ENVIRONMENTAL SCIENCE

Section I

Time—1 hour and 30 minutes

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 oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-3 refer to the following elements.

(A) Carbon
(B) Sodium
(C) Sulfur
(D) Phosphorus
(E) Potassium

1. Marine sediments that form limestone are a major sink for this element.

2. Guano from fish-eating birds is a commercial source of this element.

3. This element in pyrite contributes to acid mine drainage.

Questions 4-6 refer to the following list of United States and international environmental regulations and treaties.

(A) Endangered Species Act
(B) Kyoto Protocol
(C) Montreal Protocol
(D) National Environmental Policy Act
(E) Wilderness Act

4. Requires the federal government to produce an environmental impact statement for any construction project funded by the government

5. Contains an amendment that allows private landowners to modify their property under a habitat conservation plan

6. Addressed the issue of stratospheric ozone depletion

Questions 7-9 refer to the following sources of energy.

(A) Photovoltaics
(B) Geothermal
(C) Biomass
(D) Hydroelectric
(E) Hydrogen fuel

7. Drawbacks include noise and the release of corrosive chemicals

8. More commonly used in the least developed countries than in highly developed countries

9. Converts solar energy directly into electrical energy

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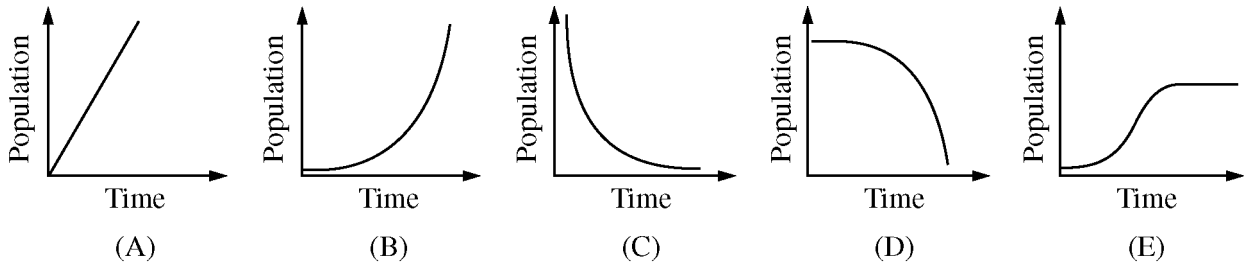
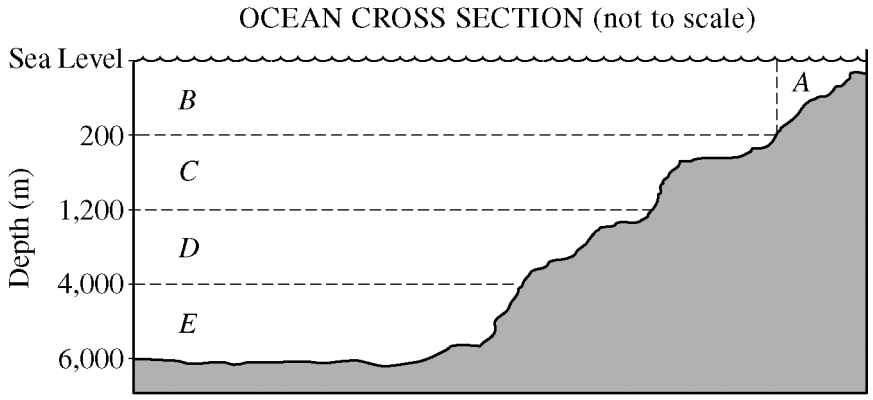
Questions 10-11 refer to the five graphs shown below, which illustrate different relationships between population and time.



10. Which graph best illustrates a population growing at its biotic potential?

11. Which graph best illustrates a population that was growing and has reached its carrying capacity?

Questions 12-14 refer to the figure below, which shows five different marine zones.



12. The zone that has the greatest biodiversity

13. The zone in which species are adapted to the lowest light and the highest pressure

14. The zone in which the greatest total mass of CO_2 is absorbed from the atmosphere

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Part B

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

15. All of the following are likely consequences of indoor air pollution EXCEPT an increase in

    (A) the development and exacerbation of asthma
    (B) the risk of developing lung cancer
    (C) the risk of developing skin cancer
    (D) flulike symptoms, chronic fatigue, and nausea
    (E) respiratory diseases leading to premature death

16. A clock draws 2.0 watts of power to operate and is in operation 8,600 hours per year. The energy usage of the clock, in kWh per year, is closest to

    (A) 4,300
    (B) 1,700
    (C) 430
    (D) 170
    (E) 17

17. For a primary producer, the main function of photosynthesis is to manufacture

    (A) oxygen
    (B) carbon dioxide
    (C) glucose
    (D) proteins
    (E) water

18. Of the following ecosystems, which has the <u>lowest</u> net primary productivity, measured as kilocalories of energy produced per square meter per year?

    (A) Taiga (boreal forest)
    (B) Open ocean
    (C) Temperate grassland
    (D) Estuary
    (E) Agricultural land

19. Which of the following is NOT a property of water?

    (A) Its melting point is 0°C at one atmosphere of pressure.
    (B) Its boiling point is 100°C at one atmosphere of pressure.
    (C) It is used in liquid form by most living organisms.
    (D) It is denser at 4°C than at 20°C.
    (E) It absorbs relatively little heat as it vaporizes.

20. Many environmentalists consider Egypt's Aswan High Dam on the Nile River to be an ecological disaster. Which of the following is the best evidence to support this viewpoint?

    (A) Creation of the dam flooded important archaeological sites.
    (B) Sardine populations near the Nile delta increased exponentially as a result of decreased annual rates of water flow.
    (C) The Aswan High Dam supplies one-third of the electrical power used in Egypt.
    (D) Some countries upstream from the dam have diverted Nile River water for their own projects.
    (E) Most of the nutrient-rich silt that the Nile annually deposited downstream is now deposited behind the dam.

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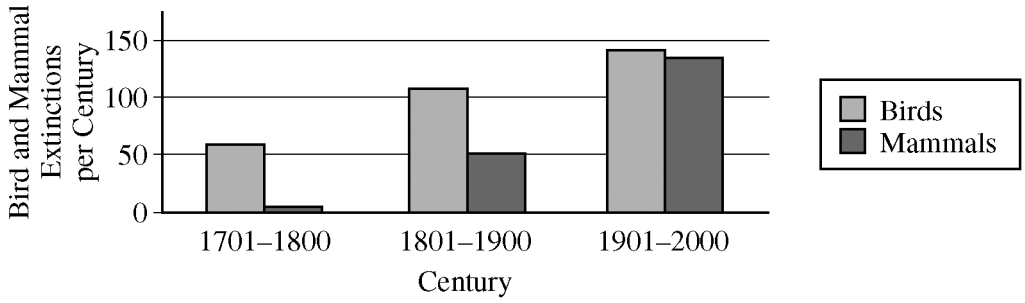
Questions 21-22 refer to the graph below of bird and mammal extinctions over three centuries.



21. Approximately how many more mammal species became extinct in the period 1901–2000 than became extinct in the period 1801–1900 ?

(A) 30
(B) 50
(C) 60
(D) 90
(E) 140

22. Which of the following is the most likely reason that the greatest number of extinctions of bird species occurred in the period 1901–2000 ?

(A) Pollution was becoming so widespread that many birds migrated to new habitats.
(B) Increased environmental disturbances from human activities altered bird habitats.
(C) Adaptive radiation produced many new species of birds.
(D) Animals were being domesticated, leading to the agricultural revolution.
(E) Ecosystems were changing rapidly because of widespread glaciation.

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23. Which of the following best describes acid mine drainage?

(A) Reclamation of mines by removing excess water
(B) The leakage of water containing toxic materials from coal and metal mines
(C) The use of acids to leach minerals from rocks to increase smelting efficiency
(D) Increased water pollution from acid rain entering copper mines
(E) Acid production by anaerobic bacteria in coal mines

24. Which of the following is a characteristic of tropical rain forests?

(A) They rarely receive more than 100 centimeters of rain per year.
(B) Their soils typically have a high pH.
(C) Their soils are relatively poor in nutrients.
(D) They do not exhibit a great deal of species diversity.
(E) They generally occur in the rain shadows of mountain ranges.

25. Which of the following best characterizes a population that is growing exponentially with time?

(A) Equal increases in number over equal increments of time
(B) Controlled growth over a finite time
(C) Doubling in size over equal increments of time
(D) Reaching a maximum then experiencing a rapid decline
(E) Growing at a rate proportional to the square root of time

26. Switching from customary large-scale agricultural practices to which of the following is most likely to reduce the exposure of farmworkers and nearby residents to toxic chemicals?

