ENVIRONMENTAL SCIENCE

SECTION I

Time—1 hour and 30 minutes

80 Questions

Part A

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1 - 4 refer to the following.

(A) Carrying capacity
(B) Total fertility rate
(C) Demographic transition model
(D) Density-independent factor

1. This can be used to illustrate the changes in birth and death rates as economic development occurs in a country.

2. This is the total number of individuals in a population that can be sustained in a given habitat.

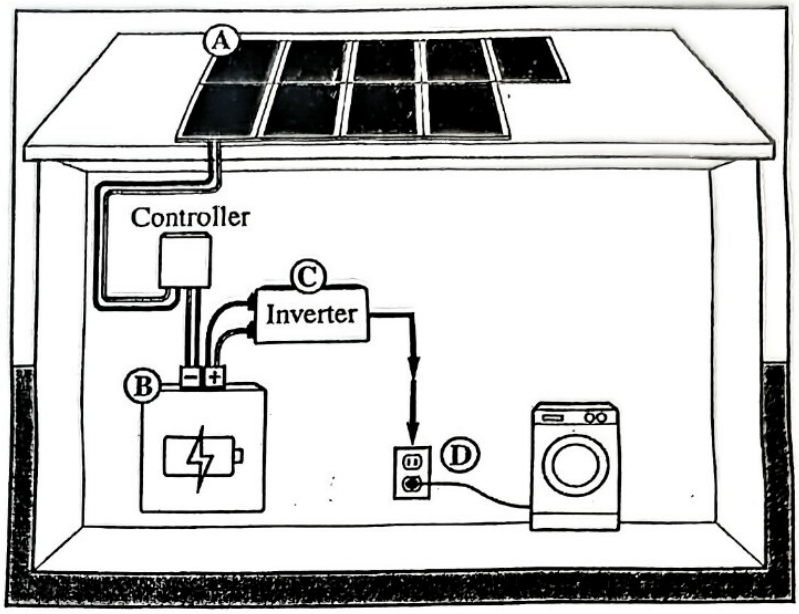
3. When this is at replacement levels, the population size will be relatively stable.

4. If a population exceeds this, the ecosystem may become unsuitable for the species to survive, since the resources in the area may become very depleted.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 5 - 7 refer to the following diagram.



The diagram shows the process of converting solar energy into electrical energy using a photovoltaic (PV) syster in a home.

5. This part of the diagram converts solar energy to electricity.

6. This part of the diagram converts direct current (DC), which comes from a storage battery, into alternating current (AC) that can be used for home appliances.

7. This part of the diagram would allow for the us of electricity on cloudy days or at night.

Unauthorized copying or reuse of

GO ON TO THE NEXT PAGE.

Questions 8 - 10 refer to the following legislation.

(A) Clean Air Act
(B) Kyoto Protocol
(C) Endangered Species Act
(D) Montreal Protocol

8. This global agreement was finalized in 1987 to protect the stratospheric ozone layer by phasing out the production and consumption of substances such as CFCs that deplete the ozone layer.

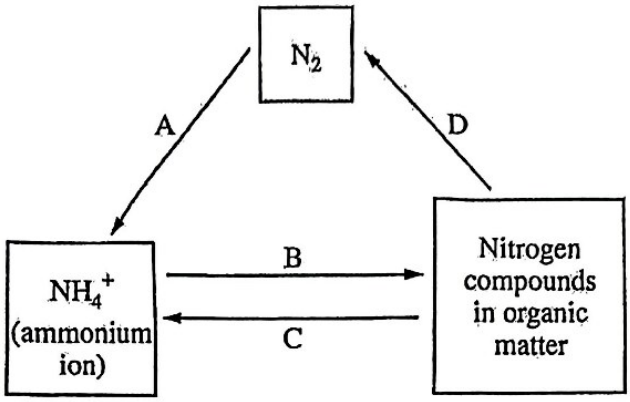
9. This law includes the protection of essential habitats and prohibits the import and export of various plants and animals in the United States.

10. This law led to the development of extensive federal and state regulations to limit emissions from stationary and mobile sources in the United States.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 11 and 12 refer to the following diagram of a simplified nitrogen cycle.



11. Which arrow in the diagram represents the process of nitrogen fixation?

12. Which arrow in the diagram represents the process that converts and transfers nitrogen in its major reservoir?

Part B

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

13. Which of the following is most responsible for reducing the amount of UV-B radiation that reaches Earth's surface by absorbing energy from the Sun?

    (A) VOCs
    (B) CFCs
    (C) NO_x
    (D) O_3

14. Which of the following ranks the biomes from greatest biodiversity to least biodiversity?

    (A) Tundra, temperate forest, grassland, tropical rainforest
    (B) Tropical rainforest, temperate forest, grassland, tundra
    (C) Grassland, temperate forest, tropical rainforest, tundra
    (D) Tropical rainforest, temperate forest, tundra, grassland

15. Which of the following is most likely to explain flash flooding in urban streams?

    (A) Increased infiltration of stormwater
    (B) Plastic trash trapped in vegetation
    (C) Large areas of impervious surfaces
    (D) Oil and gasoline runoff from city streets

16. Which of the following is the greatest disadvantage of generating energy with wind turbines?

    (A) Energy is lost when the wind forces the rotors to move.
    (B) Less energy is generated when the Sun is obscured by clouds.
    (C) Energy cannot be generated when the wind does not blow.
    (D) Rain deforms the shape of the rotors and reduces energy generation efficiency.

17. Invasive cactus moths live and lay their eggs on native prickly pear cacti, a keystone species found across Texas and Mexico. After hatching, the larvae bore into the cactus to feed and be protected from predators. The larvae kill the plant and leave only the outer layer of the cactus. Since the moths have a 90-day life cycle, a moth infestation can result in quick destruction of all prickly pear cacti in the area. Once cactus moths have infested an area, they are almost impossible to control.

    Based on the information provided, which of the following adaptations has most likely contributed to making the control of the cactus moths almost impossible once an area is infested?

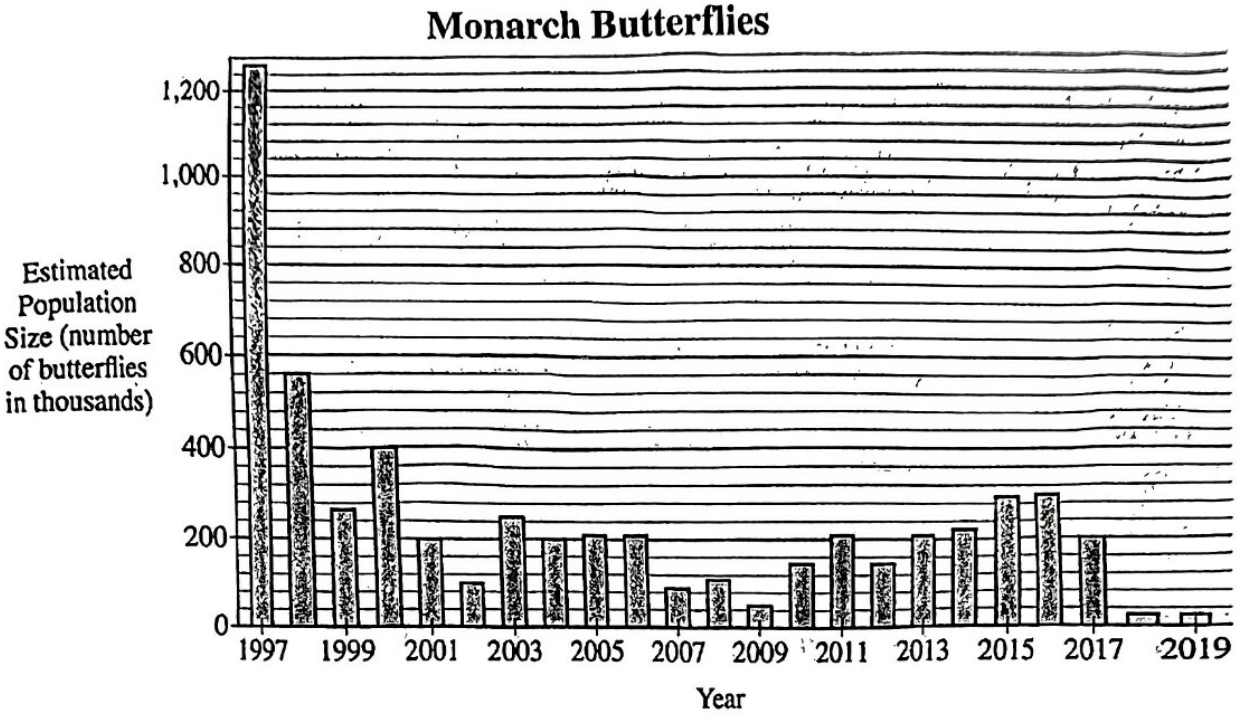
    (A) Flying adult moths can travel long distances.
    (B) Larvae feed on the inside of the prickly pear cacti.
    (C) Larvae are resistant to most pesticides.
    (D) Insects are dormant during the winter.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 18 - 21 refer to the following article.

