AP® Environmental Science Exam

SECTION I: Multiple Choice

2016

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
100
Percent of Total Score
60%
Writing Instrument
Pencil required
Electronic Device
None allowed

Instructions

Section I of this exam contains 100 multiple-choice questions. Fill in only the circles for numbers 1 through 100 on your answer sheet.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding circle on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

Sample Question	Sample Answer
Chicago is a (A) state (B) city (C) country (D) continent (E) village	Ⓐ ● Ⓒ Ⓓ Ⓔ

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

Form O
Form Code 4MBP

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 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 list of pollutants.

(A) Radon
(B) Mercury
(C) Lead
(D) Copper
(E) Iron

1. Was once widely used in the United States as a gasoline additive

2. A gaseous decay product of uranium that is found in rocks

3. A leading cause of lung cancer in the United States

4. Poses a health risk to humans who eat large quantities of marine fish such as swordfish and tuna

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Questions 5-9 refer to the locations indicated on the diagram below.



5. Large quantities of methane hydrates are located in this region and if released will contribute significantly to global climate change.

6. This region of the world is currently experiencing the largest average annual temperature increase because of anthropogenic climate change.

7. Damaging tornadoes occur most frequently in this area.

8. Fragmentation of tropical forests due to human activities is leading to a significant loss of biodiversity in this area.

9. This region has been the largest petroleum exporter for the past four decades.

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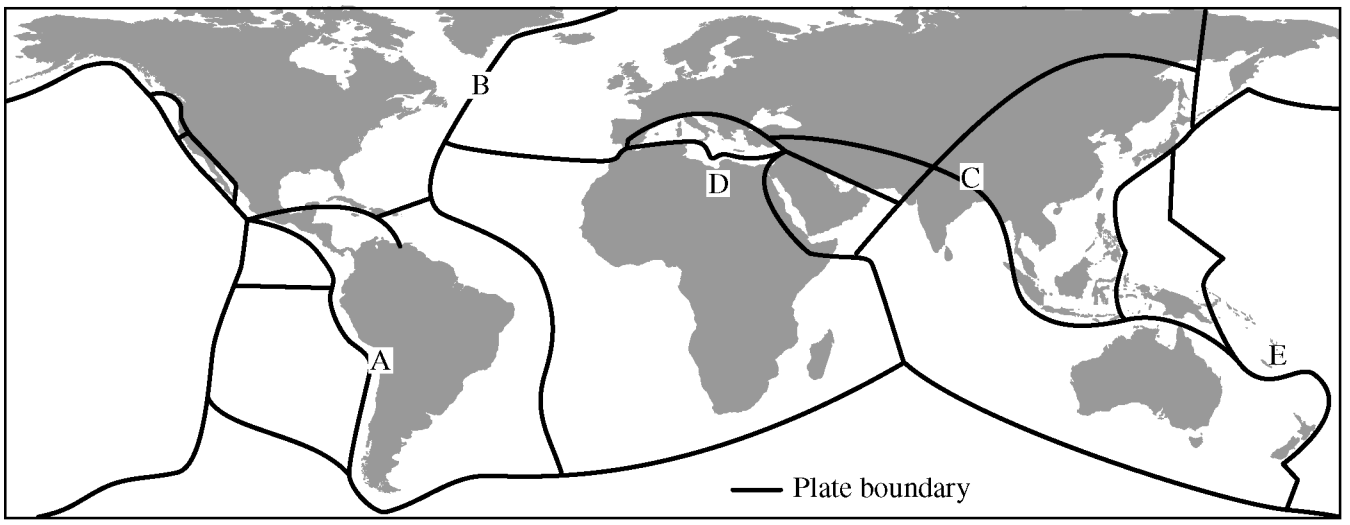
Questions 10-12 refer to the lettered areas of the map below.

EARTH'S MAJOR CRUSTAL PLATES



10. Area that exhibits island arcs

11. Area that exhibits a growing nonvolcanic mountain chain due to uplift

12. Area where new crust is being created at a divergent plate boundary

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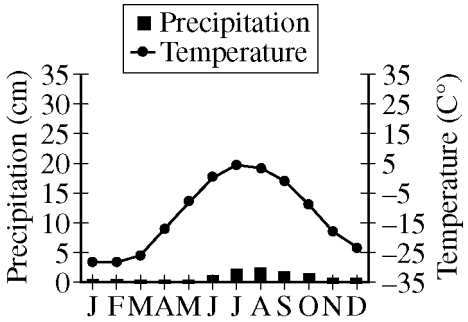
Questions 13-14 refer to the following climatographs.

(A)



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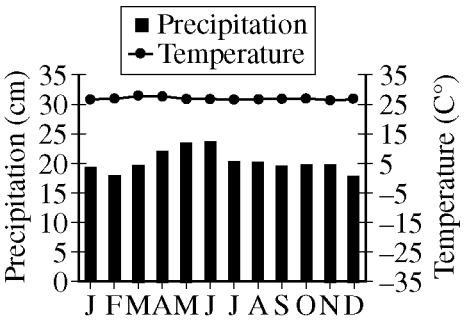

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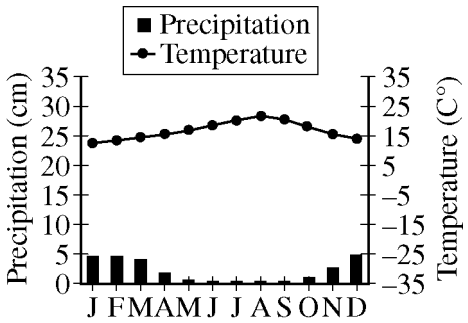

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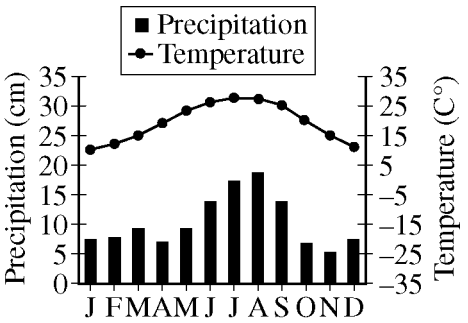

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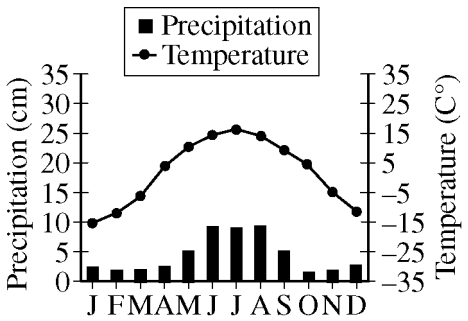

13. Which environment is characterized by the highest diversity of tree species?

14. Which environment is most likely to be characterized by dry scrub with frequent fires?

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Questions 15-16 refer to the countries listed in the following table.

Country	Total Fertility Rate (births per woman)	Infant Mortality Rate (per 1,000 births)	Life Expectancy at Birth (years)
A	6.5	150	48
B	3.3	25	68
C	1.8	60	80
D	2.1	10	80
E	2.4	10	80

15. Which of the countries listed in the chart above is most likely experiencing a population decline?

16. Which of the countries listed in the chart above is most likely to have limited educational opportunities for women?

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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 circle on the answer sheet.

