

■ Keystone species

Losing a **keystone species** (one with an outsized role, like a top predator) can collapse much of the community — its removal has effects far beyond its own numbers.

2 Practice

Now apply the methods above.

2.1 Why can an invasive species spread rapidly? [1]

2.2 Give one human cause of ecosystem disruption. [1]

2.3 What is a keystone species? [1]

3 Exam-style questions

3.1 An invasive species often thrives because it [1]

- **A** has many local predators
- **B** lacks natural predators in the new area
- **C** cannot reproduce
- **D** is a producer only

3.2 An invasive predator is introduced to an island with defenseless native prey.

(a) Predict the effect on the native prey population. [1]

(b) Explain how this could affect other species in the food web. [2]

3.3 Explain why removing a keystone species can disrupt an entire community. [2]

Solutions

2.1 It has no natural predators in the new area, so its population is not kept in check.

2.2 Any one: habitat destruction, pollution, climate change, overharvesting.

2.3 A species with an outsized role whose loss greatly affects the whole community.

3.1 **B** — lacks natural predators in the new area.

3.2 (a) The native prey population declines (may collapse). (b) Species that ate the prey lose their food, and species the prey controlled may increase — the change ripples through the food web.

3.3 A keystone species has a large effect on many others (e.g. controlling prey numbers); removing it lets some populations explode and others crash, disrupting the whole community.

The following information applies to all parts.

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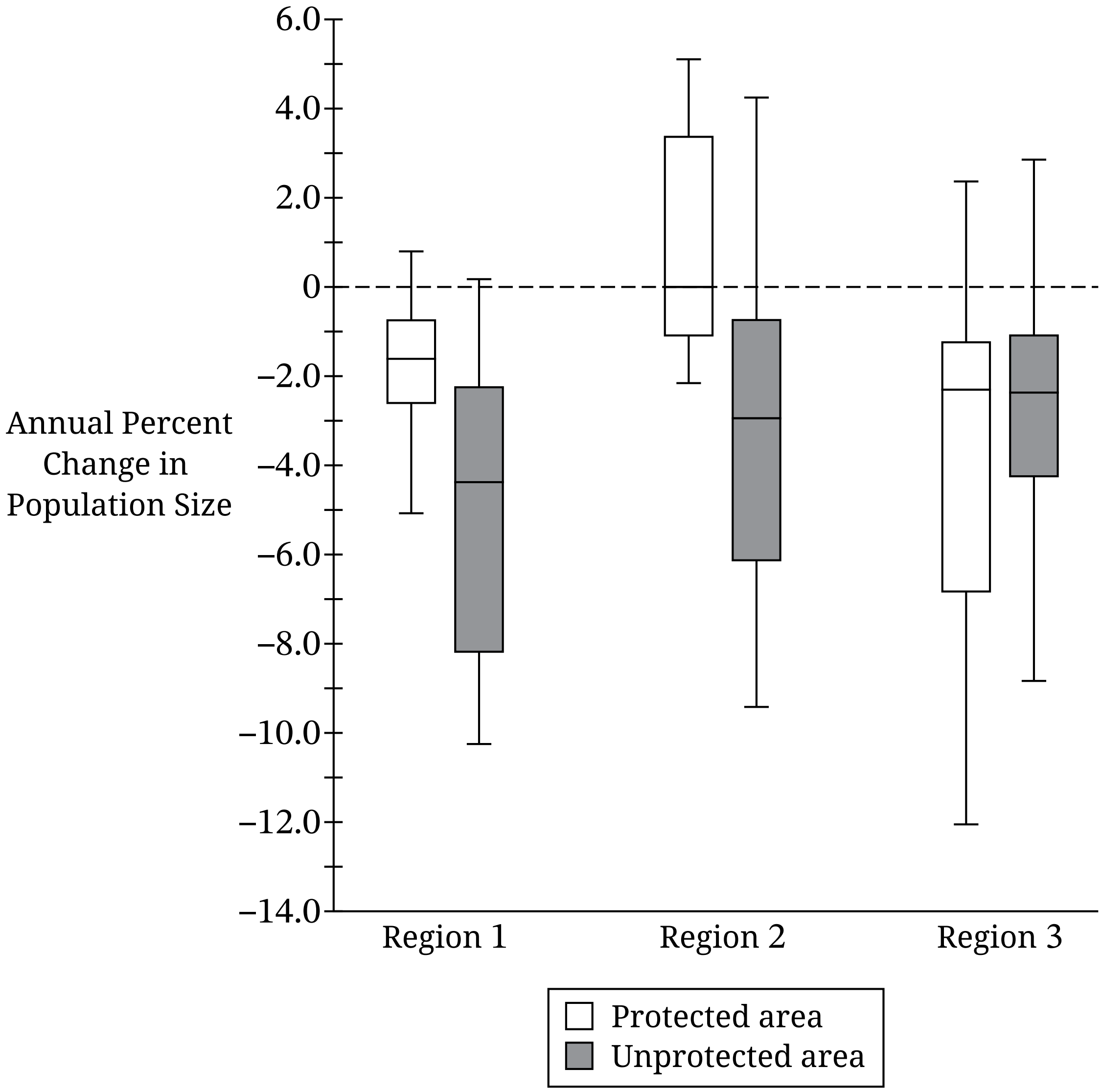
6. Many raptors in Africa are top predators and keystone species in their ecosystems. Raptor population sizes have been declining in recent years.