Slim Hope for Monarch Butterflies — Population Holds Steady This Season



The feared fatal decline of western monarch butterflies in California paused . . . this winter, when almost the exact same number as last year showed up along the coast, giving biologists . . . hope that the colorful insects can be saved.

Only 29,418 clustering monarchs were counted in the trees along the coast around the fall of 2019, when the winter population was believed to be at its peak. That's 2,000 more than during the winter of 2018–19, but volunteers surveyed more sites that year, so the numbers are considered statistically identical. . . .

Western monarchs spend the winter in more than 300 forested groves of eucalyptus, cypress and pine trees along the California coast. The California butterflies cluster together in trees from November to March, . . . before they head back north to the Pacific Northwest and Canada for the summer, mating as they go.

. . . The California population has been declining at an average of about 7% a year, according to a 2017 study by the U.S. Fish and Wildlife Service. That study calculated the point of no return would likely come when there are fewer than 30,000 butterflies.

The die-off has been blamed on a variety of factors, including urban sprawl, the spraying of pesticides and herbicides on corn and soybean crops, and the plowing under of the monarch's milkweed habitat along their migratory route.

. . . officials are urging governments to adopt plans to protect monarch overwintering sites from logging or inappropriate trimming. [It is recommended] that Californians begin growing milkweed and other native plants that produce nectar, especially flowers that bloom in early spring.

Excerpt from article by Peter Fimrite "Slim Hope for Monarch Butterflies—Population Holds Steady This Season," *San Francisco Chronicle*, January 23, 2020.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

18. Based on the graph presented in the article, which of the following is the approximate percent decline in the western monarch population from 1997 to 2019 ?

(A) 32%
(B) 53%
(C) 86%
(D) 98%

19. Based on the article, which of the following reasons does the author use to explain the decline in the western monarch population?

(A) Urban development and agricultural practices
(B) Climate change altering the blooming of the milkweed on the butterflies' migratory pathway
(C) Invasive species of wasps that parasitize the butterfly in its pupal stage
(D) Overharvesting of milkweed for commercial uses

20. Based on the article, which of the following assumptions did the author most likely make about the western monarch butterfly?

(A) They are the main source of food for other insects.
(B) They are a K-strategist species.
(C) They are an invasive species.
(D) They are an indicator species.

21. Based on the article, which of the following strategies did the author claim would help improve survival of western monarch butterflies?

(A) Creating programs to control invasive species that hunt monarchs during breeding season
(B) Protecting areas along the monarchs' migratory route to preserve vital habitat and food sources
(C) Reducing fossil fuel use to lessen the impact of severe weather events on monarchs as they migrate
(D) Beginning captive breeding programs for monarchs at universities in California

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

22. Which of the following changes implemented on a farm would most likely reduce nutrient input to a downstream wetland?

(A) Introducing integrated pest management techniques
(B) Using drip irrigation instead of flood irrigation
(C) Transitioning to growing only annual crops
(D) Switching from growing crops to ranching cattle

23. Noise pollution is most likely to cause which of the following environmental problems for wildlife?

(A) Altered migratory routes because animals avoid areas with high noise levels
(B) Wildlife populations in urban areas that exceed carrying capacity because animals are attracted to human noise
(C) Larger litter sizes as a result of maternal stress caused by increased noise levels
(D) Decreased amounts of vegetation in rural areas caused by increased noise levels

24. Researchers set up an experiment to determine the range of tolerance to air temperature for caterpillars in the sub-Antarctic region.

Which of the following best identifies the dependent variable for the study?

(A) Change in caterpillar coloration
(B) Air temperature
(C) Sub-Antarctic region
(D) Caterpillar survival rate

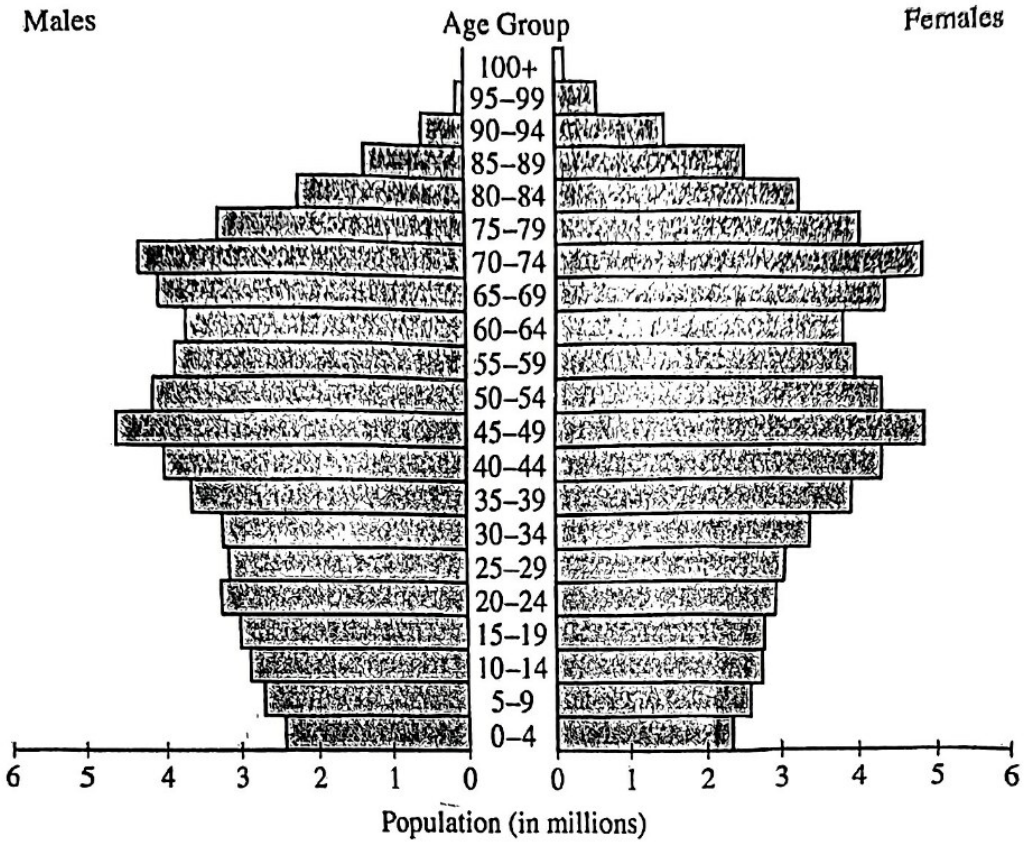
25. The pH of rainfall in a city has been consistently measured to be between 4.2 and 4.4. Based on this information, the city is likely located downwind from which of the following sources of energy?

(A) Nuclear reactor
(B) Wind turbines
(C) Coal-fired power plant
(D) Natural gas-fired power plant

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 26 - 28 refer to the following age structure diagram for Country Z.



26. Based on the age structure diagram, which of the following age ranges makes up the largest portion of the population of Country Z?

(A) Ages 0–19
(B) Ages 20–39
(C) Ages 40–74
(D) Ages 75 and higher

27. Which of the following claims about the total fertility rate in Country Z is best supported by the age structure diagram?

(A) The total fertility rate is likely at replacement-level fertility because the largest age group for females is 45–49.
(B) The total fertility rate is likely below replacement-level fertility because the majority of the population is post-reproductive age.
(C) The total fertility rate is likely above replacement-level fertility because the majority of the population is made up of children under age 18.
(D) The total fertility rate is likely much higher than replacement-level fertility because there is equal distribution of ages for males and females in the population.

Unauthorized copying or reuse of

28. Based on the age structure diagram, which of the following will most likely be a socioeconomic concern for Country Z?

(A) An aging population will require greater investment in retirement homes and healthcare.

(B) A high birth rate will require greater investment in childcare and education.

(C) An influx of young people into the workforce will require greater access to employment opportunities.