17. The Sun's radiation provides the energy for all of the following EXCEPT

    (A) plant growth
    (B) ocean currents
    (C) hurricanes
    (D) plate tectonics
    (E) cloud formation

18. Phytoplankton are most abundant in the upper few hundred feet of most bodies of water because

    (A) they can most readily hide from predators there
    (B) sunlight does not penetrate to great depths in water
    (C) as primary producers, they must be accessible to many other organisms
    (D) they are benthic organisms
    (E) they feed on zooplankton, which are found only in the top layers of water

19. Catalytic converters reduce which of the following pairs of pollutants in car exhaust?

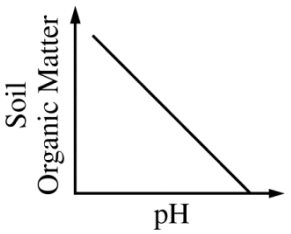
    (A) Carbon dioxide and ozone
    (B) Carbon monoxide and hydrocarbons
    (C) Carbon dioxide and particulates
    (D) Lead and mercury
    (E) Methane and particulates

20. Which of the following accurately describes a fuel cell vehicle?

    (A) Fuel cell vehicles run on both an internal combustion engine and a backup battery.
    (B) Fuel cell vehicles are able to convert waste oil from the food industry into ethanol, which is burned as a source of power.
    (C) Fuel cell vehicles use hydrogen to generate electricity that runs the motor.
    (D) Fuel cell vehicles generate energy by creating a flow of electrons in a semiconducting material such as silicon.
    (E) Fuel cell vehicles use methane to heat water, which creates steam that turns a turbine to generate electricity.

21. Long-term intensive agriculture that does not add soil amendments such as manure or fertilizer has been shown to decrease soil organic matter content. Which of the following figures best shows this relationship?

(A)



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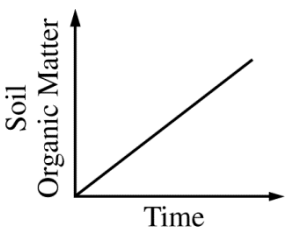

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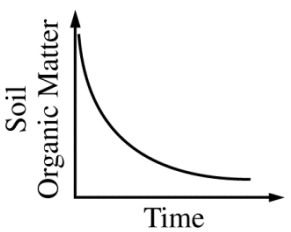

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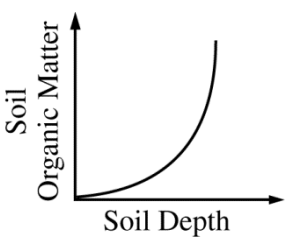

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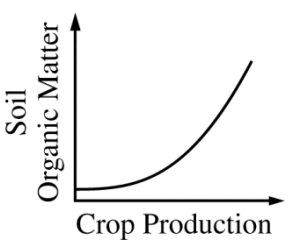

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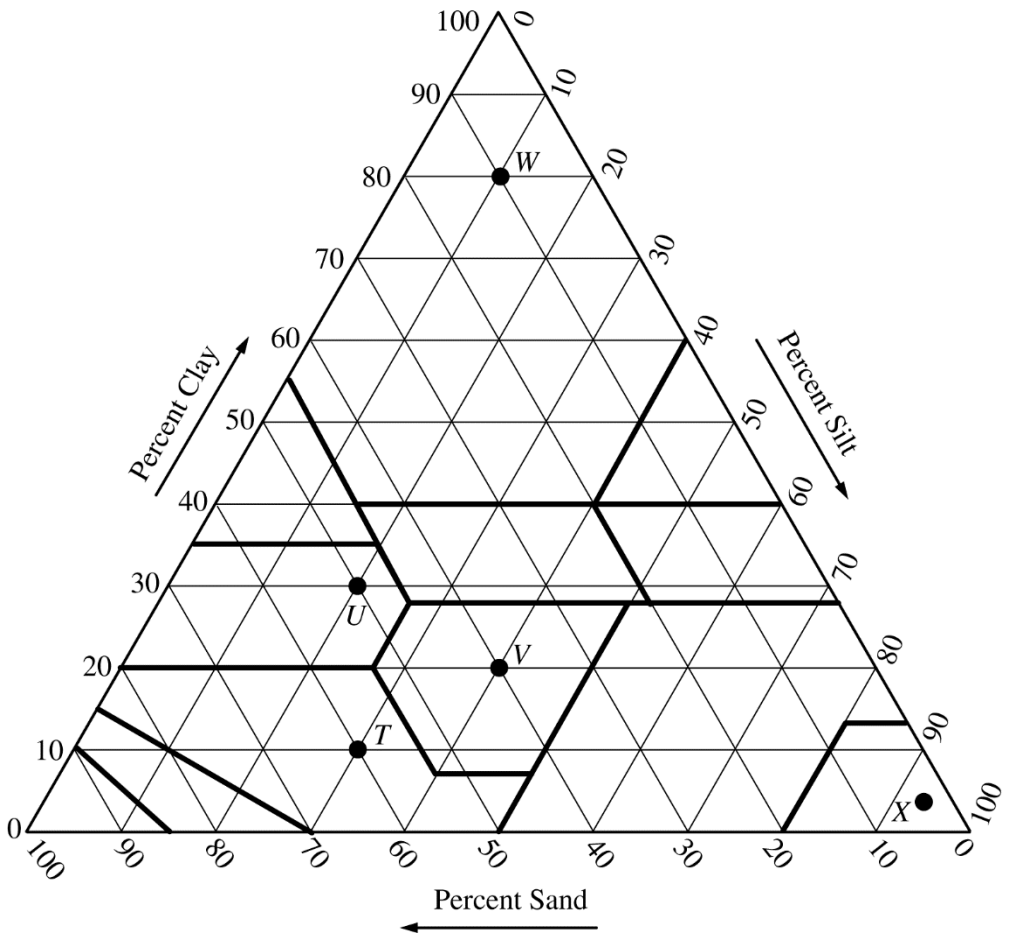
Questions 22-23 refer to the soil composition diagram below.



22. What are the proportions of sand, silt, and clay for the soil at point *T* ?

	% Sand	% Silt	% Clay
(A)	75	20	5
(B)	70	20	10
(C)	65	25	10
(D)	60	30	10
(E)	55	30	15

23. Which soil composition would be the best choice for lining a landfill?

(A) Point *T*
(B) Point *U*
(C) Point *V*
(D) Point *W*
(E) Point *X*

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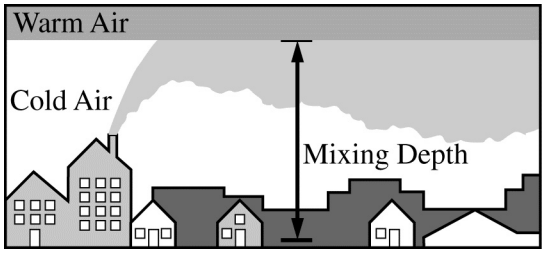

24. What important phenomenon that often plays a role in air pollution episodes is illustrated in the diagram above?

(A) Albedo
(B) Greenhouse effect
(C) Inversion
(D) Stratification
(E) Heat-island effect

25. Which of the following is true of the Ogallala Aquifer?

(A) It underlies the African Serengeti and supplies millions of people with freshwater.
(B) It underlies the Argentine Pampas and is underutilized as a source of water.
(C) It underlies eastern Quebec and is a limited source of freshwater.
(D) It underlies the United States High Plains and is being depleted by overuse.
(E) It underlies central Florida and is contaminated by pesticide and fertilizer runoff from farms.

26. Red pine trees are currently found growing in only the cool northernmost areas of the central and eastern United States. Climate change is expected to have an impact on the distribution of the species. Which of the following describes the most likely change to the distribution of red pine over the next 200 years?

(A) Red pine will grow in only the wetter areas of the southeastern United States.
(B) Red pine will spread to large areas of the Southwest.
(C) The total number of red pine trees will decrease, but red pine trees will continue to grow in the same locations as they grow currently.
(D) Red pine distribution will shift northward into Canada.
(E) Red pine distribution will expand southward to Caribbean nations.