Scientists studied the relationship between the conversion of the raptors' natural habitat into farmland and the population sizes of raptors in those regions. They compiled raptor population size data from three different regions of Africa: Region 1, Region 2, and Region 3. In each of the regions, the scientists compared the annual percent change in the raptor population size in areas that were protected from farming (protected) with the annual percent change in areas where farming occurred (unprotected). Their results are shown in the box and whisker plot.

type of bird

Median Annual Percent Change in the Population Size of Raptors in Protected and Unprotected Areas



Part A

Based on the box and whisker plot, **identify** the median annual percent change in population size in the unprotected area of Region 2.

Part B

Based on the box and whisker plot, **identify** the region and area that experienced the greatest median annual percent change in population size.

Part C

Researchers hypothesize that if farming is eliminated in Region 2, there will no longer be a decline in the raptor population size. Based on the data in the box and whisker plot, **evaluate** the researchers' hypothesis.

Part D

Based on the information provided, **explain** why ecosystem resilience in unprotected areas may decline over time.

STOP

END OF EXAM

3. Buffelgrass, an invasive grass species in southwestern desert ecosystems, is threatening the saguaro cactus, a keystone species in these ecosystems. Buffelgrass is drought-tolerant and can survive wildfires. However, the dry buffelgrass also acts as fuel for wildfires, causing the fires to be more severe. Older saguaro cacti can survive wildfires; however, many of the young cacti cannot.

Scientists conducted an experiment to determine whether they could control the abundance of the buffelgrass population. The scientists identified several native grass species that, when grown with buffelgrass, might reduce the abundance of buffelgrass. They grew buffelgrass in the presence of several different native grass species in greenhouses, in either nondrought (watered every 3 days) or drought (watered every 9 days) conditions. After twelve weeks, they measured the height and dry weight of the buffelgrass in each treatment group.

A. **Describe** the effect that removing a keystone species will have on an ecosystem.

B. **Identify** a control group the scientists should include in their experiment.

C. **State** the null hypothesis of the experiment in which buffelgrass is grown in the presence of native grass species.

D. Scientists have found that the population growth rates of native grasses are much slower than the population growth rate of buffelgrass following a wildfire. The scientists claim that wildfires will therefore increase the abundance of buffelgrass plants in the ecosystem. Based on the information given, **justify** the scientists' claim.

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

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

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

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

   (d) **Justify** your prediction in part (c).

Write your responses to this question only on the designated pages in the separate Free Response booklet.

If there are multiple parts to this question, write the part letter with your response.

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.