(D) An equal distribution of ages between males and females will require greater investment in family planning services.

---

29. Which of the following ecosystem services provides opportunities for recreation, tourism, and aesthetic enjoyment?

(A) Provisioning

(B) Regulating

(C) Cultural

(D) Supporting

Figure A

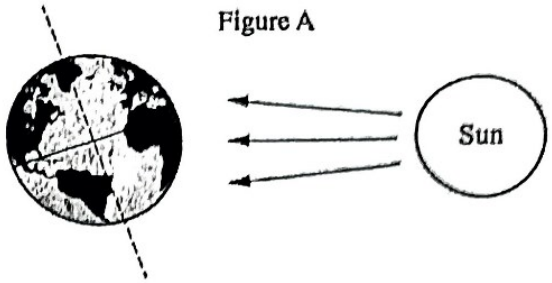
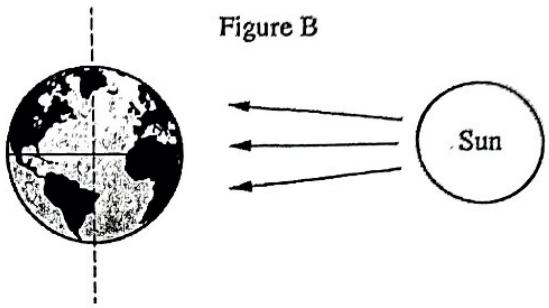


Figure B



30. The Earth is tilted at an angle of 23.5 degrees (Figure A). If the angle of the Earth's axis were changed to zero degrees (Figure B) so that there would be no tilt, then the climate of the middle latitudes would be characterized by

(A) hotter summers and colder winters

(B) no seasonal temperature variations

(C) hotter summers and warmer winters

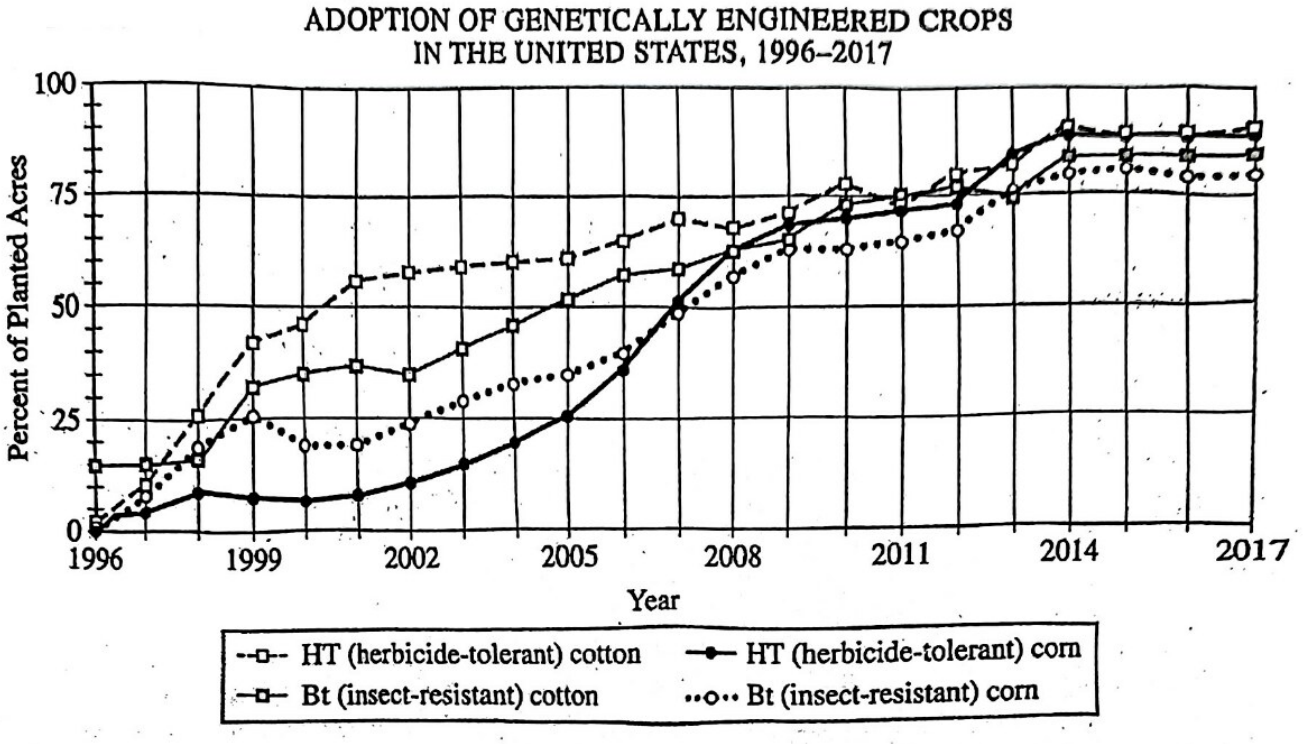
(D) cooler summers and warmer winters

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 31 - 34 refer to the graph below.

The graph below shows the adoption of genetically modified corn and cotton varieties from 1996 to 2017.



31. What was the approximate percent change in planted acres of HT corn from 2005 to 2007 ?

(A) 25%
(B) 50%
(C) 75%
(D) 100%

32. During which of the following years did the percent of planted acres of HT corn exceed the percent of planted acres of Bt cotton?

(A) 1999
(B) 2005
(C) 2010
(D) 2013

33. During which of the following time periods did the percent of planted acres of Bt corn increase at the greatest rate?

(A) 2000–2001
(B) 2006–2007
(C) 2011–2012
(D) 2016–2017

34. Which of the following best describes an advantage of using genetically modified crops, such as the corn and cotton shown in the graph?

(A) The use of genetically modified crops, such as HT cotton, has led to a decrease in herbicide use over time.
(B) The introduction of genetically modified crops increases genetic diversity in most agricultural applications.
(C) Some genetically modified crops, such as Bt corn, are modified to produce proteins that are toxic to insects.
(D) Genetically modified corn varieties have greatly decreased the reliance on fossil fuels in commercial agriculture.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

MAJOR THREATS TO ENDANGERED AMPHIBIANS AROUND THE WORLD

Threat	Threat Level	Approximate Number of Endangered Amphibian Species Affected by Threat
Habitat loss	1	1, 800
Pollution	2	500
Disease	3	400
Fires	4	300
Introduced species	5	100
Other (including natural disasters, road mortality, and unknown threats)	6	Less than 100

35. Based on the table above, which of the following strategies would best reduce the threat to the greatest number of endangered amphibian species?

(A) Paying people who live in amphibian-habitat areas to not develop their land
(B) Encouraging slash-and-burn agricultural practices to decrease the import of expensive organic fertilizers
(C) Repealing laws that require industries to report the release of pollutants in known amphibian-habitat areas
(D) Reimbursing the tuition of veterinary students who agree to open clinics specializing in amphibian diseases

36. Which of the following best exemplifies an indicator species in an ecosystem?

(A) A beaver that constructs a dam that leads to the creation of a new freshwater pond environment
(B) A moss that is the first species to grow on a newly emerged volcanic island
(C) A mouse species that cannot live in a forest ecosystem where there is competition for food
(D) A freshwater invertebrate population that declines when dissolved oxygen in a stream is reduced by urbanization

37. Which of the following describes an advantage to humans that results from catching and consuming fish that occupy lower rather than higher trophic levels?

(A) Fishers can harvest more algae and increase the price for consumers.
(B) Lower trophic levels contain lower concentrations of bioaccumulated toxins, which decreases human exposure to pollutants.
(C) Persistent organic pollutants are not found in lower trophic levels because they degrade rapidly.
(D) A positive feedback loop is more likely to occur when fish at the lowest trophic levels are harvested, which increases the biomass in the food web.

38. Which of the following best explains why a population can experience a dieback when it overshoots the carrying capacity of its environment?

(A) Once the population exceeds the carrying capacity, the population is able to grow exponentially because the environment provides an unlimited number of resources.

(B) Once the population exceeds the carrying capacity, the population crashes because of the effects of density-dependent factors, such as lack of resources or disease.

(C) Once the carrying capacity is reached, the population decreases slowly because of a sudden increase in predators.

(D) Once the carrying capacity is reached, the population increases because of the effects of density-independent factors, such as drought and intense wildfires.

39. A mining company wants to open an anthracite mine and plans to dispose of tailings in a nearby lake. Which of the following describes a likely environmental consequence of the company's plan?

(A) The lake could become contaminated with heavy metals that could leach from the tailings.