(A) No-till cultivation
(B) Integrated pest management
(C) Contour plowing
(D) Crop dusting
(E) Use of cover crops

27. Which of the following best illustrates a mitigation approach to climate change?

(A) Increasing the proportion of commercial energy that is produced by wind farms
(B) Increasing the global land area that is devoted to agriculture
(C) Increasing the global sales of air conditioners
(D) Decreasing the price of gasoline for automobiles
(E) Decreasing the cost of electricity derived from coal-fired power plants

28. Which of the following is a common component of photochemical smog and is a reddish-brown gas with a pungent odor?

(A) Carbon monoxide, CO
(B) Nitrogen dioxide, NO_2
(C) Ammonia, NH_3
(D) Ozone, O_3
(E) Methane, CH_4

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29. The release of a large amount of sewage and other organic wastes into a river would likely result in a sharp

(A) increase in the biological oxygen demand
(B) increase in the amount of dissolved oxygen
(C) increase in the population size of fish that require high levels of oxygen
(D) decrease in coliform bacteria counts
(E) decrease in the temperature of the river water

30. All of the following statements about invasive exotic species are true EXCEPT:

(A) They may compete with native species for food.
(B) They may prey on native species.
(C) They are generally introduced by human activity.
(D) They may be plant or animal species.
(E) They tend to have low reproductive rates.

31. Which of the following is the best example of gray water?

(A) Water that is high in calcium, magnesium, and iron
(B) Water that has been used for bathing and for washing clothes
(C) Water from toilets and garbage disposals
(D) Runoff from parking lots
(E) Rainwater collected from roofs

32. The increase in mean global temperature is likely to result in all of the following EXCEPT

(A) decreased size of the Greenland ice sheet
(B) increased range of some plant species
(C) increased populations of insects
(D) increased ground-level ultraviolet radiation
(E) increased sea level

33. A laboratory study using rats showed a steady increase in physical effects as the concentration of a toxic substance in their food was increased. This suggests that

(A) tolerance increases with dosage
(B) there is a threshold dosage
(C) there are no chronic effects of the toxin
(D) the dose-response relationship is linear
(E) the substance is safe to use as a rat poison

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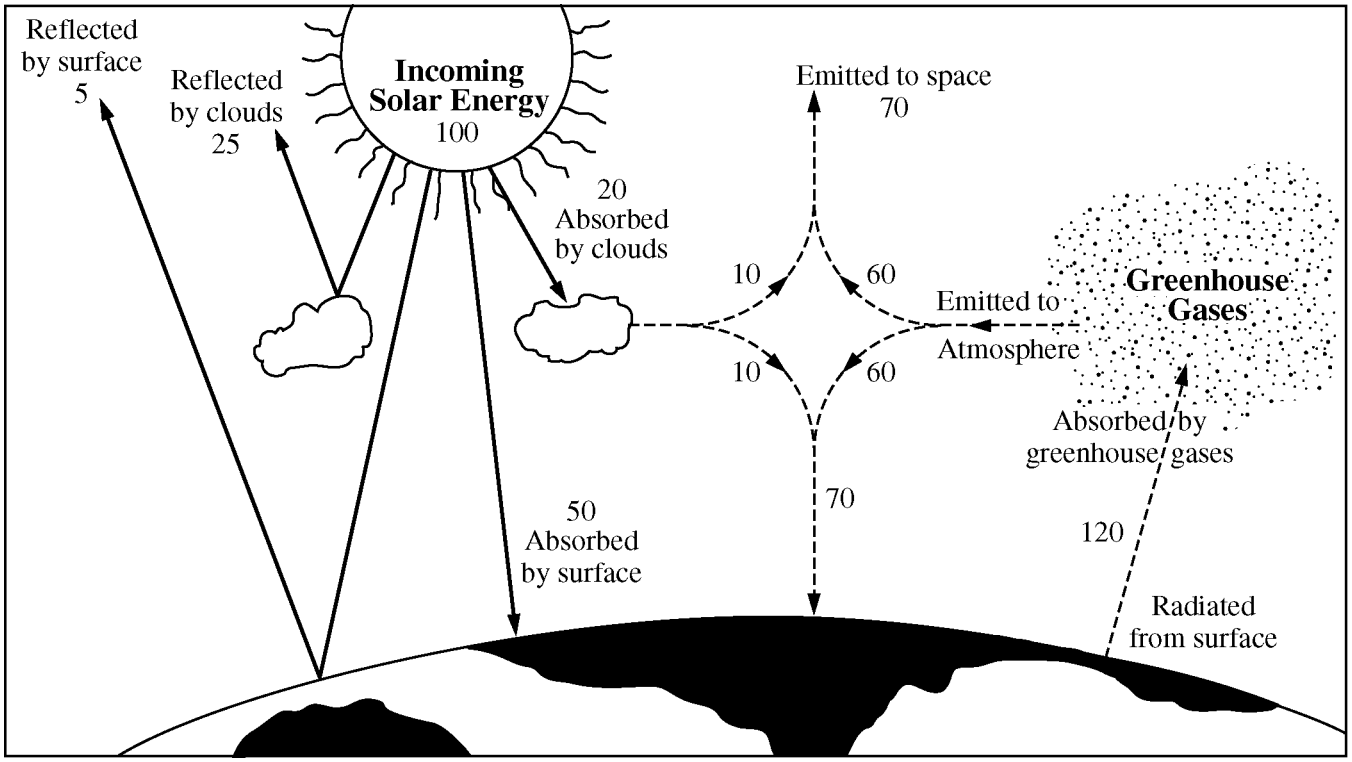
Questions 34-36 refer to the diagram below, which illustrates Earth's atmospheric greenhouse effect.



The solid arrows and the dashed arrows indicate the direction of solar radiation and infrared radiation, respectively, which flow to and from Earth, the atmosphere, and space. The numbers express units, in relative terms, of the total incoming solar or outgoing infrared energy.

34. How many units of energy do greenhouse gases contribute to the greenhouse effect?

(A) 20
(B) 50
(C) 60
(D) 100
(E) 120

35. How many units of energy are absorbed by Earth's surface?

(A) 45
(B) 50
(C) 60
(D) 70
(E) 120

36. How many units of energy return to space from Earth and its atmosphere?

(A) 25
(B) 30
(C) 95
(D) 100
(E) 120

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37. In a human population, the population momentum effect is most likely to occur in cases in which a large percent of people in the population are in which age-group?

(A) Younger than eighteen years old
(B) Between thirty and forty-four years old
(C) Between forty-five and fifty-four years old
(D) Between fifty-five and sixty years old
(E) Older than sixty-five years old

38. Which of the following pairs of statistics would most likely indicate the highest quality of life in a country?

(A) High rate of teenage pregnancy and low gross domestic product
(B) High life expectancy and low infant mortality
(C) High crude birth rate and low literacy rate
(D) High level of exports and low social status of women
(E) High emigration rate and low total fertility rate

39. Which of the following is most likely to reduce the United States contribution to the increase in concentration of atmospheric CO_2 ?

(A) Requiring all farming practices to be organic
(B) Stopping logging in United States forests
(C) Switching fuel use for residential heating from oil to coal
(D) Switching from cars and trucks to rail for mass transit and freight movement
(E) Preventing depletion of stratospheric ozone

40. Many synthetic chemicals, such as PCBs, act as estrogen mimics. In an ecosystem, these persistent chemicals would have the greatest effect on which of the following?

(A) Decomposers
(B) Primary producers
(C) Parasites
(D) Secondary consumers
(E) Autotrophs

41. Correct statements about the northern spotted owl include which of the following?

I. It is a pioneer species that is an opportunistic feeder.
II. It is dependent on mature, old-growth forest for its habitat.
III. It is a carnivore at or near the top of the food chain.

(A) I only
(B) II only
(C) III only
(D) I and II
(E) II and III

Item 42 was not scored.

43. Which of the following compounds is NOT involved in the depletion of stratospheric ozone?

(A) Carbon dioxide
(B) Carbon tetrachloride
(C) Dichlorodifluoromethane
(D) Methyl bromide
(E) Trichloromethane

44. Which of the following is a greenhouse gas that comes only from human sources?

(A) Nitrous oxide
(B) Carbon dioxide
(C) Methane
(D) Chlorofluorocarbons
(E) Carbon monoxide

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45. A small developing country with negligible rates of immigration and emigration is going through a demographic change. Thirty years ago the crude birth rate was 44 per thousand per year and the crude death rate was 17 per thousand per year. Now the crude birth rate is 16 per thousand per year and the crude death rate is 5 per thousand per year. Which of the following statements about the country now is most likely to be true?

(A) The population is decreasing.
(B) The growth rate of the population is increasing.
(C) The country is at the preindustrial stage of the demographic transition.
(D) The country is at the industrial stage of the demographic transition.
(E) The country is at the postindustrial stage of the demographic transition.

46. Which of the following best explains why decomposers in soils and water are important to ecosystems?

(A) They remove heavy metals.
(B) They store carbon dioxide.
(C) They recycle nutrients.
(D) They neutralize acid deposition.
(E) They produce more oxygen than they consume.

Questions 47-48 refer to a pond in southern Canada.

In 1950 the pH of the pond water was 8.2, but by 2000 the pH had decreased to 5.2.