27. Which of the following represents a positive feedback loop in the Arctic that is associated with anthropogenic climate change?

(A) Arctic Ocean ice melts → ocean surface water temperature increases → more ice melts
(B) Arctic Ocean ice melts → ocean surface water temperature decreases → more ice melts
(C) Arctic Ocean ice melts → ocean surface water temperature increases → more ice forms
(D) Arctic Ocean ice forms → ocean surface water temperature increases → more ice melts
(E) Arctic Ocean ice melts → ocean surface water temperature decreases → less ice melts

28. Construction of a solar power plant is proposed for a desert area near a school. A student has hypothesized that the shade cast by the solar panels will increase the mortality of creosote bush, a native desert plant in the area. Before construction begins, what experimental data should the student collect in order to eventually test the hypothesis?

(A) The rate of increase in atmospheric CO_2 worldwide (in ppm) that occurs in the 12-month period prior to the start of construction
(B) Average noise levels (in decibels) at a construction site, compared to average noise levels in the desert 20 km away from the construction site
(C) The rate of wind-caused soil erosion (in kg/yr) near solar panels at a similar desert location where creosote bush grows
(D) The direct sunlight received by creosote bush in the desert area (in kWh/m^2) during a 12-month period
(E) The changes in monthly precipitation (in mm/yr) at a similar desert location where creosote bush grows

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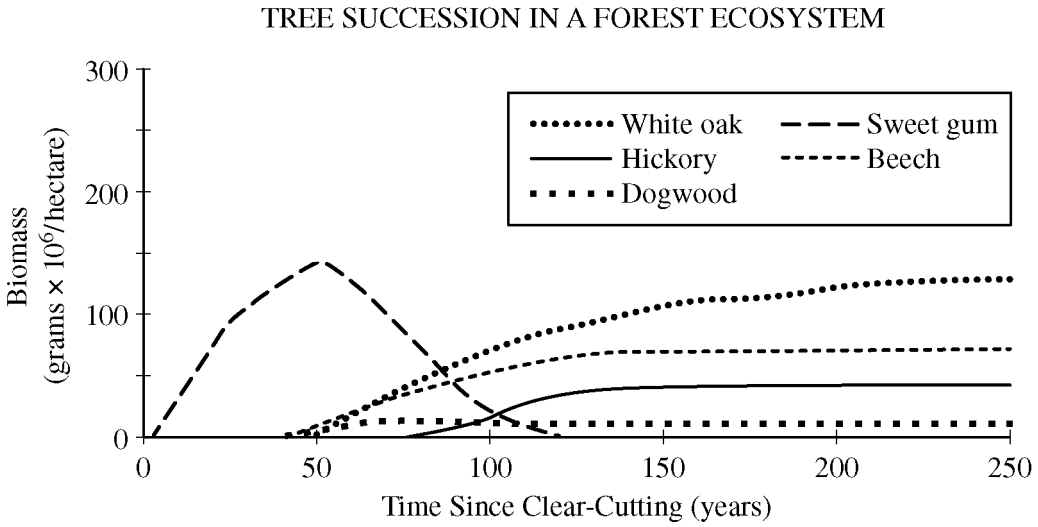
Questions 29-30 refer to the following graph.



29. At which time after clear-cutting does the ecosystem exhibit the greatest species richness?

(A) 50 years
(B) 100 years
(C) 150 years
(D) 200 years
(E) 250 years

30. Which tree species grows best with full sunlight?

(A) White oak
(B) Hickory
(C) Dogwood
(D) Sweet gum
(E) Beech

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31. Most deserts on Earth are located near the 30° north and 30° south latitudes because humidity is lower at 30°. The best explanation for the lower humidity is that

(A) warm air rises at 90° latitude, cools, and sinks at 30°
(B) cool air rises at 30° latitude, warms, and sinks at the equator
(C) warm air rises at the equator, cools, and sinks at 30° latitude
(D) trade winds transfer moisture away from 30° latitude
(E) rain-shadow effects are most pronounced at 30° latitude

32. Many homeowners are unaware that their garbage may contain hazardous waste, which should be taken to a designated hazardous waste dump site instead of being placed in their regular trash. All of the following are considered household hazardous waste EXCEPT

(A) batteries
(B) bug spray
(C) motor oil
(D) oil-based paint
(E) food scraps

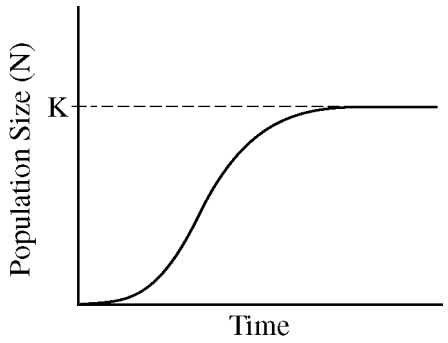
33. Which of the following is a reason why hybrid electric vehicles use less fossil fuel per mile traveled than a typical internal combustion engine vehicle uses?

(A) Hybrid electric vehicles don't burn fossil fuels; they run on electric energy.
(B) Hybrid electric vehicles are powered by the Sun using rooftop photovoltaic panels.
(C) When the brakes are applied in hybrid electric vehicles, kinetic energy is converted into electric energy to charge the batteries that assist the electric motor.
(D) Batteries in hybrid electric vehicles can be charged in the driveway overnight, when rates for electricity usage are typically low.
(E) The engines in hybrid electric vehicles are powered by biofuels made from genetically modified corn.

34. For which of the following reasons do small isolated islands have a greater rate of species extinction than larger, less isolated islands ?

(A) Small isolated islands are more likely to receive more migrating species.
(B) Small isolated islands provide opportunities for a greater diversity of species.
(C) Because of their size, small isolated islands accumulate more species by chance.
(D) Small isolated islands have a lower availability of resources.
(E) Because they have fewer available niches, small isolated islands are targeted and colonized by species.

35. In the graph below charting the growth of a population of organisms, the line labeled K represents the



(A) biotic potential of the organism
(B) doubling time of the population in the environment
(C) carrying capacity of the population
(D) reproductive lag time of the organism
(E) intrinsic rate of increase of the population in the environment

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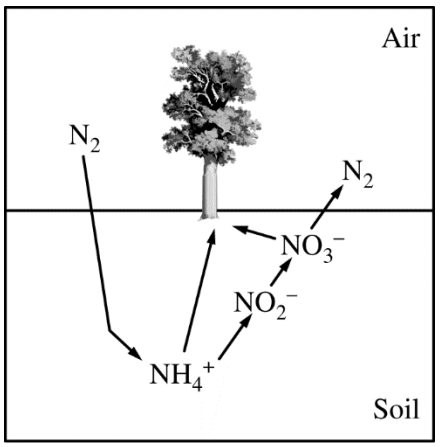
36. Which of the following diagrams correctly illustrates the nitrogen cycle?