(B) The high levels of radioactive products in the tailings could leach out of the lake and contaminate drinking water supplies.

(C) The lake could become hypoxic following an algal bloom caused by the nutrients in the tailings.

(D) The pH of the lake sediments could exceed 7.0 because of the chemical reactions between the tailings and local air pollutants.

40. Which of the following would most likely lead to a depletion of stratospheric ozone?

(A) Increased burning of fossil fuels

(B) Use of chlorofluorocarbon propellants

(C) Release of methane from melting ice caps

(D) Decreased use of sewage lagoons

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 41 - 44 refer to the following data table.

Coastal Wetlands Loss in the United States

Coastal Wetland Type	Acres Lost	Reason for Loss
Freshwater	10,000	Conversion to intertidal wetland
	50,000	Loss of shoreline
	100,000	Urban development
	180,000	Tree farming
Saltwater	3,000	Urban development
	101,000	Rise in sea level

41. Based on the data in the table, which of the following reasons is the cause for the most acres of freshwater wetlands lost?

(A) Conversion to intertidal wetland
(B) Loss of shoreline
(C) Urban development
(D) Tree farming

42. Based on the data in the table, which of the following conclusions can be drawn about wetland loss?

(A) Freshwater wetlands have lost a greater percentage of area to rising sea level than saltwater wetlands have.
(B) Freshwater wetlands have lost more total acres than saltwater wetlands have.
(C) Freshwater wetlands have been converted into new habitats, but saltwater wetlands have not.
(D) Both freshwater and saltwater wetlands have lost approximately the same number of acres to urban development.

43. Based on the data in the table, which of the following best explains the change in acres of saltwater wetlands?

(A) The acres of saltwater wetlands are increasing as a result of an increase in flooding from offshore wind farms.
(B) The acres of saltwater wetlands are increasing as urban development declin in coastal communities.
(C) The acres of saltwater wetlands are decreasing as the open ocean is used to generate tidal power.
(D) The acres of saltwater wetlands are decreasing as sea level rise is submergin wetland habitat.

Unauthorized copying or reuse of

44. There are approximately 40 million acres of wetlands in the United States. Which of following methods should be used to calculate the percent of wetlands lost to urban development?

(A) $\frac{(100{,}000 \text{ acres} + 3{,}000 \text{ acres})}{100{,}000 \text{ acres}} \times 100$

(B) $\frac{(100{,}000 \text{ acres} + 3{,}000 \text{ acres})}{40 \text{ million acres}} \times 100$

(C) $\frac{3{,}000 \text{ acres}}{100{,}000 \text{ acres}} \times 100$

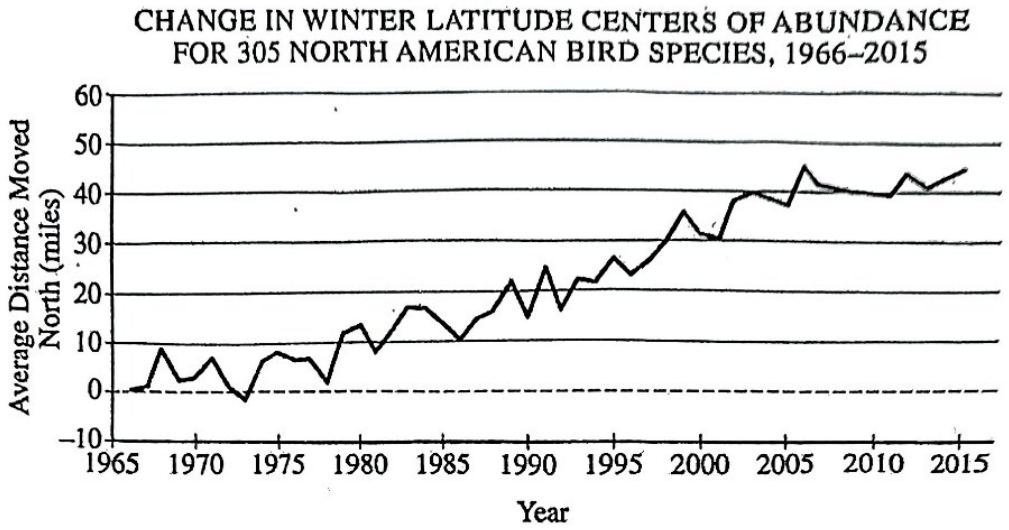
(D) $\frac{40 \text{ million acres}}{(100{,}000 \text{ acres} - 3{,}000 \text{ acres})} \times 100$

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

45. The graph below shows the change in the winter ranges of 305 bird species in North America from 1966 to 2015.

Which of the following best identifies a hypothesis for the investigation that resulted in the collection of the data in the graph shown?



(A) The rate of bird deaths will increase if there is an increase in habitat loss from human activity.

(B) The number of bird species that migrate in the winter has been increasing over time as a result of increased numbers of potential mates in the south.

(C) When resources are limited during the winter months, specialist species are more likely to colonize new island habitats.

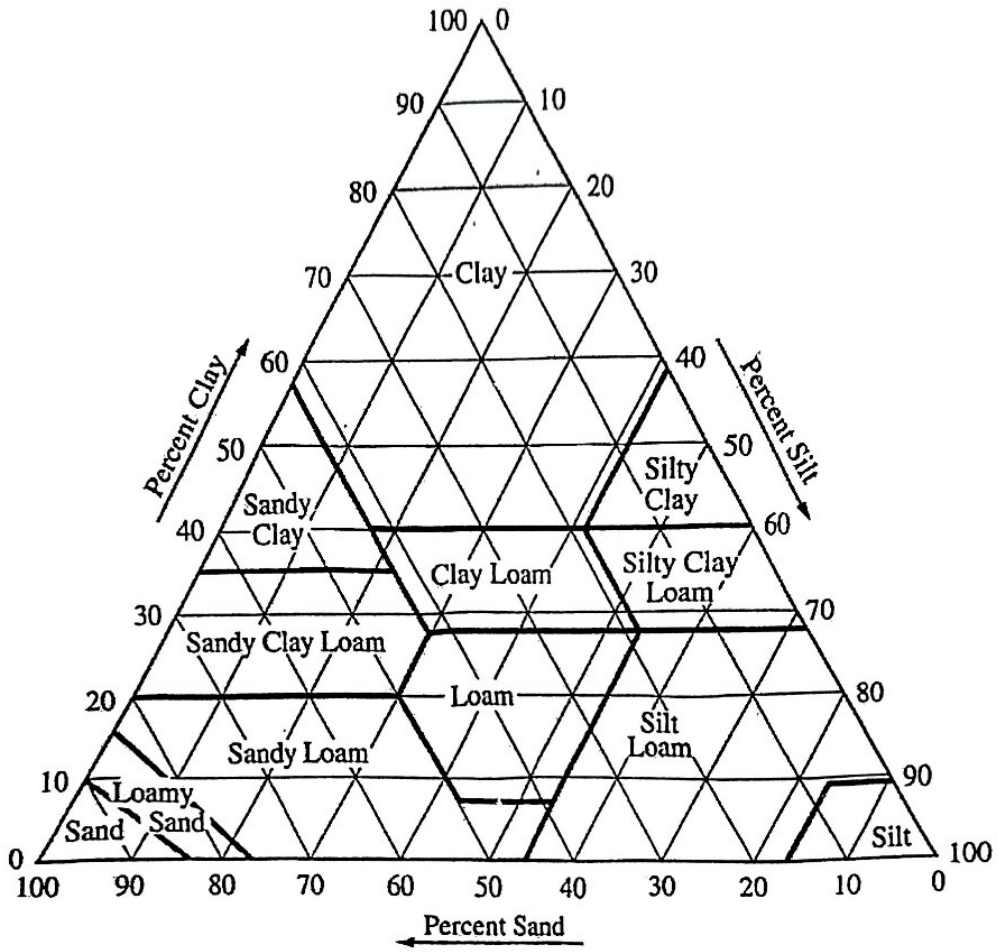
(D) Birds will spend the winter farther north because of increased temperatures in higher latitudes that result from global climate change.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 46 - 48 are based on the soil triangle and the table of soil properties below.