47. Which of the following changes would also be expected in the pond over the same time period?

I. Increased levels of dissolved oxygen
II. Increased levels of heavy metals
III. Increased number of fish species

(A) I only
(B) II only
(C) III only
(D) II and III
(E) I, II, and III

48. An effective short-term remediation strategy for the pond would be to

(A) build taller smokestacks downwind from the pond
(B) prevent fertilizer runoff from entering the pond
(C) periodically stock the pond with brown trout
(D) add calcium carbonate to the pond water
(E) use tertiary wastewater-treatment protocols

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Questions 49-52

A series of experiments was designed to test the effects of ultraviolet (UV) radiation on the productivity of polar phytoplankton. Samples of these single-celled organisms were placed in four tanks, which were exposed to ambient natural solar radiation and to three modifications of ambient radiation. The design of the experiments is shown in the table below, along with measurements of photosynthesis in each tank.

Tank Number	Treatment (All treatments include ambient light.)	Photosynthesis (CO_2 uptake in $mg/m^2 \cdot hr$)
1	No added treatment	22
2	Filters to remove all UV	720
3	Filters to remove 33% of UV	31
4	UV lamps to enhance ambient UV by 16%	12

49. Which of the following inferences is supported by the results of this series of experiments?

(A) The atmosphere over Antarctica still contains some ozone.
(B) Doubling of UV radiation will suppress photosynthesis completely.
(C) The ozone hole over Antarctica is being destroyed by chlorofluorocarbons (CFCs).
(D) Increased UV penetration through the Antarctic ozone hole would further depress productivity of phytoplankton.
(E) Higher levels of UV radiation will eventually occur over Antarctica.

50. Which of the following is the most valid conclusion that can be inferred from this experiment?

(A) Natural UV levels are having a dramatic effect on productivity in the upper levels of the tropical oceans, where light intensity is high.
(B) The thinning of the Antarctic ozone layer is likely to have a dramatic effect on the entire polar food chain.
(C) Photosynthetic rates of polar phytoplankton under ambient conditions of light are very similar to those of phytoplankton in temperate areas.
(D) UV radiation reaching the ocean surface near Antarctica has already increased about 500% over preindustrial levels.
(E) UV radiation is a very important wavelength needed for photosynthesis in polar phytoplankton.

51. Which two-tank comparison provides the strongest evidence that the presence of UV light at natural levels inhibits photosynthesis?

(A) Tank 1 versus tank 2
(B) Tank 1 versus tank 4
(C) Tank 2 versus tank 3
(D) Tank 2 versus tank 4
(E) Tank 3 versus tank 4

52. Which of the following would add the most support to the reliability of this series of experiments?

(A) Duplicate the experiment under identical conditions, and get similar results.
(B) Add a fifth tank with even higher levels of UV radiation.
(C) Repeat the experiment under different conditions with different scientists.
(D) Use phytoplankton from widely varying locations, and get similar results.
(E) Increase sample size by using a greater number of phytoplankton in each tank.

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53. Which of the following would be the most likely effect of acid deposition on a northern forest?

(A) Decreased ability of trees to withstand cold weather
(B) Decreased concentration of H^+ ions in the soil
(C) Decreased levels of light on the forest floor
(D) Increased buffering capacity of the soil
(E) Increased rates of photosynthesis in evergreen needles

54. In 1986 Country X established regulations to reduce the maximum allowable concentration of chromium in industrial effluents from 37 ppm to 25 ppm. In 1994 government research indicated that a chromium concentration of up to 35 ppm in effluents presented an acceptable risk; in the same year the government also discovered that a certain chemical company had been discharging effluents with chromium concentrations of 32 ppm each year since 1981. Based on this information, which of the following statements is correct?

(A) 35 ppm of chromium was considered retroactively to be the legal limit for the 1987–1994 period.
(B) 35 ppm of chromium served automatically as the new legal limit in the post-1994 period.
(C) The chemical company did not violate effluent regulations in the 1982–1985 period, but it violated them at some other time.
(D) The chemical company did not violate effluent regulations in the 1987–1994 period, but did violate them at some other time.
(E) The chemical company never violated effluent regulations for chromium.

55. If the population of a country is growing at a rate of 1.75 percent per year, the population will double in approximately how many years?

(A) 30 years
(B) 40 years
(C) 50 years
(D) 70 years
(E) 140 years

56. True statements about ozone include which of the following?

I. Ozone is a precursor of acid rain.
II. Contact with ozone can be injurious to human health.
III. Ozone absorbs some wavelengths of ultraviolet radiation

(A) II only
(B) III only
(C) I and III only
(D) II and III only
(E) I, II, and III

57. The danger from radon gas would most likely be greatest in

(A) airplanes at high altitudes
(B) areas with a high density of automobiles
(C) crop-dusted agricultural fields
(D) high-rise office buildings
(E) well-insulated homes

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58. Most plastics pose a special problem in the waste stream because they

(A) decompose readily in water and become a source of water pollution
(B) decompose to produce methane, which is explosive and creates a significant hazard
(C) decompose slowly, if at all, and persist as solid waste
(D) release radioactive isotopes when they decompose
(E) release ozone when they are recycled

59. Which of the following air pollutants is correctly paired with one of its major effects?

(A) Particulates . . production of photochemical smog
(B) Radon . . global climate change
(C) Sulfur oxides . . acid deposition
(D) Lead . . skin cancer
(E) Carbon oxides . . ozone layer depletion

60. The activity with the health risk most likely to be overestimated by the general public in the United States is

(A) driving an automobile
(B) drinking alcohol
(C) living near a nuclear power plant
(D) riding a bicycle
(E) smoking tobacco

61. Which of the following is a primary air pollutant produced from burning coal?

(A) Carbon monoxide
(B) CFCs (chlorofluorocarbons)
(C) PCBs (polychlorinated biphenyls)
(D) Ozone
(E) Sulfuric acid

62. A farmer observes that increasingly higher concentrations of a particular pesticide have been required each year over the past ten years to achieve the same level of effectiveness on a specific insect pest. Which of the following best helps explain the observation?

(A) Some individual insects live longer than others and pass on traits acquired during their lives.
(B) Only the most aggressive and territorial insects survive and reproduce.
(C) Some individual insects are more likely than others to survive and reproduce due to their inherited traits.
(D) Some individual insects produce many offspring, and thus their offspring live longer.
(E) Some individual insects reproduce before the pesticide is applied, thereby avoiding its harmful effects.

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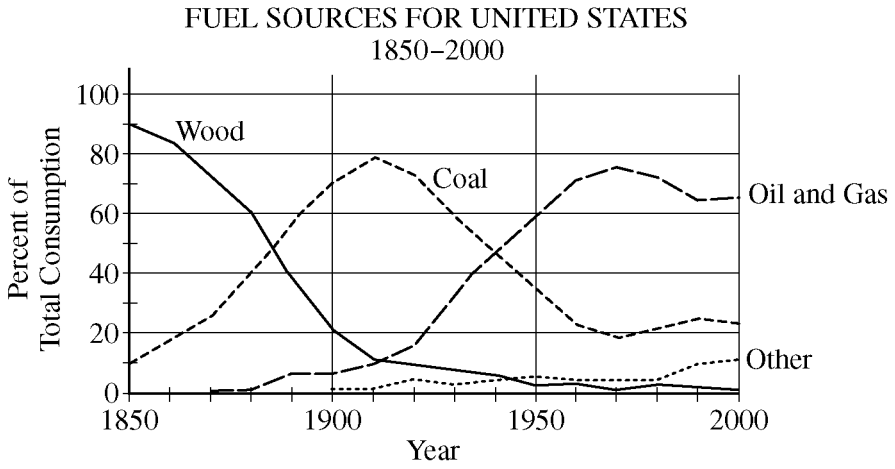
Questions 63-66 refer to the graph below showing the percent contribution of major fuel sources that have supplied energy for the United States for the past 150 years. The category labeled "Other" includes nuclear power, hydroelectricity, solar and wind power, and other alternative sources of energy.



63. In what year was the fraction of energy supplied by coal the greatest?

(A) 1880
(B) 1910
(C) 1940
(D) 1970
(E) 2000

64. In approximately what year did oil and gas become the dominant fuels for the United States?

(A) 1880
(B) 1910
(C) 1940
(D) 1970
(E) 2000

65. Nuclear power is a component of the line labeled "Other" in the graph. Why is it impossible for nuclear energy to completely replace oil and gas in the future?

(A) Nuclear power is unacceptable to the public, so they will not allow it.
(B) At the current rate of consumption, there is only enough uranium to last for fifteen more years.
(C) Nuclear power can supply electricity, but it cannot replace other uses of oil and gas.
(D) Nuclear energy is too costly for general use.
(E) Nuclear waste contributes more to global climate change than do oil and gas.

66. The primary cause for the decline in the use of wood as a fuel in the eighteen hundreds was the

(A) discovery of major oil fields in the Middle East
(B) lowering of per capita energy consumption
(C) reduced wood availability resulting from widespread deforestation
(D) global rise in temperatures during the 1800s
(E) lower energy density of coal as compared to wood

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67. Which of the following is true about the region of Earth's atmosphere known as the stratosphere?

(A) It is the warmest layer of the atmosphere because it is closest to the Sun.
(B) Most of the atmospheric water vapor is found in this layer.
(C) It is the layer of the atmosphere in which nearly all weather takes place.
(D) The highest concentration of naturally occurring ozone forms in this layer.
(E) It is characterized by steadily decreasing temperature with altitude.