(A)



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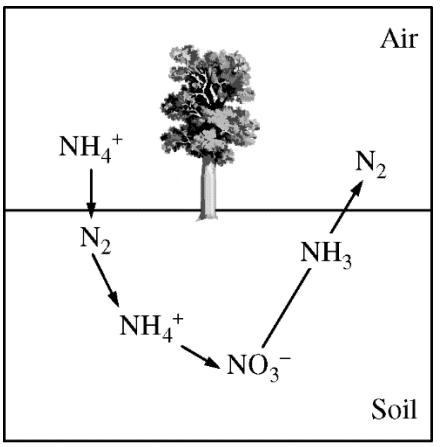

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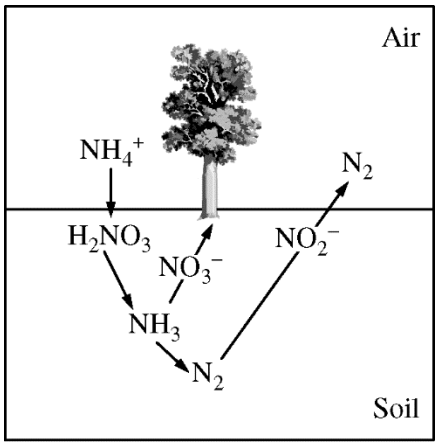

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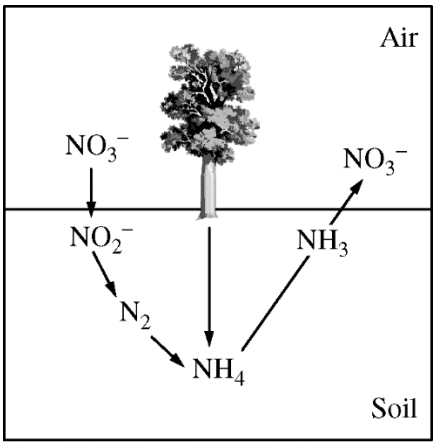

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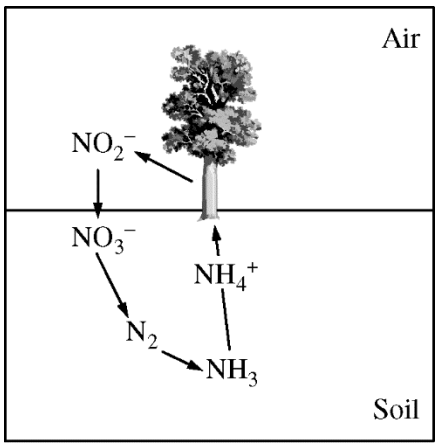

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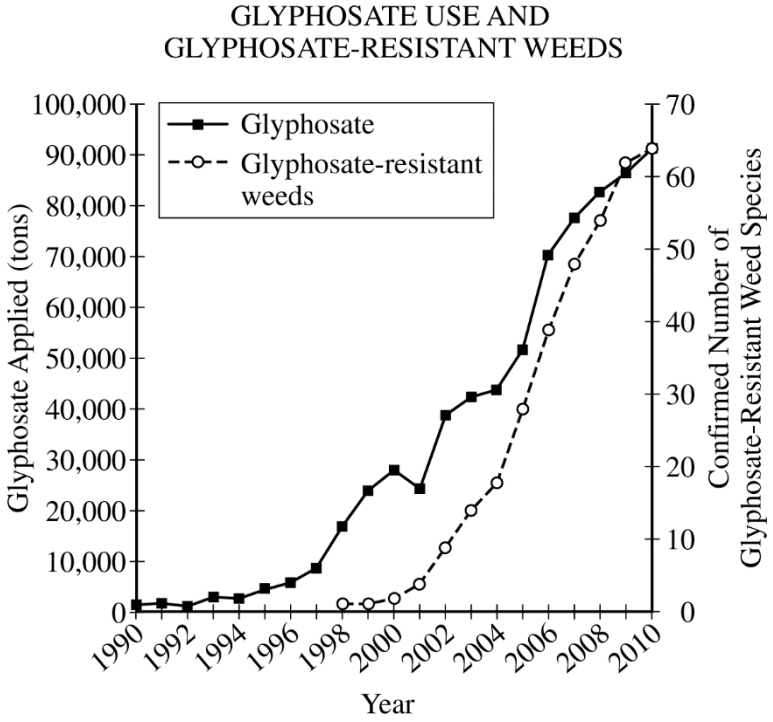
Questions 37-39 refer to the graph.

Glyphosates are herbicides that are often applied to genetically modified (GM) crops to kill weeds without harming the crop itself.



37. Which of the following statements best explains the relationship shown on the graph?

(A) Increased use of glyphosate herbicides kills more weeds and thus leads to higher crop yields.
(B) The use of glyphosate herbicides has decreased because it has been shown to be ineffective in killing weeds.
(C) The use of glyphosate has selected for herbicide resistance in weed populations.
(D) The use of glyphosate herbicides has decreased because the cost of the herbicides has increased.
(E) Increased use of glyphosate herbicides correlates to increased agricultural profit.

38. Which of the following statements identifies a concern associated with the increased proportion of GM crops being grown?

(A) Planting GM crops results in reduced crop yield, which causes more land to be put into production.
(B) Use of GM seeds can lead to loss of genetic diversity in crops.
(C) GM crops cannot be grown in marginal soils.
(D) Runoff from GM crop fields can lead to increased eutrophication.
(E) GM crops cannot withstand herbicide application, reducing crop yield.

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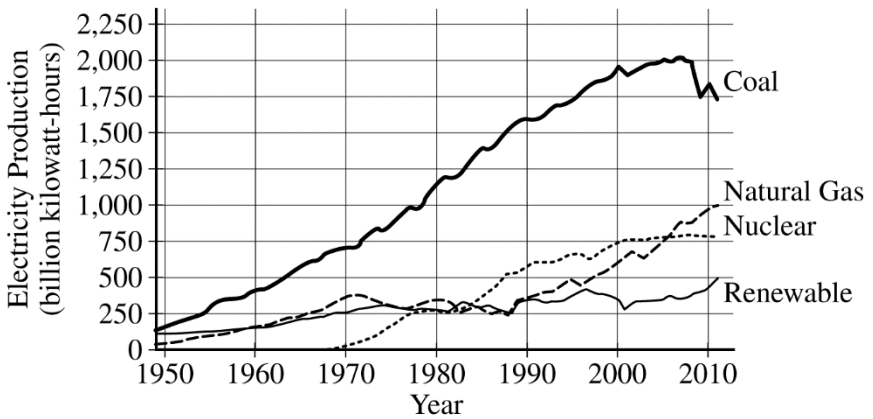
39. Some studies have indicated that global amphibian populations are declining and that exposure to herbicides in agricultural runoff is implicated in the decline. Which of the following is the most likely explanation of how herbicides affect amphibians?

(A) The herbicides are fat soluble and accumulate in groundwater.
(B) The herbicides act as a plant nutrient, causing algal blooms.
(C) The herbicides act as endocrine disruptors.
(D) The herbicides are ingested by amphibians that mistake them for food.
(E) The herbicides contain heavy metals.

SOURCES OF ELECTRICITY IN THE UNITED STATES, 1950–2010



40. Which of the following is the most valid inference regarding electricity production, based on the graph above?

(A) Electricity production from coal began to decrease in 2008 because of shortages in coal supplies.
(B) Electricity production from coal began to decrease in 2008 because of the increasing use of natural gas and renewable energy.
(C) The use of nuclear energy increased from 1970 to 2010 because of the low cost of constructing nuclear power plants.
(D) The use of nuclear energy increased from 1970 to 2010 because of shortages in coal supplies.
(E) Renewable energy has not increased as much as nuclear energy has since 1970 because of federal laws restricting construction of wind farms.

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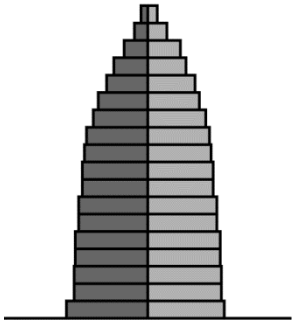
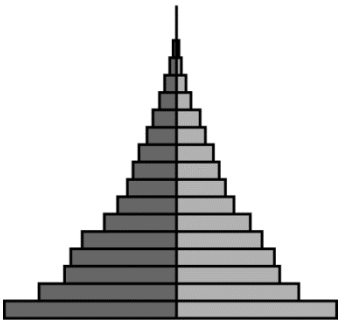
41. Which of the following age structure diagrams represents a population that most likely has a negative growth rate?