SOIL TEXTURE TRIANGLE



Unauthorized copying or reuse of any part of this page is illegal

Soil Components	Relative Water Intake Rate	Relative Water Retention	Drainage	Susceptibility to Water Erosion
Sand	Very high	Very low	High	Low
Loamy Sand	High	Low	Moderately high	Low
Sandy Loam	Moderately high	Moderately low	Moderately high	Low
Loam	Medium	Moderately high	Medium	Medium
Silt Loam	Medium	Moderately high	Medium	High
Silt	Medium	Moderately high	Medium	High
Clay Loam	Moderately low	High	Slow to medium	Medium to high
Sandy Clay Loam	Moderately low	High	Slow to medium	High
Silty Clay Loam	Moderately low	High	Slow	Low to medium
Sandy Clay	Low	High	Slow	Low to medium
Silty Clay	Low	High	Slow to very slow	Severe
Clay	Low	High	Very slow	Low if aggregated, otherwise high

46. Students measured the composition of the different sediments in a sample of soil. The sample had 35% clay, 40% sand, and 25% silt. Based on the data above, which of the following best describes the soil properties of the sample?

(A) The soil sample will have a very low water retention rate and a low erosion rate.

(B) The soil sample will have a moderately low water intake rate and a high water retention rate.

(C) The soil sample will have a very high water intake rate and a low erosion rate.

(D) The soil sample will have a moderately high water retention rate and a low erosion rate.

47. Which of the following components would be the best to add to soil with poor drainage to increase relative drainage rates?

(A) Sand

(B) Loam

(C) Silt

(D) Clay

48. Which of the following soil types is best for growing citrus crops that require a mixed soil composition and a high drainage rate?

(A) Sand

(B) Sandy Loam

(C) Sandy Clay Loam

(D) Clay

Unauthorized copying or reuse of

GO ON TO THE NEXT PAGE.

49. Kudzu is an edible vine that was introduced to the United States to control erosion and was distributed to farmers and developers to improve and retain soils, particularly on slopes.

Although kudzu is considered invasive, it can have economic advantages. Which of the following best describes an economic advantage to the rapid-growing kudzu in the United States?

(A) Kudzu breaks down quickly, which leads to increased amounts of carbon dioxide released into the atmosphere.

(B) Kudzu can be consumed by grazing animals such as goats or can be harvested for food for poultry and cattle.

(C) Kudzu covers old-growth trees, reducing the rates of photosynthesis in many forests.

(D) Kudzu can survive in arid areas with low nitrogen levels, allowing it to outcompete native species.

50. Photochemical smog forms when

(A) SO_3 reacts with water vapor in the stratosphere

(B) stratospheric ozone absorbs ultraviolet energy

(C) biomass burning emits CO and particulates

(D) volatile organic compounds absorb ultraviolet energy in the troposphere

51. A country has an age structure diagram with a pyramid shape and a large percentage of the population in the prereproductive cohorts.

Based on the age structure of this country, which of the following best describes an environmental problem that may occur in the next 10 years?

(A) The country will have an increasing volume of wastewater and household waste that will require appropriate infrastructure for proper disposal.

(B) The country will have an increasing elderly population that will require increased spending for health and long-term care.

(C) The country will have lower carbon emissions because of a decrease in the stress on the food systems resulting from a shrinking population.

(D) The country will experience a decrease in air pollution because of a decline in economic growth resulting from a smaller workforce.

52. Which of the following is a correct sequence of events to produce electricity in a fossil fuel-burning power plant?

(A) Water is boiled and sent to a generator. The water rotates the generator. The rotation of the generator turns the water into steam, which produces electricity.

(B) Water is turned into steam and sent to a reactor. The steam pushes rods, which rotate a turbine. The rotation of the turbine produces electricity.

(C) Water is turned into steam and sent to a turbine. The steam rotates the turbine. The turbine rotates a generator, which produces electricity.

(D) Water is boiled and sent to an alternator. The water rotates the alternator, which produces electricity.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

Questions 53 - 56 refer to the following article.

Seismic Shockwave Pattern May Be Redirecting Earthquake Damage

New research from The University of Texas at Austin could change the way scientists think about potential damage from earthquakes.

. . . [S]cientists examined data from one of the densest seismic arrays ever deployed and found that earthquakes emit their strongest seismic shockwaves in four opposing directions. The effect, which leaves a pattern resembling a four-leaf clover, has been known for decades but never measured in such vivid detail.

. . . The analysis . . . is based on measurements of two-dozen small earthquakes recorded by the LArge-n Seismic Survey in Oklahoma, an array of 1,829 seismic sensors deployed to monitor a remote corner of the state measuring 15 by 20 miles.

When earthquakes strike, they release a thunderclap of seismic energy at many frequencies, but the actual ground shaking people feel ranges from about 1 hertz to 20 hertz. The study found that low frequency energy — about 1 to 10 hertz — shot from the fault in four directions, but barely registered outside of the four-leaf clover pattern.

That's important, the researchers said, because buildings are more vulnerable to low frequency waves. The four-leaf clover pattern wasn't found in higher frequency waves, which [traveled] at equal strength in all directions, like ripples in a pond.

. . . "What happens when you have an earthquake is that pieces of broken rock inside the fault zone start to move around like pinballs," . . . The jostling pieces redirect the energy randomly, but at lower frequencies, seismic waves simply bypass the rough geologic mess near the fault, [traveling] in a nice four-leaf clover pattern just as physics predicts.

This means that on the surface, a person might feel the same shaking regardless of where he or she stood, but buildings — which are sensitive to low frequency waves — would be affected by the earthquake much more intensely within the lines of the four-leaf clover pattern.

Courtesy: National Science Foundation

Unauthorized copying or reuse of

GO ON TO THE NEXT PAGE.

Which of the following best identifies the author's primary claim in the article?

(A) The newly discovered four-leaf clover pattern made by the seismic waves of earthquakes will help explain why some people in the same building experience a difference in the severity of ground shaking.

(B) The four-leaf clover pattern left behind by earthquakes will help explain the rock movements occurring inside fault zones during an earthquake.

(C) The type of seismic waves that create the four-leaf clover pattern near earthquake sources will help scientists better predict when an earthquake will occur.

(D) Data gathered from studying the four-leaf clover pattern near the source of earthquakes will help determine the most likely locations of potential damage to buildings.

54. Which of the following best describes an assumption the author likely has about the four-leaf clover pattern created by an earthquake?

(A) The pattern created is dictated by the number of seismic waves.

(B) The exact pattern that is created is largely unpredictable.

(C) The size of the clover pattern depends on earthquake magnitude.

(D) The pattern is created by broken pieces of rock inside the fault.

55. Which of the following pieces of evidence best supports the claim that the four-leaf clover pattern is produced by seismic waves of a specific frequency?

(A) Even though earthquakes release seismic waves at many frequencies, the ground shaking that people feel from an earthquake ranges from about 1 to 20 hertz.

(B) Data showed that low-frequency waves, about 1 to 10 hertz, extend from a fault in four directions but do not register outside of the four-leaf clover pattern.

(C) About 1,829 seismic sensors were used in Oklahoma to study the four-leaf clover pattern produced by two dozen small earthquakes.

(D) Data showed that earthquakes release the strongest seismic waves in four opposing directions, about 15 to 20 miles from the fault zone.

56. Which of the following best explains how the four-leaf clover pattern of seismic waves discussed in the article could influence urban development?

(A) City parks would likely need to be built outside the four-leaf clover pattern because the radiation from low-frequency waves affects human DNA.

(B) The layout of city blocks would likely need to resemble a four-leaf clover, rather than a grid, because of the mixing of low- and high-frequency seismic waves near fault zones.

(C) Building urban areas within the four-leaf clover pattern will help avoid structural damage because of the high-frequency waves that extend outside the pattern.

(D) Urban planners would likely have to avoid placing large buildings near fault zones because buildings are sensitive to the low-frequency waves within the four-leaf clover pattern.

Unauthorized copying or reuse of

GO ON TO THE NEXT PAGE.

57. Manatees are large aquatic mammals that require warm waters and large seagrass beds to feed. DNA samples from two different populations of manatee (Amazonian and Antillean) show that there is little mating between populations and that the Antillean population has a higher genetic diversity than the Amazonian population does.

Which of the following conclusions can best be drawn about the two different manatee populations?

(A) The two manatee populations will increase as a result of ocean warming and biomagnification of nutrients in waters near the coast.