68. The crude growth rate, r, of a population is calculated by

(A) multiplying the existing population size by life expectancy
(B) dividing the crude birth rate by 2
(C) dividing the doubling time by 70
(D) adding the crude birth rate to the crude death rate
(E) subtracting the crude death rate from the crude birth rate

69. Recent studies show that the decline of some tree populations in the northeastern United States is due to a combination of factors. Which of the following is the most important factor?

(A) Toxic metals freed by acid deposition
(B) Carbon dioxide produced by coal-fueled electric power plants
(C) Carbon monoxide released in motor vehicle exhaust
(D) Lead emissions produced by smelters
(E) Radon produced in the Earth's crust

70. Which of the following characteristically produces non-point-source pollution?

(A) Seepage from a landfill
(B) Industrial effluent
(C) Testing of nuclear weapons
(D) Erosion from agricultural land
(E) Overflow from a sewage treatment plant

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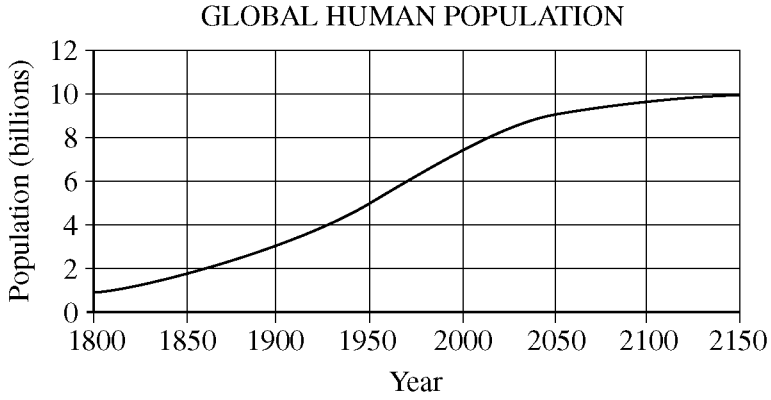

71. According to the graph above, the global human population will most likely

(A) reach a maximum value that is less than 8 billion
(B) reach a maximum rate of growth in 2150
(C) have doubled between 1950 and 2150
(D) be growing exponentially in 2100
(E) be declining after 2150

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72. Factors that increase the spread of infectious diseases include all of the following EXCEPT

(A) flooding, which contaminates water supplies with raw sewage
(B) global warming, which can transfer carriers of disease from tropical to temperate areas
(C) introduction of insect vectors, which transmit disease
(D) exposure to neurotoxins, which affect the endocrine system
(E) rural poverty, which causes people to move into urban areas

73. It has been observed that forest fires can produce up to 40 percent of the mean annual global emissions of which of the following gases?

(A) Methane
(B) Ozone
(C) Carbon dioxide
(D) Sulfur dioxide
(E) Water vapor

74. Which of the following does NOT exert a major influence on Earth's overall climate?

(A) The annual amount of solar radiation that reaches Earth's surface
(B) The concentrations of the specific gases in Earth's atmosphere
(C) The distribution of land masses and oceans, in combination with Earth's topography
(D) The daily rotation of Earth on its axis, and its annual revolution around the Sun
(E) The seasonal development of temperature inversions in geographical basins

75. Salmon farming threatens the health of wild salmon stocks primarily because

(A) salmon farming prevents commercial fishing fleets from overharvesting wild salmon
(B) salmon farming prevents interbreeding between domesticated varieties of salmon and their wild counterparts
(C) farmed salmon can spread parasites and disease to wild salmon
(D) farmed salmon compete with wild salmon for spawning sites
(E) farmed salmon can contain chemicals derived from food additives and antibiotics that may be harmful to human consumers

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76. Members of an r-selected species characteristically

(A) grow slowly
(B) produce few offspring
(C) reach sexual maturity quickly
(D) have long life spans
(E) are very protective of their offspring

77. Biological control methods for managing insect pests are effective for reasons that include which of the following?

I. They promote genetic resistance in the target species, resulting in a population explosion of the target species.
II. They generally focus on one target insect to ensure that the target insect population remains low.
III. They can lead to a self-perpetuating population of a control species.

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

78. Which of the following is the best example of an economic incentive that could be used to improve environmental quality and reduce resource waste?

(A) Charging user fees for extracting lumber from national forests
(B) Requiring a pollution prevention bond for building a new landfill
(C) Charging user fees for livestock grazing on public lands
(D) Levying taxes on companies that discharge pollution into air and water
(E) Providing tax breaks for companies that use recycled materials

79. West Nile virus was identified in the Western Hemisphere during the summer of 1999 and was associated with human, equine, and avian deaths. This virus is acquired by

(A) ingesting certain imported foods
(B) coming in contact with polluted water
(C) coming in contact with a sick horse or bird
(D) being bitten by an infected mosquito
(E) inhaling contaminated airborne droplets

80. The great grasslands of the world have which of the following primary characteristics in common?

(A) They are restricted in occurrence to the region between 30° north latitude and 30° south latitude.
(B) Due to high humidity, fires are uncommon and rarely affect large areas.
(C) They are typically created by overgrazing by livestock.
(D) Seasonal cycles of temperature and precipitation produce abundant vegetative growth.
(E) High winds blow seeds of trees away such that only grasses exist.

81. A cost-benefit analysis done to investigate a proposed mine site would likely take which of the following into account?

I. The medical costs of mine worker injuries
II. The cost of environmental restoration of the site when it is shut down
III. The value of the ore to be extracted from the mine

(A) II only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

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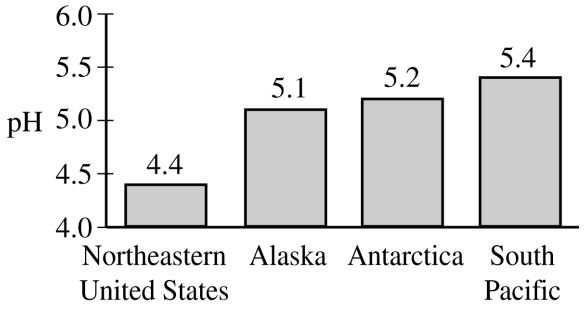
GO ON TO THE NEXT PAGE.

Questions 82-83

The graph below shows the average pH of precipitation from several regions of the world.



82. Approximately how many more times acidic, in terms of H^+ concentration, is precipitation in the northeastern United States as compared to precipitation in the South Pacific?

(A) 0.1
(B) 2
(C) 10
(D) 20
(E) 100

83. The primary cause of acid precipitation in the northeastern United States is

(A) the large number of automobile air conditioners leaking Freon
(B) burning of sulfur-containing fossil fuels to produce electricity
(C) deforestation, which reduces the number of trees removing atmospheric CO_2
(D) strip-mining, which releases large quantities of particulates into the atmosphere
(E) global warming, which speeds the chemical reactions that produce acids

84. Which of the following ecological concepts includes all of the others?

(A) Community
(B) Ecosystem
(C) Genus
(D) Population
(E) Species

85. The risk that many cancer-causing chemicals pose to humans can be estimated using laboratory tests on rats. A significant scientific limitation of such tests is that

(A) they require thousands of rats
(B) they take several decades to conduct
(C) they are banned in the United States
(D) animal models may not reflect human responses
(E) the test animals may be killed as a result of the tests

86. Which of the following is the most successful solution to the problem of fish mortality caused by dams?

(A) Placing fish repellents on dam turbines
(B) Eliminating keystone species above the dam
(C) Building fish ladders around the dam
(D) Harvesting the fish before they reach the dam
(E) Dredging the sediments upstream of the dam

87. Which of the following actions would be most likely to increase the protection of ecological systems in national forests?

(A) Encourage timber harvesting of old-growth forests within national parks
(B) Allow national forest managers to use revenues from timber sales as they see fit
(C) Encourage the building of new roads in national forests and improve existing roads
(D) Make the growing, harvesting, and sale of timber the primary use of national forests
(E) Mandate that the government sale of logging rights in national forests be at fair market value

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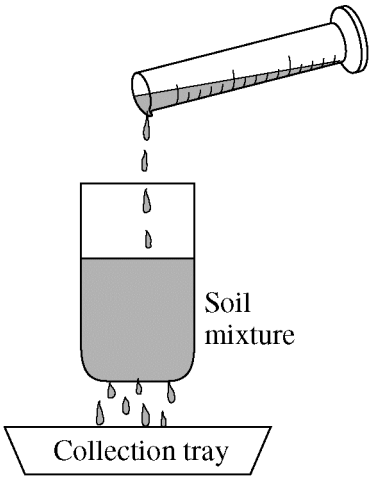
Questions 88-89 refer to the diagram below, which shows 100 ml of water being poured through a soil sample. After the water has passed through the soil, 98 ml of water is measured in the collection tray below the sample.