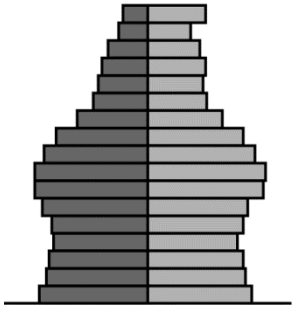
(A) Male Female



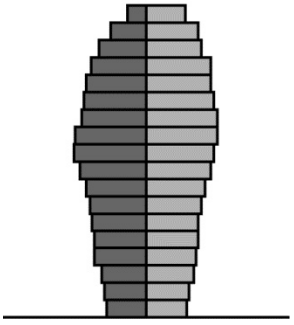
(B) Male Female



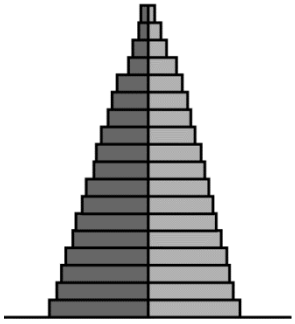
(C) Male Female



(D) Male Female



(E) Male Female



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WATER QUALITY DATA FOR AN ILLINOIS STREAM

Site	Water Temperature (°C)	Forest Canopy (% shaded)	Turbidity (NTU for 24 hr)	Total Dissolved Solids (mg/L)	pH	Hardness (ppm)
A	20	35	10	220	7.2	85.7
B	15	80	8	220	7.2	85.5
C	22	70	100	2,000	7.0	86.0
D	15	80	2	220	7.1	84.3
E	15	90	30	800	4.0	150.3

42. Based on the data table above for a stream in Illinois, which site most likely has a construction site immediately upstream from it?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

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43. Corn can be grown at a rate of 1,000 kcal per hectare, and it takes 20 times more land to produce beef than it does to produce corn. Which of the following equations would correctly calculate the amount of land needed to produce 10,000 kcal of beef?

(A) $10{,}000 \text{ kcal corn} \times \frac{20 \text{ ha}}{\text{kcal beef}} \times 100 \text{ ha}$

(B) $\frac{1 \text{ ha}}{1{,}000 \text{ kcal corn}} \times \frac{20 \text{ kcal corn}}{1 \text{ kcal beef}} \times 10{,}000 \text{ kcal beef}$

(C) $\frac{20 \text{ kcal beef}}{1 \text{ kcal corn}} \times \frac{10{,}000 \text{ kcal}}{10 \text{ ha}} \times \frac{20 \text{ beef}}{1 \text{ corn}}$

(D) $\frac{20 \text{ ha}}{1{,}000 \text{ kcal beef}} \times \frac{1{,}000 \text{ kcal corn}}{1 \text{ ha}}$

(E) $\frac{10 \text{ ha}}{10{,}000 \text{ kcal beef}} \times \frac{10{,}000 \text{ cal corn}}{1 \text{ ha}} \times \frac{1 \text{ ha corn}}{20 \text{ ha beef}}$

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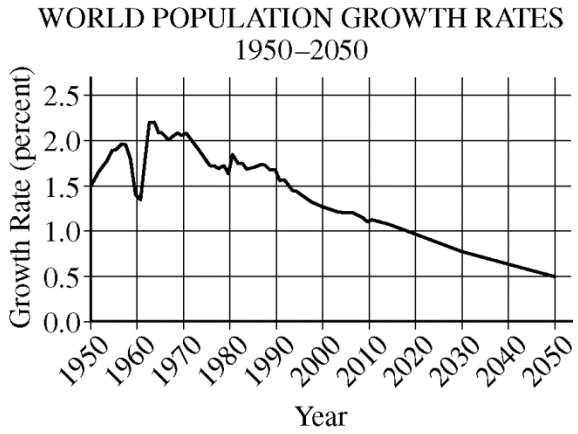
44. Which of the following is considered an advantage of using nuclear power to generate electricity?

(A) No waste is generated.
(B) There is a limitless supply of the raw material needed for the process of generating energy.
(C) Nuclear power plants are inexpensive to build and maintain.
(D) There is no potential for thermal pollution.
(E) There is no CO_2 emitted from the nuclear reaction.

45. The presence of which of the following in soil is most likely to neutralize acid rain?

(A) Limestone
(B) Granite
(C) Sand
(D) Radon
(E) Humus



46. The world population growth rate in 2015 is about 1 percent. It is expected to drop to 0.5 percent by 2050, partly because of increased access to birth control in developing nations. Another likely cause for the expected decline is

(A) a decrease in the spread of pandemic diseases like Ebola
(B) an increase in the total fertility rate in developed nations
(C) an increased global food supply as a result of climate change
(D) increasing numbers of women entering the workforce in developing nations
(E) medical advances that will increase the life spans of people in developing nations

47. Brown pelicans are fish-eating birds. As a result of an El Niño event, the population of brown pelicans in southern California declines. Which of the following best explains the relationship between the El Niño event and the population decline?

(A) Warmer ocean temperatures can cause fish to move to colder water farther from pelican nest sites.
(B) Lower sea surface heights can result in pelican nest sites being isolated too far from their food supply in the ocean.
(C) The female reproductive tract of birds does not function at the lower water temperatures of El Niño.
(D) Male pelicans get disoriented due to the lack of moisture and fail to return to the nest with food.
(E) Predatory seal populations increase dramatically due to decreased rainfall.

48. Open oceans produce the largest share of Earth's biomass because the net primary productivity (NPP) of the oceans is

(A) high and thus can support a high proportion of producers
(B) high as a result of the high concentration of nutrients in the open oceans
(C) low, but the large expanse of the oceans supports enormous numbers of producers such as phytoplankton
(D) low, but the individual producers found there are huge in size
(E) low, but still higher than that of other ecosystems of the world

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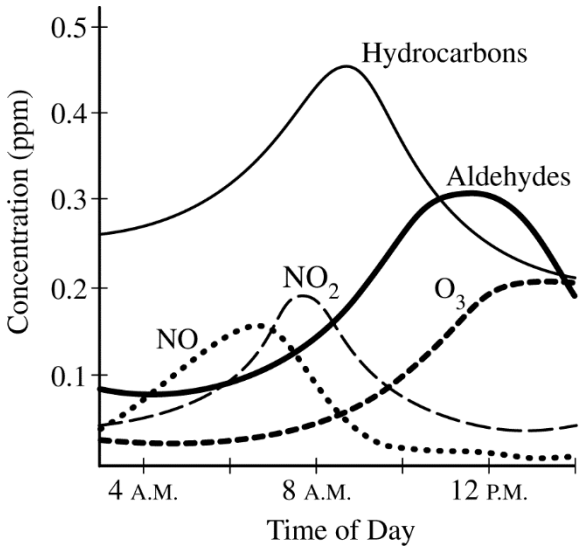
Questions 49-50 refer to the diagram below, which depicts the concentrations of various gases in the air over a city on a typical smoggy day.



49. Which of the following best explains the pattern in NO concentration?

(A) NO is a secondary pollutant with a long residence time in the atmosphere.
(B) NO does not play a significant role in smog formation.
(C) NO is formed in the lower atmosphere in the morning by the rising Sun.
(D) NO is produced by rush-hour traffic and is quickly oxidized in the atmosphere.
(E) NO is quickly absorbed by plants and converted to sugars.