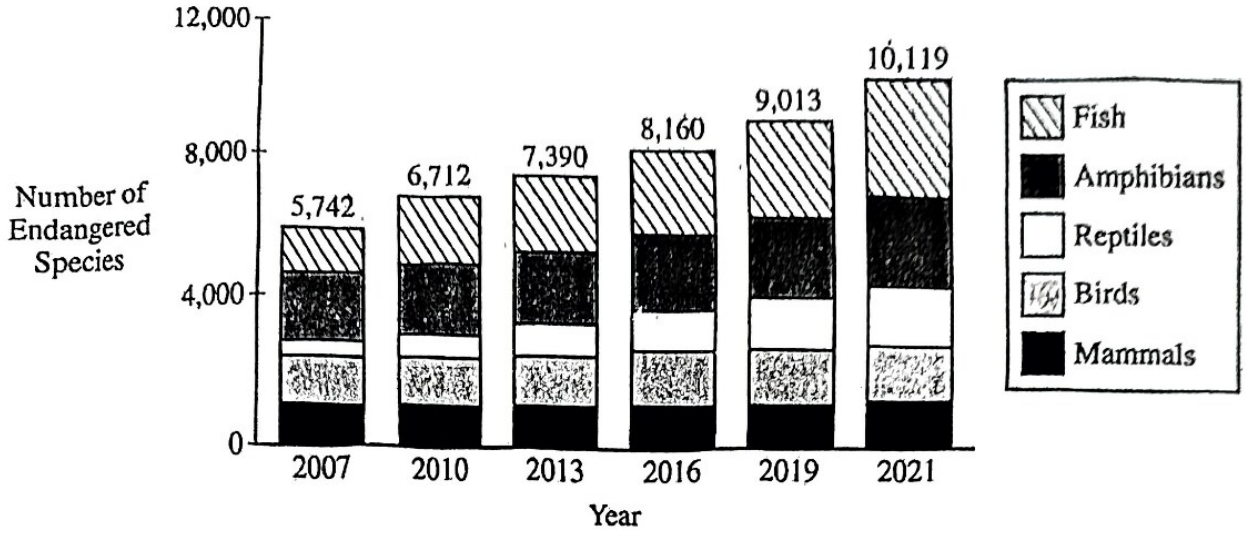
(B) The Antillean population may be better able to respond to the threats from humans because of its genetic diversity.

(C) The Amazonian and Antillean populations can be bred in captive breeding programs to increase the overall population sizes.

(D) Amazonian manatees are considered a specialist species, while Antillean manatees are considered a generalist species.

Questions 58 - 60 refer to the following graph.

Number of Vertebrate Species, by Class, Listed as Endangered



58. Based on the data in the graph, which of the following classes of vertebrates had the greatest number of species listed as endangered in 2021 ?

(A) Fish
(B) Amphibians
(C) Birds
(D) Mammals

59. Which of the following approaches should be used to calculate the percent change in the total number of endangered species listed from 2007 to 2021, based on the data in the graph?

(A) $\frac{5{,}742 \text{ species}}{10{,}119 \text{ species}} \times 100$

(B) $\frac{(10{,}119 \text{ species} - 5{,}742 \text{ species})}{2021 - 2007}$

(C) $\frac{(10{,}119 \text{ species} - 5{,}742 \text{ species})}{5{,}742 \text{ species}} \times 100$

(D) $\frac{10{,}119 \text{ species}}{2021} - \frac{5{,}742 \text{ species}}{2007}$

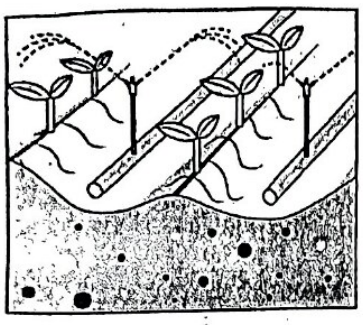
60. Which of the following strategies would most likely slow the trend illustrated in the graph for the number of endangered species from 2007 to 2021 ?

(A) Protect animal habitats and enforce poaching laws.
(B) Build roads to create fragmented habitats and decrease the use of fertilizers in agriculture.
(C) Promote sustainable land-use practices in commercial agriculture, logging, and housing developments.
(D) Use captive breeding practices to create genetically engineered invasive species and predators.

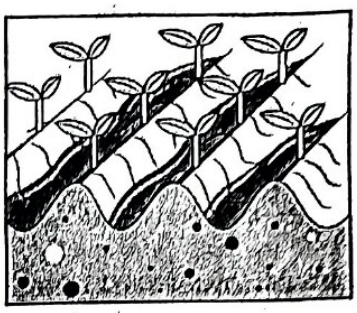
GO ON TO THE NEXT PAGE.

Which of the following diagrams best illustrates traditional furrow irrigation?

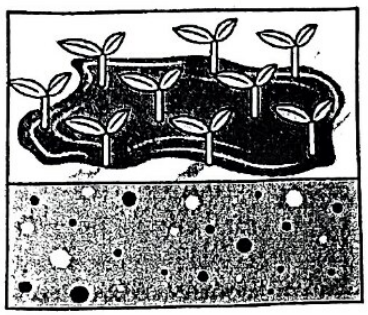
(A)



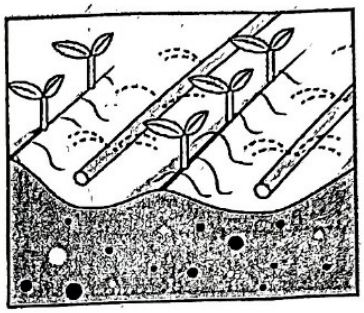
(B)



(C)



(D)



GO ON TO THE NEXT PAGE.

63. Which of the following are all renewable energy sources?

(A) Hydroelectric, solar, geothermal
(B) Oil, natural gas, coal
(C) Nuclear, hydroelectric, natural gas
(D) Biomass, nuclear, solar

Country	Annual Percent Change in Population
Afghanistan	2.4
Brazil	0.8
Indonesia	1.0
Uganda	3.3

64. Based on the annual percent change in the population, which of the population doubling times is correctly matched to the country in the table?

(A) Afghanistan: 70 years
(B) Brazil: 56 years
(C) Indonesia: 29 years
(D) Uganda: 21 years

65. Spearfishing has drastically reduced the number of herbivorous damselfish and parrot fish in a coral-reef ecosystem. Which of the following best describes the most likely effect of spearfishing on the reef ecosystem?

(A) Overgrowth of algae will damage healthy coral and lead to a loss of species diversity.
(B) Damselfish and parrot fish will experience increased reproductive rates to compensate for the loss of competitors.
(C) Carnivorous fish like barracuda will become more abundant in a trophic cascade.
(D) Primary producers will decrease while the number of primary consumers will increase.

Unauthorized copying or reuse of any part of this page is illegal

GO ON TO THE NEXT PAGE.

61. Which of the following describes the most likely negative effect of building a large solar panel farm in a desert?

(A) Solar panels are prone to damage from precipitation, and solar availability is inconsistent in desert regions as a result of cloud cover.

(B) Solar radiation is considered nonrenewable and, therefore, long-term use of solar panels is not sustainable.

(C) Solar energy systems can be expensive, and the farms degrade large tracts of habitat.

(D) Solar panels generate noise and visual pollution and can disrupt bird migration patterns.

GO ON TO THE NEXT PAGE.

Unauthorized copying or reuse of any part of this page is illegal.

Questions 66 and 67 refer to the nuclear incident in Fukushima, Japan.

In 2011 a nuclear incident occurred at the Fukushima Daiichi nuclear power plant in Japan. As a result of the incident, radioactive isotopes, including I-131 and Cs-137, were released and contaminated the surrounding area.

66. Which of the following is the most likely long-term human health effect caused by the release of the radioactive isotopes after a disaster like the one at Fukushima?

(A) Populations in the surrounding area may experience increased cases of thyroid cancer.

(B) Workers exposed to the isotopes may have increased cases of mesothelioma.

(C) There may be increased spread of malaria from increased habitat for infected mosquitoes.

(D) Overall lung function may be negatively affected by elevated levels of tropospheric ozone.

67. Research has shown that radioactive isotopes decay to a safe level after 10 half-lives. I-131 has a half-life of about 8 days, while Cs-137 has a half-life of about 30 years. Based on this information, which of the following equations should be used to calculate the time required for both isotopes to decay to a safe level?

(A) $(30 \text{ years} \times 10) - (8 \text{ days} \times 10)$

(B) $30 \text{ years} \times 10$

(C) $10 \times \frac{30 \text{ years}}{2} \times 10 \times \frac{8 \text{ days}}{2}$

(D) $(8 \text{ days}) \times \left(\frac{1}{2}\right)^{10}$

zed copying or reuse of
f this page is illegal.