88. Of the following, which is the most likely composition of the soil sample?

	Clay	Silt	Sand
(A)	80%	10%	10%
(B)	50%	40%	10%
(C)	40%	50%	10%
(D)	30%	40%	30%
(E)	10%	10%	80%

89. Which of the following properties of the soil sample most influences the flow of water through the sample?

(A) Color
(B) Fertility
(C) Permeability
(D) pH
(E) Salinity

Questions 90-91

The data table below shows the annual anchovy catch and average sea surface temperature off the coast of Peru from 1995 through 2001.

Year	Anchovy Catch (10^6 metric tons)	Sea Surface Temperature (ºC)
1995	8.6	18.9
1996	8.9	15.5
1997	7.7	15.6
1998	1.7	26.2
1999	8.7	15.4
2000	11.2	15.5
2001	7.2	16.9

90. The low anchovy catch in 1998 was most likely the result of

(A) an increase in the number of hurricanes
(B) an increase in the population of anchovy predators
(C) reduced ocean upwelling along the coast
(D) reduced surface runoff due to drought
(E) unusually strong trade winds

91. The high sea surface temperature in 1998 was most likely due to

(A) global warming
(B) El Niño
(C) eutrophication
(D) salinization
(E) Pacific Annual Oscillation

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92. Which of the following is an example of an external cost?

(A) Individuals pay for medical treatment of lung disease aggravated by pollution from a coal-fired power plant.
(B) A gas station goes out of business when gasoline prices go so high that drivers drastically decrease their use of gasoline.
(C) A fish-packing company pays unemployment compensation to workers displaced by automation.
(D) A company that manufactures x-ray machines triples its profits when a new law mandates increased airport security.
(E) A landfill owner buys more land to increase the size and profitability of the landfill.

---

93. Which of the following best represents the percent of water that is used for various purposes worldwide?

	Agriculture	Industrial and Municipal	Residential and Commercial
(A)	10%	20%	70%
(B)	20%	30%	50%
(C)	30%	50%	20%
(D)	50%	10%	40%
(E)	70%	20%	10%

---

94. In North America, native pollinators often increase the quantity and quality of crops of native plants that are insect pollinated more effectively than European honeybees do. The most likely reason for the phenomenon is that native pollinators

(A) are unaffected by commercial pesticides
(B) are uniformly smaller than European honeybees
(C) have no known native predators
(D) have coevolved with native plant species
(E) mature quickly without undergoing metamorphosis

95. Which of the following best describes the process of leaching?

(A) Water percolating through soil, dissolving some of its material
(B) The falling of acid precipitation from the atmosphere to Earth's surface
(C) The use of chemicals to reduce the amount of *E. coli* in wastewater
(D) Rocks embedded in a glacier being carried downslope
(E) The use of drip irrigation on a crop of wheat

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96. Which of the following problems is best addressed with contour plowing?

(A) Eutrophication
(B) Denitrification
(C) The pesticide treadmill
(D) Soil erosion
(E) Soil salinization

97. Which of the following is the best example of cogeneration?

(A) A power plant uses both coal and natural gas as fuel.
(B) A trash-to-steam power plant accepts both residential and commercial waste.
(C) Several power plants supply the same city with electrical energy.
(D) Emissions from power plants are captured and stripped of sulfur for commercial sale.
(E) A coal-fired power plant captures waste heat and uses it to heat adjacent buildings.

98. Which of the following represents a correct pairing of an agricultural practice with its environmental consequence?

(A) Paddy rice cultivation and methane emissions
(B) Plowing under cover crops and nutrient depletion
(C) Organic corn cultivation and pesticide accumulation
(D) No-till farming and increased soil erosion
(E) Planting vegetated buffers on stream banks and increased levels of nonpoint-source pollution

99. Small populations of animals, such as those typically found on islands, are prone to extinction because

(A) they contain a high degree of genetic variability
(B) they tend to have more predators
(C) their habitats are more stable
(D) they are more vulnerable to unpredictable events
(E) they are usually generalist species

100. In the stratosphere, which of the following increases Earth's albedo by reflecting solar energy back into space?

(A) Carbon monoxide
(B) Carbon dioxide
(C) Nitrogen dioxide
(D) Peroxyacyl nitrates (PANs)
(E) Sulfate aerosols

S T O P

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 PLACED YOUR AP NUMBER LABEL ON YOUR ANSWER SHEET AND HAVE WRITTEN AND GRIDDED YOUR AP NUMBER IN THE APPROPRIATE SECTION OF YOUR ANSWER SHEET.

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ENVIRONMENTAL SCIENCE
SECTION II
Time—90 minutes
4 Questions

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in the pink booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Gazette* and answer the questions that follow.

Fremont Gazette **Page 17**

Deadly Pollutants Kill Children in India and China

"Contaminated industrial sites in India and China top a new ranking of the world's most polluted places, where millions of people are threatened by various chemical pollutants," said Dr. Egguen, president of Fremont Friends of the Planet, an environmental advocacy organization. She said that the industrial town of Vapi, India, is a new addition to the list of worst-polluted places on Earth, based on the magnitude of the pollution and the number of people who are put at risk. She said, "Thousands of children, who are especially susceptible to toxic pollutants, are sick and dying in these top ten polluted places."

Dr. Egguen pointed out that mining and unregulated industrial production are the major culprits behind the menacing pollution. She described Vapi as a region overwhelmed by more than 50 chemical manufacturers that poison the local soils and groundwater with toxic pollutants such as PCBs, mercury, and lead. In fact, levels of heavy metals found in local produce are 60 times greater than those found in produce grown in unpolluted areas.

(a) Choose any ONE of the three pollutants mentioned above and respond to each of the following.

(i) Describe one specific source, other than the local chemical plants, for the toxic pollutant you chose.

(ii) Describe how the pollutant you chose enters the human body and one specific effect it can have on human health.

(iii) Describe TWO specific steps, other than an outright ban, that a city or nation can take to reduce the threat posed by this pollutant.

(b) Give one reason why Dr. Egguen is correct in asserting that children are particularly susceptible to toxic pollutants.

GO ON TO THE NEXT PAGE.

(c) An important contributor to global climate change is the release of CO_2 from the rapidly increasing number of coal-burning power plants in China. Assume that the coal burned at these plants to provide the power to manufacture a single MP3 player releases 40 kg of CO_2 and that it costs \$0.75 to capture 1 kg of CO_2 and keep it from entering the atmosphere. Determine the cost, in dollars, to capture the total amount of CO_2 released from manufacturing one MP3 player.

(d) Coal-burning power plants also release other pollutants, including nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulates. Select one of these pollutants and identify one technology that can be used to remove it from the waste stream of coal-burning power plants.

(e) Discuss TWO reasons why a multinational company would choose to build a manufacturing facility in India and/or China rather than in the United States or Europe.

2. Termites are social insects that are essential decomposers in tropical rain forest ecosystems. Termites may account for up to 95 percent of insect biomass in tropical rain forests. Termites consume vast amounts of dead and decomposing plant material, thanks to the work of mutualistic cellulose-digesting microorganisms that inhabit their guts. In addition to their roles as important decomposers, termites digest plant materials and directly contribute to carbon dioxide and methane emissions into the atmosphere. It is likely that, like many insect species, termites and their symbionts may be sensitive to changes in their microclimate caused by global climate change, especially with regard to temperature and humidity.

		Relative Humidity		
		50%	70%	90%
Temperature	20°C	0.04	0.05	0.05
	25°C	0.05	0.07	0.10
	30°C	0.12	0.13	0.27
	35°C	0.09	0.13	0.15
	40°C	0.00	0.00	0.00

(a) Respond to the following using the data in the table above, which gives the rate of wood consumption by termites, in mg per day per termite, under various temperature and relative humidity conditions. Under optimal conditions, the emission rate of methane by termites is approximately 70 kilograms of CH_4 per year per 1,000 termites.

(i) According to the data, what are the optimal temperature and relative humidity for termite activity?

(ii) Given a density of 4.5×10^7 termites per hectare and optimal conditions, calculate the annual amount of methane emitted, in kilograms, by the termites inhabiting a 2,000-hectare tropical rain forest.

(iii) Suppose the temperature increases to 35°C and the relative humidity decreases to 50 percent. Using the data provided, determine the amount of methane, in kilograms, that would be emitted by the termites in the 2,000-hectare tropical rain forest.

(iv) Explain why the population size of termites is also affected by temperature and humidity.