50. If technology that reduces the hydrocarbon concentration had been utilized, which of the following would have been the most likely result?

(A) The concentration of NO would have been higher.
(B) The concentration of CO_2 would have been lower.
(C) The concentration of O_3 would have been higher.
(D) The concentration of O_3 would have been lower.
(E) The concentration of aldehydes would have been higher.

---

51. Coal was surface mined from five sites, labeled 1 through 5, that had originally been covered by forest. Each site was planted with a mix of tree seedlings to reclaim the area to forest. Grass was also seeded over each site to prevent initial erosion and to provide forage. Ten years after planting, information was collected at the five sites and is given in the table below. Select the letter of the row that indicates the site with the most successful forest reclamation.

	Site Number	Percent Grass Cover	Number of Tree Species Surviving	Percent Tree Cover	Average Height Increase of Seedlings (cm/yr)
(A)	1	90	4	5	4
(B)	2	80	4	10	5
(C)	3	70	4	25	8
(D)	4	50	3	40	10
(E)	5	35	3	65	20

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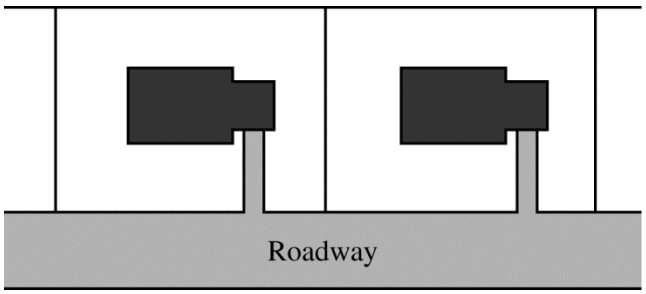
Questions 52-54

A new 450-unit housing development will replace several small farms on the outskirts of Fremont. The development will be composed of 1/4-hectare lots with nearly identical footprints, as show below.



52. Which of the following will be the greatest impact of the development on the local water supply?

(A) There will be less recharge of groundwater.
(B) There will be less runoff to fill reservoirs.
(C) There will be higher humidity in the suburb.
(D) There will be decreased soil exposure, reducing bacteria loads in surface water.
(E) There will be decreased erosion in local streams.

53. Storm water runoff from the new development into nearby Samel Creek will likely lead to which of the following?

(A) Biomagnification of mercury in birds of prey such as eagles and osprey
(B) Improved recreational opportunities for swimmers and boaters
(C) Destruction of fish habitats by high levels of suspended solids and sediments
(D) Contamination of drinking water supplies by volatile organic compounds such as ozone
(E) Increased incidence of waterborne diseases such as malaria

54. One important step that homeowners in the new development can take to protect water quality in Samel Creek would be to

(A) apply lawn fertilizers immediately before storm events
(B) channelize Samel Creek to improve water flow during storm events
(C) use only persistent organic pesticides to control weed species in their lawns
(D) make certain that pet waste is disposed of directly into storm drains
(E) use rain barrels to reduce the flow of storm water into the creek

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55. The table below shows measurements of the beak size of a sample of ten ground finches on each of two islands in the Galápagos archipelago. The two islands are about ten kilometers apart, and all the birds are the same species. Given that beak size is genetically determined, which of the following hypotheses is the most likely explanation for the differences in data between the islands?

Daphne Island Beak Size (mm)	Santa Cruz Island Beak Size (mm)
9.55	10.05
8.70	9.74
9.62	10.27
9.22	9.81
8.79	10.46
9.61	10.24
9.02	10.02
7.85	10.30
9.01	10.43
8.26	10.52

(A) Egg mortality differs on the islands.
(B) Beak size exerts selective pressure on prey size.
(C) Birds on Daphne Island live longer than birds on Santa Cruz Island.
(D) Large-beaked birds move to Santa Cruz Island and small-beaked birds move to Daphne Island.
(E) The types of food found on the two islands exert selective pressure on beak size.

56. A family of five recently replaced its 5-gallon-per-minute showerheads with water-saving 2-gallon-per-minute showerheads. Each member of the family averages 8 minutes in the shower per day. In a 30-day period, how many fewer gallons of water will the family use with the new showerheads?

(A) 60
(B) 800
(C) 2,400
(D) 3,600
(E) 7,200

57. Hydraulic fracturing, or fracking, is the pumping of highly pressurized water with a mixture of sand and chemicals into boreholes to

(A) create cracks within the rock in order to provide pathways for the release of gas and oil
(B) pulverize the rock in order to let gas and oil rise through the soil horizons
(C) reopen old mine shafts, from which gas and oil can be collected
(D) create seismic movement and artificial earthquakes in order to liberate gas and oil
(E) supersaturate the rock with the fracking fluid, which scrubs gas and oil from the rock by abrasion

58. Which of the following describes the changes in a country's demographics as it begins its transition from a preindustrial state to an industrial state?

(A) Population increases rapidly, birth rate declines, death rate increases
(B) Population increases rapidly, birth rate declines, death rate remains high
(C) Population decreases rapidly, birth rate declines, death rate decreases
(D) Population decreases rapidly, birth rate remains high, death rate increases
(E) Population increases rapidly, birth rate remains high, death rate decreases

59. All of the following are negative externalities EXCEPT

(A) illnesses related to living near a manufacturing facility
(B) noise associated with living near a major airport
(C) air pollution caused by refinery emissions
(D) bees pollinating vegetables in addition to creating honey
(E) damage to crops from automobile exhaust

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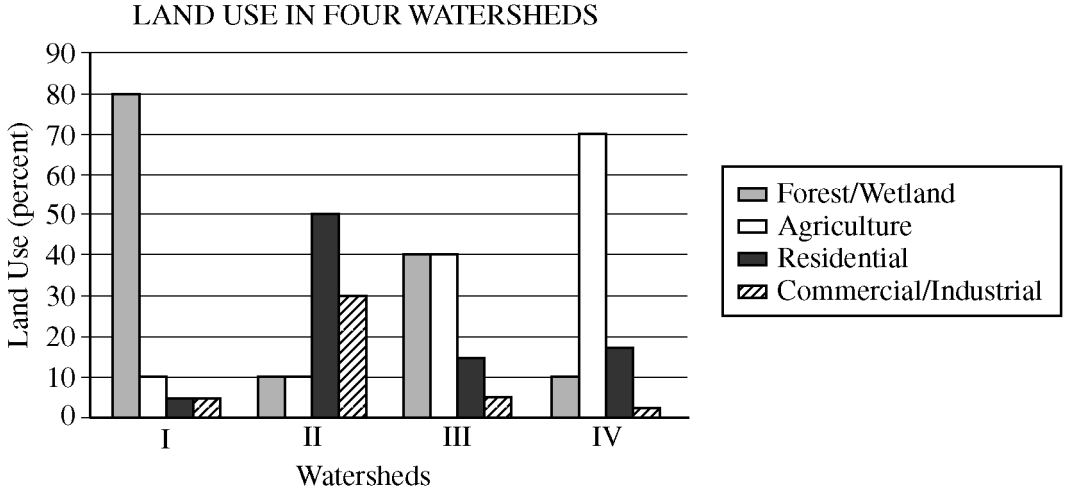

60. Based on the information shown in the graph, which of the following statements is most likely to be true?

(A) Streams in watershed I experience substantially more algal blooms than those in watershed IV.
(B) When precipitation varies, streams in watershed II experience the greatest fluctuations in water volume.
(C) Watershed III has the highest percentage of impervious surfaces.
(D) The water quality of streams in watershed IV is excellent because of the abundance of nutrients available to aquatic organisms.
(E) Low dissolved oxygen is a severe problem in the streams in watershed I because of the inability of light to penetrate the forest canopy.