GO ON TO THE NEXT PAGE.

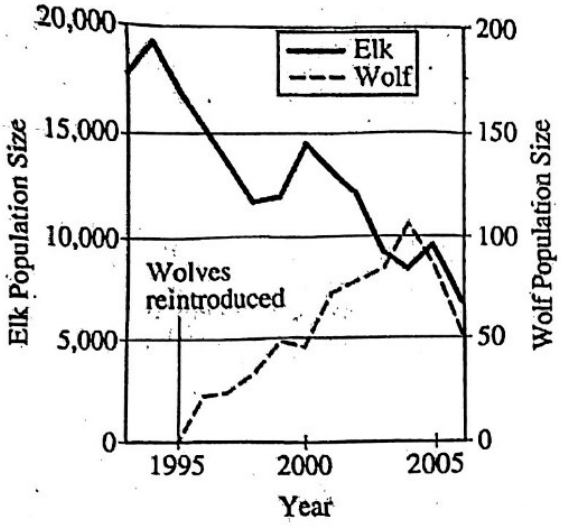


Figure 1. Number of elk and wolves in Yellowstone National Park, 1995–2005

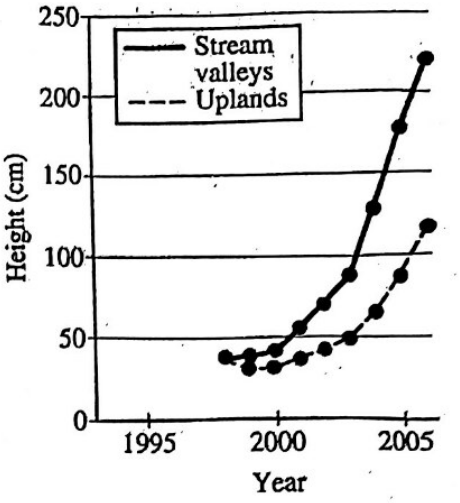


Figure 2. Average height of aspen trees in Yellowstone National Park, 1995–2005

68. Young aspen shoots are an important food source for elk in Yellowstone National Park. Wolves, which are a predator of elk, were reintroduced in the park in 1995. Based on the diagrams above, which outcome is most likely to result from the presence of wolves in Yellowstone National Park?

(A) Elk population numbers will continue to decline as wolf numbers decline.
(B) Aspen height will continue to increase with fewer elk in the park.
(C) Wolf population numbers will begin to rise as elk numbers decline.
(D) Aspen height will continue to increase as wolf numbers decline.

69. Which of the following accurately describes a difference between concentrated animal feeding operations (CAFOs) and free-range farms?

(A) More land is required to raise livestock on CAFOs than on free-range farms.
(B) Meat produced from CAFOs is generally less expensive than meat produced from free-range farms.
(C) Less organic waste is produced from livestock on CAFOs than from livestock on free-range farms.
(D) Livestock raised on CAFOs are typically allowed to graze on grass while those on free-range farms eat corn-based feed.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

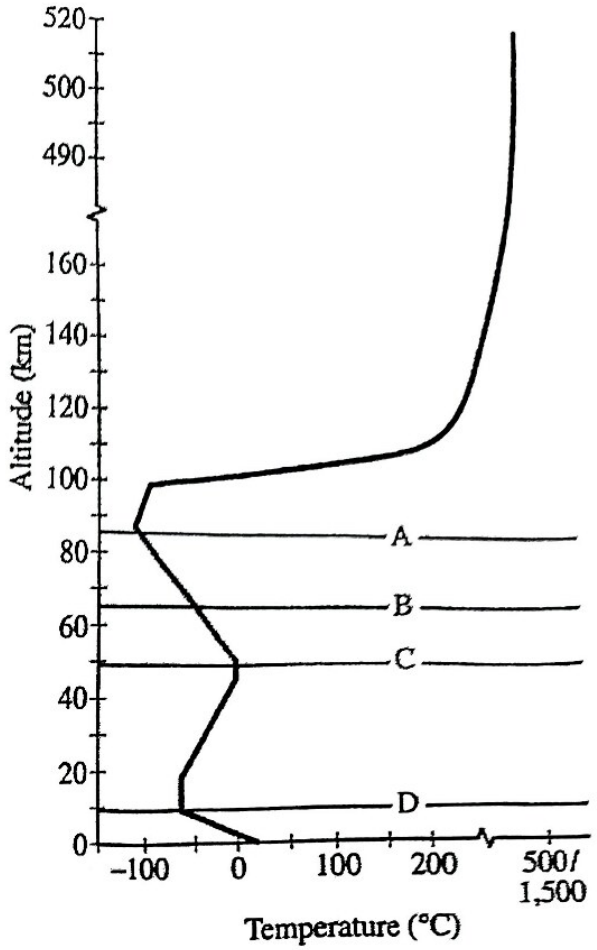
The first human case of West Nile virus in Colorado was in 2002. During the following year, 2,947 cases of West Nile virus were reported in Colorado, primarily in the lower elevations. Colorado's tourism industry is concerned that the number of West Nile virus cases in the future will rapidly increase among runners, hikers, and cyclists who participate in activities at higher elevations. Which of the following is the most likely cause for this concern?

(A) Mosquito habitat will expand to higher elevations because temperatures will increase at higher elevations.

(B) Mosquitoes will have difficulty finding food in lower elevations and will experience increased competition.

(C) Mosquitoes will migrate to higher elevation areas because the areas experience less summer rainfall.

(D) Mosquitoes migrating to Colorado from other areas will cause an increase in the gene pool.



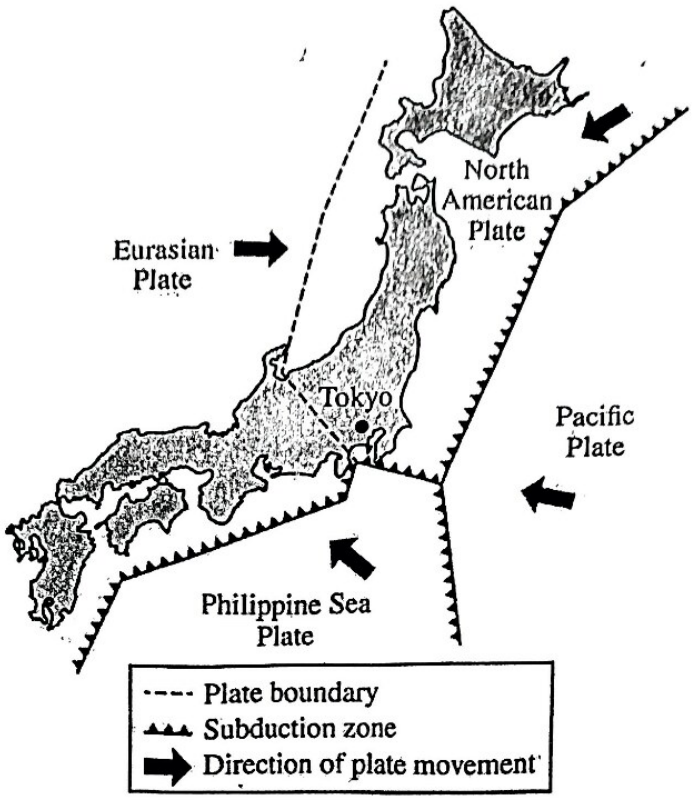
71. Based on properties of the atmosphere, such as density, altitude, and temperature, which line best divides the stratosphere from the mesosphere?

(A) Line A
(B) Line B
(C) Line C
(D) Line D

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

72. The following diagram illustrates the movement of tectonic plates near Japan.



Based on the diagram, which of the following best explains why the city of Tokyo is subject to earthquakes?

(A) Tokyo is located on the island of Japan, which is at the transform plate boundary between the Eurasian Plate and the Pacific Plate.

(B) Tokyo is located near the intersection of different tectonic plates where two of the plates are converging on the other two plates.

(C) Tokyo is located on the island of Japan, which has been created by volcanoes that resulted from a hot spot in Earth's mantle.

(D) Tokyo is at the intersection of divergent plates, which has led to the formation of new mountains.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

73. In 2015 solar generation in the United States provided 25 million MWh of electricity. In 2020 solar generation provided 90 million MWh of electricity. Which of the following is the percent increase in solar generation from 2015 to 2020 ?