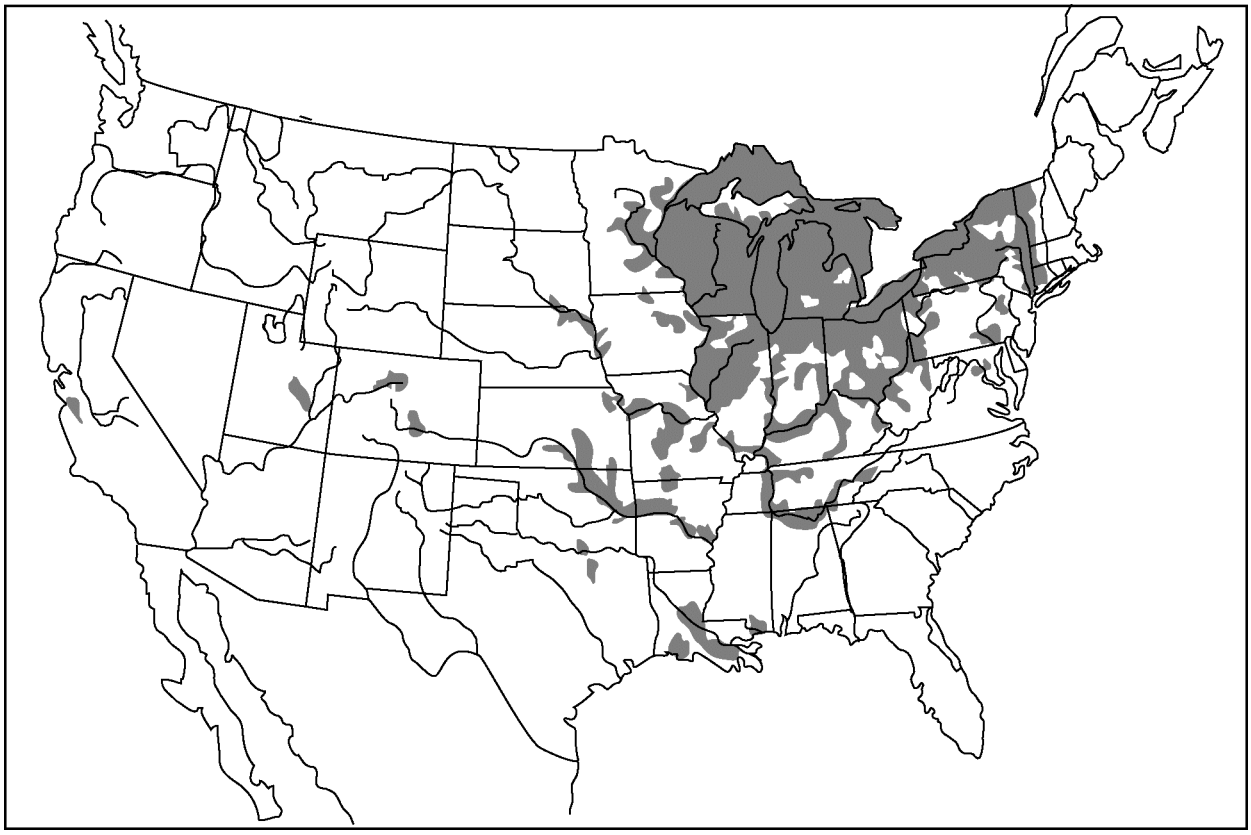
(b) It has been observed that soon after a tropical rain forest is cleared, termite density increases to an estimated 6.8×10^7 termites per hectare. Thereafter, the termite population size decreases dramatically.

(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

(ii) Why do the termite populations eventually decrease dramatically?

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

GO ON TO THE NEXT PAGE.



3. The zebra mussel, a mollusk native to Eurasia, was first discovered in the Great Lakes of North America in 1988. Zebra mussels attach to solid substrates and are filter feeders. Adult zebra mussels can survive for several days or even weeks out of water if the temperature and humidity are favorable. An adult female zebra mussel can produce as many as one million eggs per year. The recent range of occurrence of zebra mussels in the United States is indicated by shading in the map above.

   (a) Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?

   (b) How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.

   (c) Identify and explain one impact that zebra mussels can have on aquatic ecosystems.

   (d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.

   (e) One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.

   (f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

GO ON TO THE NEXT PAGE.

4. Scientific evidence shows a direct relationship between sea level and the global mean atmospheric temperature at Earth's surface. Increases in the global mean atmospheric temperature during the past century have been accompanied by a gradual increase in sea level; currently the average rate of increase in sea level is 3.0 mm/yr. Additional increases in sea level are expected during the next century as global mean atmospheric temperatures continue to rise. These increases in sea level will affect coastal ecosystems as well as human activity along coastal margins.

   (a) Based on the rate cited above, calculate the expected increase in sea level, in meters, during the next 50 years.

   (b) Identify TWO phenomena that result from an increase in global mean atmospheric temperature and that contribute to increases in sea level. For each phenomenon that you identify, explain how it causes sea level to increase.

   (c) Describe TWO environmental impacts that increasing sea level will have on an estuarine ecosystem such as those in the Mississippi Delta, Chesapeake Bay, and San Francisco Bay.

   (d) Although sea level has been rising for over a century, human populations in coastal areas have increased dramatically during this period.

      (i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.

      (ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

STOP

END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX(ES) ON THE COVER(S).**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

AP Environmental Science

2010

APPENDIX - ANSWERS

Matching multiple-choice answers and free-response scoring follow.

Answer Key for AP Environmental Science Practice Exam, Section I

Question 1: A
Question 2: D
Question 3: C
Question 4: D
Question 5: A
Question 6: C
Question 7: B
Question 8: C
Question 9: A
Question 10: B
Question 11: E
Question 12: A
Question 13: E
Question 14: B
Question 15: C
Question 16: E
Question 17: C
Question 18: B
Question 19: E
Question 20: E
Question 21: D
Question 22: B
Question 23: B
Question 24: C
Question 25: C
Question 26: B
Question 27: A
Question 28: B
Question 29: A
Question 30: E
Question 31: B
Question 32: D
Question 33: D
Question 34: C
Question 35: E
Question 36: D
Question 37: A
Question 38: B
Question 39: D
Question 40: D
Question 41: E
Question 42: *
Question 43: A
Question 44: D
Question 45: D
Question 46: C
Question 47: B
Question 48: D
Question 49: D
Question 50: B
Question 51: A
Question 52: A
Question 53: A
Question 54: C
Question 55: B
Question 56: D
Question 57: E
Question 58: C
Question 59: C
Question 60: C
Question 61: A
Question 62: C
Question 63: B
Question 64: C
Question 65: C
Question 66: C
Question 67: D
Question 68: E
Question 69: A
Question 70: D
Question 71: C
Question 72: D
Question 73: C
Question 74: E
Question 75: C
Question 76: C
Question 77: D
Question 78: E
Question 79: D
Question 80: D
Question 81: E
Question 82: C
Question 83: B
Question 84: B
Question 85: D
Question 86: C
Question 87: E
Question 88: E
Question 89: C
Question 90: C
Question 91: B
Question 92: A
Question 93: E
Question 94: D
Question 95: A
Question 96: D
Question 97: E
Question 98: A
Question 99: D
Question 100: E

*Item 42 was not used in scoring.

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Question 1

(a) Choose any ONE of the three pollutants mentioned above and respond to each of the following.

(i) Describe one specific source, other than the local chemical plants, for the toxic pollutant you chose.

One point can be earned for the description of a specific source of the pollutant. (Only the first answer is scored.)

PCBs	Mercury	Lead
• Transformers • Miscellaneous electronics • Hydraulic systems • Gas pipelines • Mining equipment • Lubricants • Pesticides • Wood treatments • Printing ink • Paint • Carbonless copy paper • Plastic • Waste oil • Roofing materials	• Coal burning • Gold mining • Thermometers • Barometers • Thermostats • Compact fluorescent lightbulbs • Switches • Appliances • Dental amalgam (fillings) • Use of Hg in cultural and religious practices • Batteries • Jewelry • Fungicides • Mine waste containing mercury	• Paint • Water pipes • Lead glaze on ceramics • Gasoline additives • Lead bullets and shot • Cosmetics • Jewelry • Traditional foods and medicines • Batteries • Electronics • Mine waste containing lead • Smelting

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Question 1 (continued)

(ii) Describe how the pollutant you chose enters the human body and one specific effect it can have on human health.

Two points can be earned: 1 point for describing how the pollutant enters the human body and 1 point for describing one human health effect of the pollutant.

How the pollutant enters the human body (Only the first answer is scored.)		
PCBs	**Mercury**	**Lead**
• Ingesting seafood contaminated with PCBs • Inhaling dust contaminated with PCBs • Absorption through skin • Drinking contaminated water	• Ingesting seafood contaminated with mercury • Ingesting food or water contaminated by soil, mine waste or particulates containing mercury • Inhaling mercury vapors (from broken thermometers, barometers, compact fluorescent lightbulbs, etc.) • Absorption through skin • Medical and dental procedures	• Ingesting food or water from ceramic tableware produced with lead-containing glazes • Ingesting food or water contaminated by soil, mine waste, particulates or plumbing containing lead • Ingesting lead-based paint • Inhaling dust or vapors contaminated with lead

Human health effects (Only the first answer is scored.)		
PCBs	**Mercury**	**Lead**
• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Damage to the reproductive system • Feminization • Low sperm counts • Hermaphroditism • Cancer	• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Reproductive system damage • Feminization • Low sperm counts • Hermaphroditism • Kidney damage • Hearing loss • Minamata disease • Autism* * While controversial, published studies have suggested a link between mercury and autism.	• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Kidney damage • Hearing loss • Anemia • Liver or stomach damage

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Question 1 (continued)

(iii) Describe TWO specific steps, other than an outright ban, that a city or nation can take to reduce the threat posed by this pollutant.

Two points can be earned: 1 point for each specific step that will reduce the threat posed by the pollutant. (Only the first two answers are scored.)