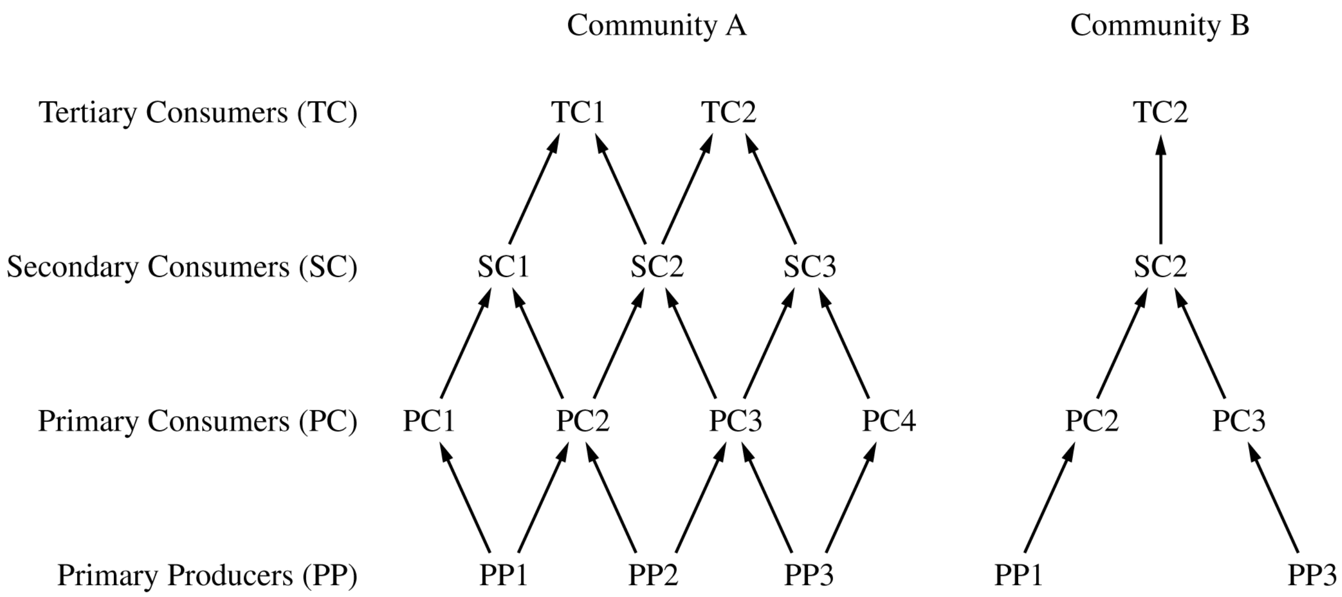


Figure 1. Models of two different communities with some of the same species

(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.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

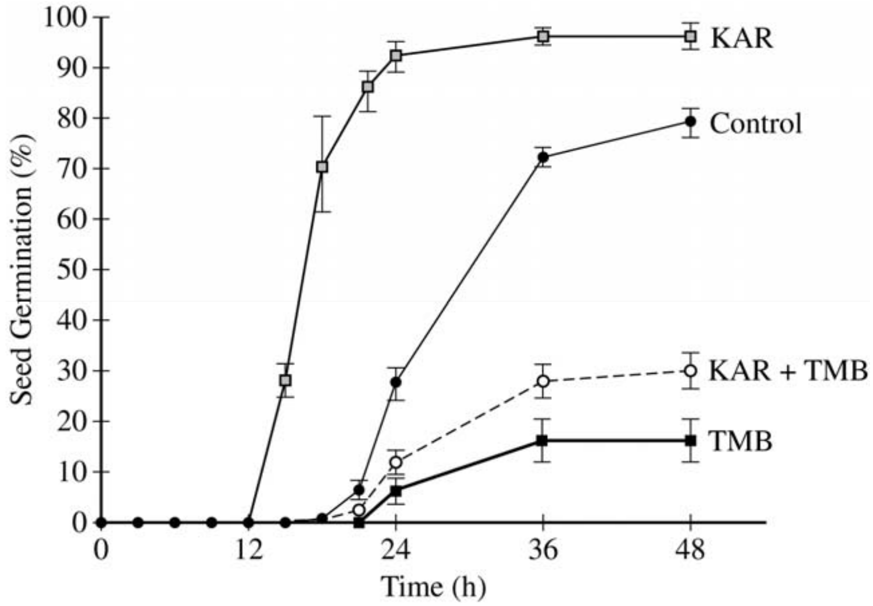


Figure 1. The effect of karrikins (KAR) and trimethylbutenolides (TMB) on seed germination in *Lactuca* plants. Error bars represent $\pm 2SE_{\bar{X}}$.

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.

   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.