(A) 65%
(B) 72%
(C) 150%
(D) 260%

74. A student is investigating the effect of changes in temperature on marine species. The student will use equal volumes of marine algae placed in three identical tanks with the same amount of water and nutrients. Tank 1 will be held at 5°C, Tank 2 will be held at 15°C, and Tank 3 will be held at 25°C. All other conditions in the tanks will be kept the same. Productivity rates of the algae will be estimated for each tank.

Which of the following best describes how a control group could be added to the experiment?

(A) Include a fourth tank held at the optimal metabolic temperature for the species of marine algae in the study.
(B) Identify the temperature at which marine algae no longer produce oxygen and add a fourth tank at that temperature.
(C) Measure the primary productivity over an extended period of time.
(D) Repeat the experiment more than once and compare the results for each experimental trial.

75. In the United States, annual catch limits are often set for commercial fisheries. Which of the following best explains the reason for this practice?

(A) It is attempting to avoid exceeding the maximum sustainable yield for that fish stock and allow for the perpetual use of the resource.
(B) It is attempting to increase the total biomass of the fish stock to offset for the loss of fish that are hunted by natural predators.
(C) It is attempting to decrease the total biomass of the fish stock to avoid overpopulation and increased competition.
(D) It is attempting to preserve the fish-stock and ban the harvest by local and commercial fishing operations.

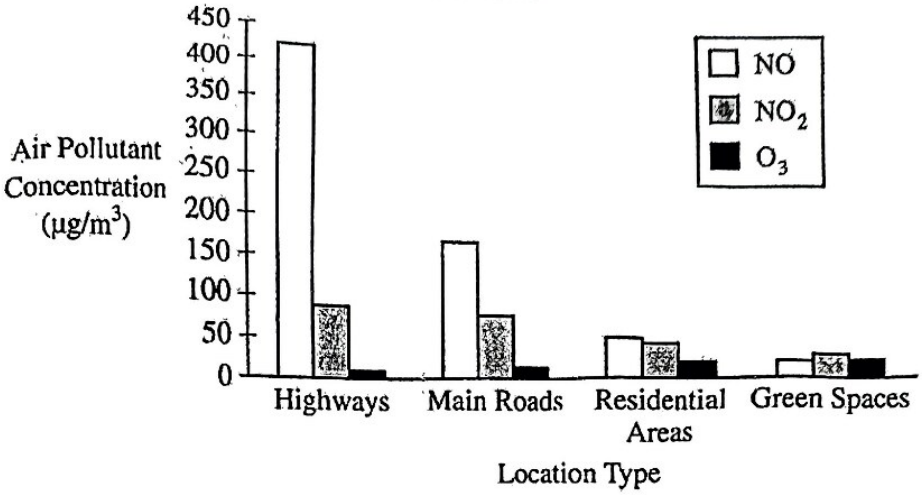
prized copying or reuse of
ft of this page is illegal.

GO ON TO THE NEXT PAGE

Questions 76 - 78 refer to the following graph.

The following graph shows the average monthly concentrations of nitric oxide (NO), nitrogen dioxide (NO_2), an ozone (O_3) at multiple locations in a city.

Average Monthly Concentration of Several Air Pollutants in Various Locations



76. Based on the data in the graph, which location type has the highest concentration of NO within the city?

(A) Highways
(B) Main roads
(C) Residential areas
(D) Green spaces

77. Based on the data in the graph, which of the following best describes how O_3 concentrations differ between locations within the city?

(A) O_3 concentrations increase during the winter months in residential areas.
(B) O_3 concentrations decrease near areas with more vegetation.
(C) O_3 concentrations are highest on highways and main roads.
(D) O_3 concentrations are higher in areas with less traffic.

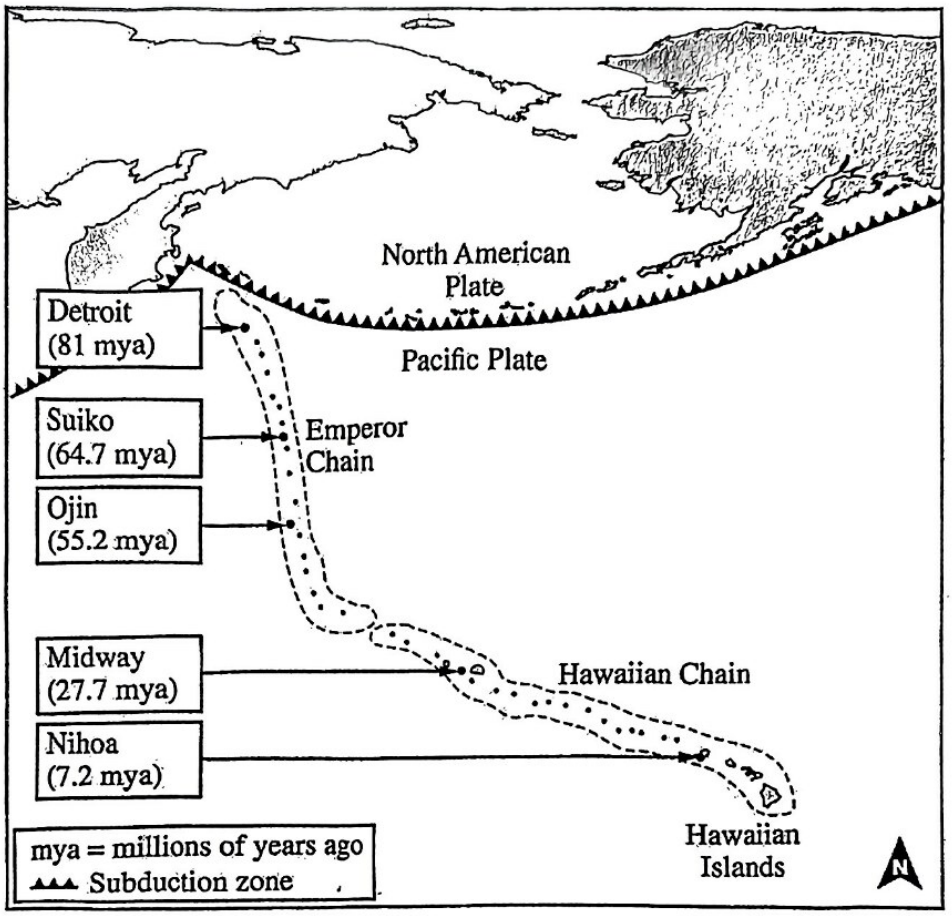
78. Based on the data in the graph, which of the following strategies would most likely lead to a decline in the NO_2 levels in the city?

(A) Installing scrubbers on smokestacks
(B) Removing green spaces throughout the city
(C) Increasing the number of highways within the city
(D) Requiring all vehicles within the city to have catalytic converters

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE.

19. The map shows part of the northern Pacific Ocean, with the location and geologic age of 5 rock samples in millions of years.



Which of the following best explains the pattern of the ages from the island of Nihoa (one of the Hawaiian Islands) to the Detroit seamount (an underwater mountain) shown in the diagram?

(A) A stationary hot spot active for over 80 million years is located beneath the Pacific Plate.

(B) The Pacific Plate has been diverging from the North American Plate for 27.7 million years.

(C) The North American Plate subducted under the Pacific Plate 7.2 million years ago.

(D) The transform fault between the North American and Pacific plates was active during the formation of the Emperor Chain.

GO ON TO THE NEXT PAGE

80. Mosquito fish are small freshwater fish that have become invasive in several areas around the world, consuming the eggs of native fish and amphibians, such as frogs. Bass and other large fish prey on the mosquito fish.

Scientists in Australia introduced a large robotic bass to areas with invasive mosquito fish. The presence of the robotic bass resulted in weight loss, reduced fertility, and reduced feeding for the invasive mosquito fish.

Which of the following best explains an advantage of using a robotic bass to limit the success of an invasive species?

(A) Even though the robotic bass mimics a predator, it could not become invasive itself because it is not living.

(B) The robotic bass may allow the mosquito fish to outcompete native fish for tadpole eggs, reducing frog populations.

(C) The mosquito fish population may increase because the robotic bass caused reduced fertility.

(D) The robotic bass may cause the mosquito fish to become increasingly aggressive and consume more amphibian eggs.

Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION.

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

MAKE SURE YOU HAVE DONE THE FOLLOWING:

- PLACED YOUR AP ID LABEL ON YOUR ANSWER SHEET
- WRITTEN AND GRIDDED YOUR AP ID CORRECTLY ON YOUR ANSWER SHEET
- TAKEN THE AP EXAM LABEL FROM THE FRONT OF THIS BOOKLET AND PLACED IT ON YOUR ANSWER SHEET