PCBs	Mercury	Lead
• Educate people about how to avoid PCBs	• Educate people about how to avoid mercury	• Educate people about how to avoid lead
• Substitute safer alternatives for PCBs	• Substitute safer alternatives for mercury	• Substitute safer alternatives for lead
• Replace products that contain PCBs with different products	• Replace products that contain mercury with different products	• Replace products that contain lead with different products
• Collect and safely dispose of products containing PCBs	• Collect and safely dispose of products containing mercury	• Collect and safely dispose of products containing lead
• Set and/or enforce policies that limit the production, use and discharge of PCBs	• Set and/or enforce policies that limit the extraction, production, use and discharge of mercury	• Set and/or enforce policies that limit the extraction, production, use and discharge of lead
• Phytoremediation of contaminated areas	• Phytoremediation of contaminated areas	• Phytoremediation of contaminated areas
• Treat water supplies to remove PCBs	• Treat water supplies to remove mercury	• Treat water supplies to remove lead
• Restrict fishing for species known to have high PCB concentrations	• Restrict fishing for species known to have high mercury concentrations	• Remove, cap or contain mine waste with high lead concentrations
• Dredge contaminated waterways	• Remove, cap or contain mine waste with high mercury concentrations	• Remove, cap or contain soils with high lead concentrations
• Wash contaminated soil	• Use technology to remove mercury from coal and smokestacks	• Remove lead-based paint from painted surfaces
• Incinerate contaminated soil	• Reduce coal burning	
	• Clean up mercury spills	

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Question 1 (continued)

(b) Give one reason why Dr. Egguen is correct in asserting that children are particularly susceptible to toxic pollutants.

One point can be earned for a correct reason that children are particularly susceptible to toxic pollutants. (Only the first answer is scored.)

- Children take in more water, food and air per unit of body weight than adults.
- Children often put dirty objects or hands in their mouths.
- Children have less developed immune systems.
- The liver of a child does not metabolize pollutants as efficiently as the liver of an adult.
- The growing organ systems of children are more sensitive to pollutants than the mature systems of adults.
- Children will accumulate pollutants for a longer period of time than adults.

(c) An important contributor to global climate change is the release of CO_2 from the rapidly increasing number of coal-burning power plants in China. Assume that the coal burned at these plants to provide the power to manufacture a single MP3 player releases 40 kg of CO_2 and that it costs $0.75 to capture 1 kg of CO_2 and keep it from entering the atmosphere. Determine the cost, in dollars, to capture the total amount of CO_2 released from manufacturing one MP3 player.

Two points can be earned: 1 point for a correct setup and 1 point for the correct answer. (Units are not required.)

$$40 \ \cancel{\text{kg CO}_2} \times \frac{\$0.75}{1 \ \cancel{\text{kg CO}_2}} = \$30$$

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Question 1 (continued)

(d) Coal-burning power plants also release other pollutants, including nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulates. Select one of these pollutants and identify one technology that can be used to remove it from the waste stream of coal-burning power plants.

One point can be earned for identifying a correct technology for the pollutant selected.

NO_x	SO_x	Particulates
• Coal gasification • Fluidized-bed combustion • Burning pulverized coal at reduced temperatures • Selective catalytic reduction	• Coal gasification • Fluidized-bed combustion • Scrubber • Removal of sulfur prior to burning coal	• Coal gasification • Fluidized-bed combustion • Scrubber • Filters • Baghouse filter • Electrostatic precipitator • Cyclone separator

(e) Discuss TWO reasons why a multinational company would choose to build a manufacturing facility in India and/or China rather than in the United States or Europe.

Two points can be earned: 1 point for each correct reason that is discussed. (Only the first two answers are scored.)

- Less stringent environmental regulations
- Lax enforcement of environmental regulations
- Less expensive labor
- Large populations of workers willing to work for lower wages
- Fewer workplace regulations
- Lower health-care costs for workers
- Less expensive property
- Less expensive raw materials
- Lower/fewer taxes and fees
- Government subsidies
- Lower litigation costs
- Expansion of markets

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Question 2

(a) Respond to the following using the data in the table above, which gives the rate of wood consumption by termites, in mg per day per termite, under various temperature and relative humidity conditions. Under optimal conditions, the emission rate of methane by termites is approximately 70 kilograms of CH_4 per year per 1,000 termites.

(i) According to the data, what are the optimal temperature and relative humidity for termite activity?

One point can be earned for correctly identifying the optimal temperature (30°C) AND relative humidity (90 percent).

(ii) Given a density of 4.5×10^7 termites per hectare and optimal conditions, calculate the annual amount of methane emitted, in kilograms, by the termites inhabiting a 2,000-hectare tropical rain forest.

One point can be earned for a correct setup (all units must be included), and 1 point can be earned for correctly calculating the amount of CH_4 produced per year. (Units are not required in the answer, but the student must show the calculation in order to receive the answer point.)

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups and arrive at a correct answer will also earn a point. Equivalent correct answers (e.g., 6,300,000,000 kg CH_4/year) are acceptable.

$$2{,}000 \text{ hectares} \times \frac{4.5 \times 10^7 \text{ termites}}{1 \text{ hectare}} \times \frac{70 \text{ kg } CH_4 / \text{year}}{1{,}000 \text{ termites}} = 6.3 \times 10^9 \text{ kg } CH_4 / \text{year}$$

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Question 2 (continued)

(iii) Suppose the temperature increases to 35°C and the relative humidity decreases to 50 percent. Using the data provided, determine the amount of methane, in kilograms, that would be emitted by the termites in the 2,000-hectare tropical rain forest.

One point can be earned for a correct setup, and 1 point can be earned for correctly calculating the amount of CH_4 produced per year (units are not required in the answer). Because this calculation could reasonably be done in a student's head, this answer point can be earned without a setup.

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups that produce a correct answer will also earn a point.
Equivalent correct answers (e.g., 21,000,000,000 kg CH_4/year) are acceptable.

$$\frac{0.09}{0.27} \times 6.3 \times 10^9 \text{ kg } CH_4\text{/year} = 2.1 \times 10^9 \text{ kg } CH_4\text{/year}$$

(iv) Explain why the population size of the termites is also affected by temperature and humidity.

One point can be earned for a reason, and 1 point can be earned for an explanation. The reason and the explanation must be correctly linked; however, students can earn an explanation point without earning a reason point.

Reason	Explanation
• Temperature and humidity are limiting factors for the termite populations and/or their symbionts. • There is a range of tolerance for temperature and humidity values for termites and/or their symbionts.	• At temperatures of 40°C, all termite wood consumption ceases; and at 20°C, activity is at its lowest regardless of relative humidity values. • At 40°C, the symbionts living in the termite's gut may die. • At relative humidity levels less than 90 percent, termite wood consumption declines regardless of temperature.
Termites reproduce less when conditions are not optimal.	Termites swarm less, and fewer new colonies are established.
Temperature and humidity are limiting factors for plant growth and survival.	With fewer plants available, less food will be available and termite numbers will decline.

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Question 2 (continued)

(b) It has been observed that soon after a tropical rain forest is cleared, termite density increases to an estimated 6.8×10^7 termites per hectare. Thereafter, the termite population size decreases dramatically.

One point can be earned in part (i) for the most likely reason, and 1 point can be earned in part (ii).

(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

- When the forest is first cleared, there is a substantial increase in dead plant material.
- The food source for the termites has dramatically increased and supports a larger population of termites.

(ii) Why do the termite populations eventually decrease dramatically?

- The termites exhaust their food supply and die off due to a lack of food.
- The termite population exceeds the carrying capacity of the forest, and the population crashes.
- With no trees, the surface temperatures increase and may exceed the upper temperature limit at which termites can survive.
- There is competition for a limited resource.

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Question 2 (continued)

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

One point can be earned for stating a correct change, and 1 point can be earned for describing the response. The change and the response must be correctly linked. Students can earn a response point without earning a change point.

Change	Climate Response
Reduction in photosynthesis.	Less CO_2 is removed from the atmosphere, increasing the concentration of CO_2, a greenhouse gas, in the atmosphere.
Loss of a carbon sink.	Increased amounts of CO_2 and/or CH_4, greenhouse gases, are released into the atmosphere.
Slash/burn removal of trees.	Increased amounts of CO_2 and N_2O, greenhouse gases, are released into the atmosphere.
Lack of shade.	Warmer surface temperatures.
Reduction in evapotranspiration.	• Loss of cooling effect (atmospheric cooling) from water evaporating. • Drier climate can result in forest fires in other areas, releasing more CO_2 and N_2O, greenhouse gases, into the atmosphere.
Bulldozers, chain saws, and trucks, which are used to remove trees, consume fossil fuels.	CO_2, a greenhouse gas, is released into the atmosphere.
Increase in albedo.	More energy is reflected from the surface.

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Question 3

(a) Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?

One point can be earned for any acceptable explanation:

- The animal was introduced in the eastern U.S. and is still spreading across the continent.
- The eastern states have more surface waters available for colonization and to act as corridors to dispersal; the western states have fewer such habitats.
- The western mountain ranges (e.g., the Rockies) serve as a natural barrier to dispersal.
- Humans spread the animal, and human population density is generally higher in the East.