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61. A vegetable farmer wishes to switch to a combination of trees and vegetables (agroforestry) on several hectares of her land to reduce erosion and to diversify what she grows. She needs to assess whether her land can produce as much income by growing two crops instead of one. The farmer estimates that the new tree crop would cover 40 percent of her fields, with the vegetable crop covering the other 60 percent. Which equation should she use to calculate how much total income she would get from using the new two-crop plan?

(A) $\left(\frac{\$\text{ income trees}}{\text{ha}} \times 0.4\right) + \left(\frac{\$\text{ income veg.}}{\text{ha}} \times 0.6\right) = \text{agroforestry income}$

(B) $\left(\frac{\$\text{ income trees}}{\text{ha}} \times \text{total ha} \times 0.6\right) + \left(\frac{\$\text{ income veg.}}{\text{ha}} \times \text{total ha} \times 0.4\right) = \text{agroforestry income}$

(C) $(\$\text{ income veg.} \times 0.4) + (\$\text{ income trees} \times 0.6) = \text{agroforestry income}$

(D) $\left(\frac{\$\text{ income trees}}{\text{ha}} \times \text{total ha} \times 0.4\right) + \left(\frac{\$\text{ income veg.}}{\text{ha}} \times \text{total ha} \times 0.6\right) = \text{agroforestry income}$

(E) Total income from old crop $\times 0.4$ = agroforestry income

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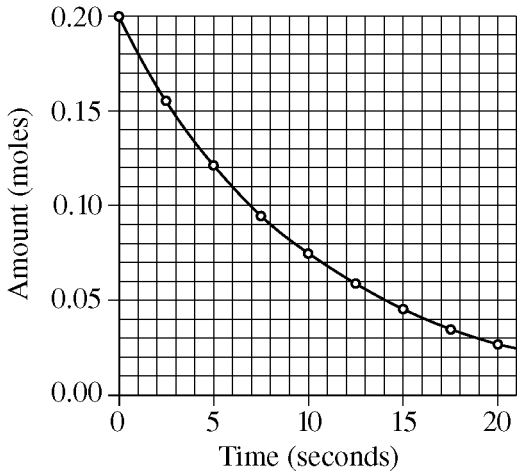
62. Surface oceanic circulation results most directly in the

(A) distribution of heat from tropical to temperate and polar regions
(B) movement of benthic organisms from polar to temperate regions
(C) spring and fall overturn of temperate bodies of water
(D) restriction of the jet stream to polar regions
(E) moderation of ocean acidification



63. The half-life of a radioactive substance with the decay rate shown in the graph above is closest to

(A) 5 seconds
(B) 7 seconds
(C) 14 seconds
(D) 18 seconds
(E) 21 seconds

64. In August of 2014, residents of several Ohio cities that use Lake Erie as a drinking water source were warned not to drink tap water because of the presence of toxins released by blue-green algae (cyanobacteria). Which of the following is the most likely cause of recent blooms of blue-green algae in Lake Erie?

(A) Increased recreational use of Lake Erie
(B) Cooler average summer temperatures
(C) Phosphorus contained in agricultural runoff
(D) Carbon in wastewater from fracking operations
(E) Chlorine from sewage treatment plants along Lake Erie's shoreline

65. Researchers have found that over the last twenty years there are fewer native plants in the alpine meadows of the Rocky Mountains east of Salt Lake City and that the abundance of two species of invasive grasses has increased. Which of the following questions is most appropriate to ask when investigating the cause of the change in the alpine meadows?

(A) Has an increase in soil nitrates from air pollution allowed the invasive grasses to outcompete the native plants?
(B) Has the increased level of tropospheric ozone raised the soil pH of the meadows to a level that the native plants cannot tolerate?
(C) Has an increased frequency of El Niño events led to drought conditions, thereby making the alpine soils too dry for native species?
(D) Has an increase in the population of wolves led to an increase in the population of deer that eat native plants?
(E) Has fire suppression accompanied by prolonged drought increased the abundance of native shrubs?

66. An experiment was carried out to determine the lethal dose of ammonium sulfate on mung bean germination. True statements about the experimental design include which of the following?

I. The control group has neither the seeds nor the ammonium sulfate.

II. The independent variable is the concentration of the ammonium sulfate.

III. The dependent variable is the number of seeds that failed to germinate.

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

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67. A major limitation of using photovoltaic cells to generate electricity is that they

(A) do not produce as much CO_2 as other energy sources do
(B) do not produce as much electricity on cloudy days
(C) have no moving parts
(D) present a danger to birds and bats
(E) cannot be connected to the electrical grid

68. Major anthropogenic sources of nitrogen pollution include commercial fertilizers, vehicle exhaust, industrial air pollution, and

(A) disposal of refrigeration units
(B) discharge of sewage to surface waters
(C) ocean dumping of trash
(D) use of persistent pesticides
(E) oil spills like those in the Gulf of Mexico

69. Burning one gallon of gasoline in a car releases approximately 20 pounds of CO_2 into the atmosphere.

One person drives 60,000 miles in a car that averages 30 miles per gallon (mpg), while another person drives 60,000 miles in a car that averages 20 mpg. Over the course of the 60,000 miles, how many fewer pounds of CO_2 are released by the 30 mpg car than by the 20 mpg car?

(A) 2,000
(B) 8,000
(C) 20,000
(D) 80,000
(E) 100,000

70. Which of the following measures would be most likely to promote fertility above replacement level?

(A) Government endorsement of the two-child family
(B) Education of society on the long-term benefits of having smaller families
(C) Government advocacy of abstinence to discourage teen pregnancies
(D) Elimination of tax benefits for families with more than two children
(E) Public housing priority for families with more than two children

71. Which of the following is true about the Clean Air Act Amendments of 1990 ?

(A) They allowed power plants to buy and sell SO_2 pollution allowances.
(B) They decreased the CAFE (corporate average fuel economy) standards for light trucks from 29 mpg to 12 mpg.
(C) They regulated the concentration of eleven common pollutants inside homes.
(D) They increased the allowable level of tropospheric ozone from 80 ppb to 100 ppb.
(E) They regulated the emission of CO_2 by power plants.

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POSTAWKO CREEK WATERSHED ANALYSIS

Site	Macroinvertebrate Diversity Index	pH	Nitrates (mg /L)	Phosphorus (mg /L)	Dissolved Oxygen (ppm)	Fecal Coliform (# colonies/100 mL)
A	0.852	7.2	15.0	0.10	8.0	80
B	0.795	7.0	7.0	0.07	10.0	47
C	0.439	7.1	40.0	1.00	1.5	500
D	0.923	7.3	8.0	0.08	9.0	58
E	0.848	7.3	17.0	0.15	7.9	90

72. Until 2005 the entire Postawko Creek Watershed in Fremont County consisted of a national forest interspersed with hay meadows and houses on lots with a minimum size of five acres. In 2005 Farmer Cobb opened a dairy farm in the watershed, and the citizens of Fremont County became concerned that the runoff from the dairy farm would negatively impact the water quality of the watershed. Scientists employed by the county collected water quality data at five sites in the watershed; some of the data are compiled in the table above. Based on these data, which site is most likely immediately downstream from the dairy farm?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

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73. Which of the following is the most likely route for mercury to enter the food web?

(A) Municipal waste → landfill → groundwater → plants and vegetation
(B) Coal-burning emissions → deposition → ocean → plankton → fishes
(C) Organic fertilizers → soil → groundwater → lake → trout
(D) Medical waste incinerators → stratosphere → grass → cows
(E) Mining waste → acid deposition → surface runoff → plants and vegetation

74. A student group is involved in a restoration study of a nearby disturbed area. They decide to collect six soil samples and analyze them for carbon (C) and nitrogen (N). Two of the samples are found to be very high in C and N, but the other four samples are low in both. The students also notice that the color of the two soil samples that are high in C and N is very dark. Which of the following is the most likely explanation of the data?