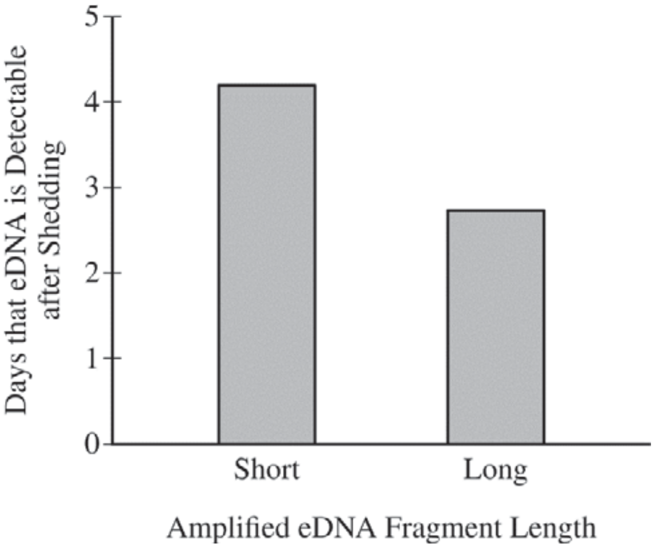


Figure 1. Detectability of eDNA fragments of varying lengths

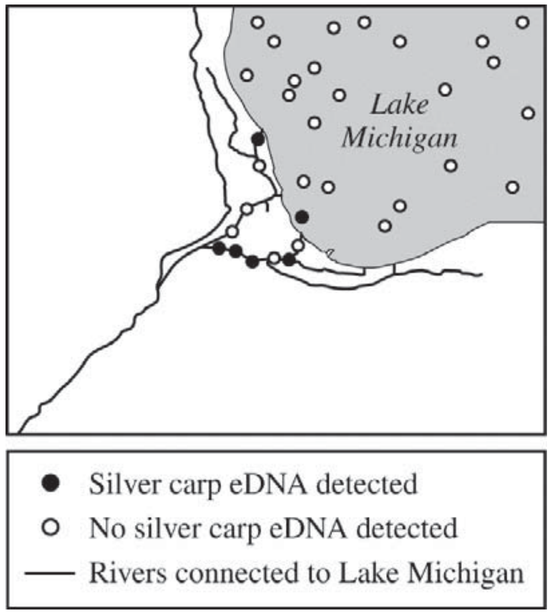


Figure 2. Map of the waterways that connect a nearby river system to Lake Michigan

6. Living and dead organisms continuously shed DNA fragments, known as eDNA, into the environment. To detect eDNA fragments in the environment, the polymerase chain reaction (PCR) can be used to amplify specific eDNA fragments. eDNA fragments of different lengths persist in the environment for varying amounts of time before becoming undetectable (Figure 1).

   To investigate whether silver carp, an invasive fish, have moved from a nearby river system into Lake Michigan, researchers tested water samples for the presence of eDNA specific to silver carp (Figure 2).

   (a) **Justify** the use of eDNA sampling as an appropriate technique for detecting the presence of silver carp in an environment where many different species of fish are found. **Propose** ONE advantage of identifying long eDNA fragments as opposed to short fragments for detecting silver carp.

   (b) The researchers tested a large number of water samples from Lake Michigan and found eDNA specific to silver carp in a single sample in the lake, as indicated in Figure 2. The researchers concluded that the single positive sample was a false positive and that no silver carp had entered Lake Michigan. **Provide reasoning** other than human error to support the researchers' claim.

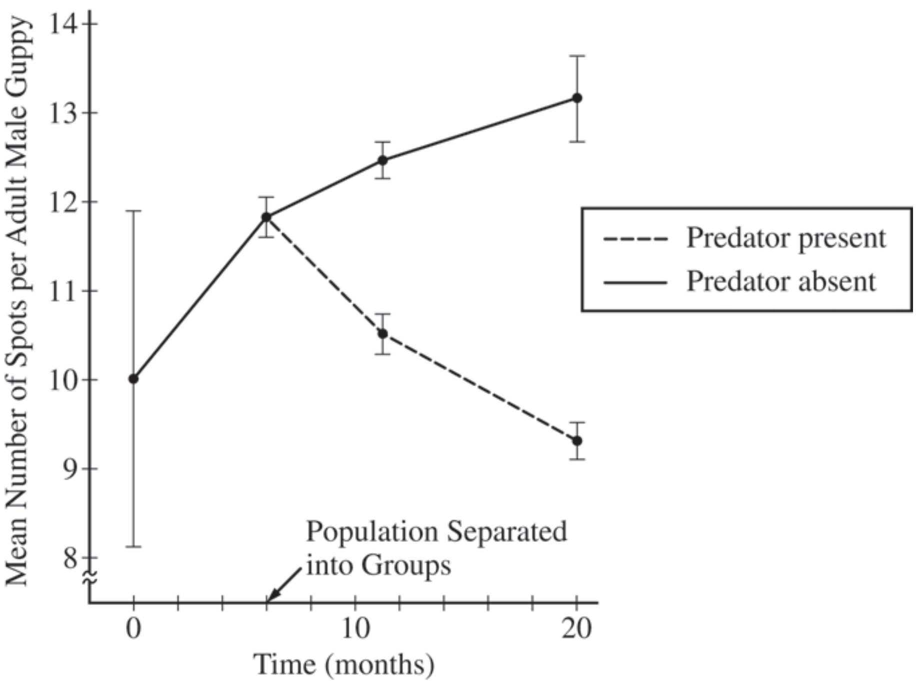
3. As part of a new suburban development, a sports complex consisting of athletic fields and buildings is constructed in a formerly wooded area.

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

   (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.

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

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



   (a) **Describe** the change in genetic variation in the population between 0 and 6 months and **provide** reasoning for your description based on the means and SEM.

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

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

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