(b) How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.

Two points can be earned: 1 point for a mechanism by which the mussels are spread and 1 point for a method to prevent mussel introductions. The two responses need not be linked.

Mechanisms of zebra mussel introduction

- Transport of boats or boat trailers with mussels attached
- Carried in water in boats (excluding ballast, which implies oceangoing vessels)
- Inundation of isolated lakes with floodwater containing mussels
- Building canals or other waterways between previously isolated lakes
- Transport by animal vectors (migratory waterfowl, etc.)
- Brought with fish used to stock water bodies

Methods to prevent spread of zebra mussels

- Thorough inspection/cleaning of boats before transport or launch
- Flushing or draining of water between water bodies
- Refraining from building connecting waterways
- Education/information campaigns to discourage practices causing spread
- Prohibiting transport of boats to unaffected lakes

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Question 3 (continued)

(c) Identify and explain one impact that zebra mussels can have on aquatic ecosystems.

One point can be earned for naming an impact, and 1 point can be earned for an appropriate explanation. The identification and explanation must be linked.

Impact on Ecosystem	Explanation
Increased water clarity/transparency	Mussels are filter feeders, removing solids from water as they feed.
Increased light penetration in water column	Remove suspended matter from water.
Increased photosynthesis/primary productivity	Results from increased water clarity.
Increased populations of other species (certain fish, waterfowl, etc.)	Results either from greater primary productivity (base of trophic pyramid) or greater ability of fish that are visual feeders to see their prey.
Competition from zebra mussels for available resources	Decreased populations of other species (mollusks, insects, etc.).
Decreased populations of other species (mollusks, insects, etc.)	Competition from zebra mussels for available resources.
Altered water chemistry	Mussels change biogeochemistry through filtering and digestion of food; shells sequester/store minerals.
Disrupts food chains/trophic dynamics	Eats food required by other species.

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Question 3 (continued)

(d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.

One point can be earned for naming a species, and 1 additional point can be earned for an appropriate explanation of its impact. The identification and explanation must be linked.

Acceptable examples include:

Invasive Species	Negative Impact
Cane toad	Toxin kills native predators.
Rats	Eat bird's eggs; spread disease.
Purple loosestrife	Crowds out native plant species in wetlands.
(Eurasian) water milfoil	Crowds out native plants, clogs waterways.
Snakehead fish	Preys on native fish, reducing populations.
Rabbits	Clear vegetation.
Kudzu vine	Smothers other vegetation.
Emerald ash borer	Burrowing and feeding kill trees.
Sea lamprey	Predation harms other fish.
Nutria	Eats marsh vegetation, destroying wetlands.
(Brazilian) pepper tree	Tissues are toxic; shades out other plants.
Pythons, constrictors	Eat native species, lowering populations.
Japanese/Asian beetles	Eat native plant species.
Pigeon/rock dove	Nuisance in cities; vectors of disease.
(European) starlings	Compete with native birds for nest sites.
Feral domestic animals (e.g., boar, cat)	Predators of native species.
Ice plant	Competes with native plant species.
Africanized ("killer") bees	Attacks people/animals; displaces honeybees.
Boll weevil	Important crop pest.

Note: A correct response must identify a specific organism. General categories of biota (e.g., "snakes") are not acceptable.

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Question 3 (continued)

(e) One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.

One point can be earned for identifying a specific example of biological control, and 1 additional point can be earned for an appropriate explanation of a potential negative impact. The two responses need not be linked.

Acceptable examples include:

Biological Control
• Insects (stem borers, leaf eaters) to feed on purple loosestrife
• Ladybird beetles (ladybugs) to feed on pest insects
• Parasitoid wasps to control weevils
• Bacteria (e.g., Bt) or viruses to control animal pests
• Mongoose to hunt rats
• Cane toads to prey on insect pests

Negative Impact
• Predation of nontarget species
• Competition with native species
• Toxic to native predators, or reduces available food to native predators
• Alters ecological interactions, e.g., food webs or biogeochemical cycles

Note: The "specific example" cannot be hypothetical or a general prescription, e.g., "introduce a predator of agricultural pests."

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Question 3 (continued)

(f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

Two points can be awarded: 1 point for each specific characteristic.

- Generalist species
- Excellent dispersal mechanisms, allowing it to spread
- R-selected or r-strategist

OR any of the following characteristics:

  - Large clutch size/many offspring produced
  - Early onset of reproduction/early maturation
  - Frequent reproduction

- Superior defenses against predators in new environment
- Superior skills as a predator in new environment

Note: Listed characteristics must be specific. Generic qualities or life-history strategies are not acceptable.

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Question 4

(a) Based on the rate cited above, calculate the expected increase in sea level, in meters, during the next 50 years.

One point can be earned for the correct setup, and 1 point can be earned for the correct answer.

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} = 150 \text{ mm} = 0.15 \text{ m}$$

OR

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} \times \frac{1 \text{ m}}{1{,}000 \text{ mm}} = 0.15 \text{ m}$$

(b) Identify TWO phenomena that result from an increase in global mean atmospheric temperature and that contribute to increases in sea level. For each phenomenon that you identify, explain how it causes sea level to increase.

One point can be earned for each identification, and 1 point can be earned for each explanation. Only the first two answers will be considered.

Phenomenon	Explanation
Melting of glaciers, continental ice caps (*"Ice caps" or "polar ice caps" are NOT acceptable answers by themselves.*)	As ice melts, the amount of water in the ocean increases.
Melting of ice sheets (Greenland and Antarctica)	As ice melts, the amount of water in the ocean increases.
Thermal expansion of the ocean	As water warms, water molecules move farther apart and the volume of the ocean increases.
Melting of Antarctic ice shelves	Ice shelves are attached to continental ice and do not displace liquid water; if they break off, they will displace water and raise sea level.

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Question 4 (continued)

(c) Describe TWO environmental impacts that increasing sea level will have on an estuarine ecosystem such as those in the Mississippi Delta, Chesapeake Bay, and San Francisco Bay.

One point can be earned for each description of an environmental impact. Only the first two impacts are considered.

Impact	Description
Loss/flooding/erosion of estuary habitat (conversion to open water)	• Loss of wetlands, marshes, salt marshes, intertidal zone, riparian zone, mangroves. • May lead to changes in water depth, light levels and temperature, causing migration or local extinction of species that have specific requirements. • Inland migration of wetlands. • May lead to loss of species (fish, shellfish, birds) that rely on estuary as a nursery/breeding area.***** • May lead to loss of species that rely on estuary for protection from predators. • May lead to loss of migratory species (birds) that rely on estuary as a stopover.
Increased nutrient loads in the water	Estuaries filter out excess nutrients; without them, eutrophication may lead to algal blooms.
Increased storm destruction of areas adjacent to the estuary	• Estuaries absorb excess water, reducing flooding. • Estuaries provide a physical barrier that protects the area from storm surges, preventing erosion. • Increased erosion of coastline leads to habitat loss.
Change in salinity	• Salinity may increase. • May lead to loss of species that have a small salinity-tolerance range.
Waterlogged soils due to flooding	Loss of marsh plant species.

***Student response should show understanding of estuarine ecosystem.*

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Question 4 (continued)

Impact	Description
Spreading of oil spills that occur in ocean to inland areas	• Oil may coat birds' feathers, reducing insulation and ability to fly. • Oil may coat mammals' coats; animals may ingest the oil during cleaning and die. • Oil may cause suffocation (organisms unable to perform gas exchange).

(d) Although sea level has been rising for over a century, human populations in coastal areas have increased dramatically during this period.

(i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.

One point can be earned: only the first negative economic impact stated will be considered.

Impact	Description
Damage to private property	• Cost of replacement, relocation, or improved construction to reduce storm damage. • Increased insurance premiums. • Decrease in property values (unable to sell).
Loss of income/livelihood	• Loss of commercial fishing. • Loss of income-producing agricultural lands. • Loss of tourism dollars.
Loss of food supply	People who rely on fishing or agriculture in coastal areas will need to buy food.
Saltwater intrusion	Water supplies for drinking and irrigation may require expensive desalination treatment.

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Question 4 (continued)

(ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

One point can be earned for each description; only the first two strategies will be considered.

- Raise premiums or refuse to insure in areas that repeatedly flood/are damaged by storms
- Raise property taxes in coastal areas
- Education campaigns, PSAs, advertising that discourage movement to the coast or encourage movement away from the coast
- Offer incentives to relocate inland, such as jobs, schools, reduced property taxes
- Designate the area as a preserve/reserve making it illegal to build
- Impose stricter penalties for infringements of regulations designed to protect the coastline
- Zone to restrict building in coastal areas, limit distance to coast
- Designate the beach as public property
- Remove or ban human structures designed to stabilize shoreline (seawalls, bulkheads)
- Ban the practice of beach nourishment
- Pass rolling easements in which property owners agree to abandon buildings when their properties become flooded
- Impose a tax to support beach-area protection
- Prevent the building of infrastructure/services (roads, power lines, water lines) that service coastal areas

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