(A) Two of the samples were collected from an A horizon, and the others were collected from a B horizon.
(B) Two of the samples had more sand and gravel than the other four.
(C) Four of the samples were collected from an area that had been restored previously and now has thick vegetation.
(D) Four of the samples were collected from an area that had been mulched.
(E) Four of the sample sites had been treated recently with a chemical fertilizer.

75. Eutrophication results in the death of trout and other fish as a result of

(A) toxic pH levels in the water
(B) asphyxiation from lack of oxygen
(C) toxic levels of mercury in the water
(D) toxic concentrations of salt in the water
(E) a lack of sufficient minerals in the water

76. Consumers who get their electricity from coal-fired power plants are not paying the true cost of energy production in their monthly utility bills. Which of the following is true about utility bills for these consumers?

(A) The bills do not include public health costs, such as those associated with air pollution.
(B) The bills do not include the cost of power distribution.
(C) The bills do not include the cost of marketing electricity.
(D) The bills include the cost of environmental damage associated with transporting coal.
(E) The bills include the cost of cleaning up acid mine damage.

77. Which of the following is an example of a carbon sink?

(A) Deposition of organic matter on the deep ocean floor
(B) Clearing of trees in the Amazon forest
(C) Combustion of fossil fuels in power plants
(D) Decomposition of food waste by bacteria
(E) Nutrient uptake by the roots of grasses in a suburban lawn

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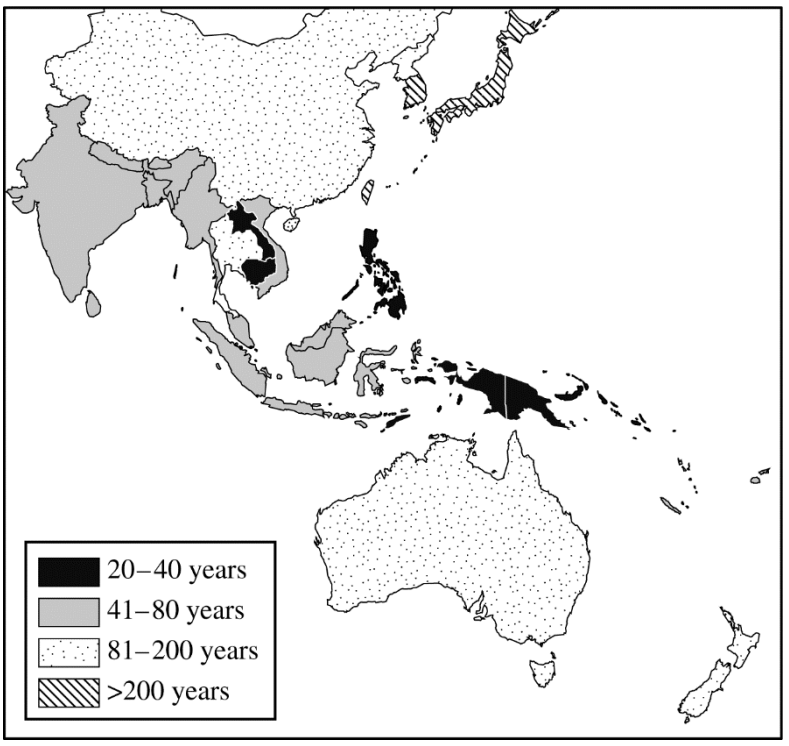
POPULATION DOUBLING TIMES, BY COUNTRY



78. Which of the following statements is best supported by the population doubling times indicated on the map?

(A) Australia and China both have a greater population than the other countries have.
(B) India has a higher population growth rate than China and Australia have.
(C) The countries with the shortest doubling times have higher population densities than the other countries have.
(D) The countries with the longest doubling times are less developed than the other countries.
(E) The most arable land for growing crops is in Australia and China.

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79. Extraction of natural gas by the process of hydraulic fracturing (fracking) is most likely to result in which of the following environmental problems?

(A) Groundwater contamination
(B) Ozone depletion
(C) Eutrophication
(D) Denitrification
(E) Desertification

80. An alpine area of a national park near a trail is normally covered by plants, but much of the area is now bare soil. Park rangers suspect that trampling by hikers has killed the plants. Which of the following will best test the hypothesis?

(A) Counting the number of hikers leaving the trail in comparison with the number of hikers leaving other trails
(B) Counting the number of plants along the trail in comparison with the number of plants along other trails
(C) Comparing the number of hikers this year to the number of hikers last year on various trails
(D) Comparing plant survivorship in areas where hikers stay on the trail with plant survivorship in the area where hikers leave the trail
(E) Comparing the ages, heights, and weights of hikers on different trails

81. The K-selection reproductive strategy maximizes survival of offspring by producing

(A) few offspring with high levels of parental care
(B) few offspring with low levels of parental care
(C) many offspring with high levels of parental care
(D) many offspring with low levels of parental care
(E) many offspring without parental care

82. Approximately 60 percent of municipal solid waste in the United States is composed of some form of organic matter that could be composted. Every American generates approximately 2 kg of waste every day. The amount of compostable waste that could be generated by one individual in a week would be closest to

(A) 0.6 kg
(B) 1.2 kg
(C) 4.2 kg
(D) 6.0 kg
(E) 8.4 kg

83. Which of the following scenarios is NOT likely to result from increased temperatures in the Arctic?

(A) Increased numbers of mosquitoes drive caribou to higher, cooler elevations where there is less vegetation.
(B) Increased melting of the permafrost increases the amount of methane that escapes into the atmosphere, which increases the temperature even more.
(C) Increased melting of sea ice decreases travel distance for ships but increases the distance that polar bears and other Arctic species have to travel to find food, thus leading to their possible extinction.
(D) Increased melting of the permafrost decreases the number of days that large vehicles can travel over the area to transport drilling equipment to extract oil from the region.
(E) Increased melting of sea ice decreases the sea level and leads to more arable land area that can be farmed.

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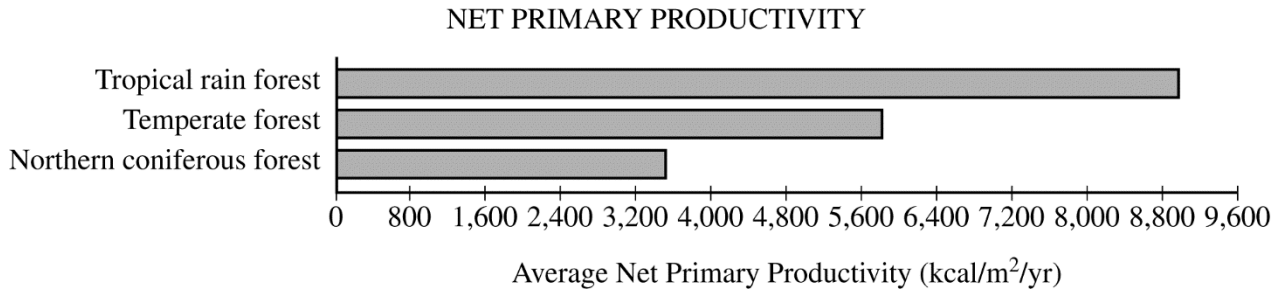

84. The terrestrial biomes shown in the diagram above vary in net primary productivity. The explanation for the variation includes which of the following?

I. Temperature
II. Precipitation
III. Longitude

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

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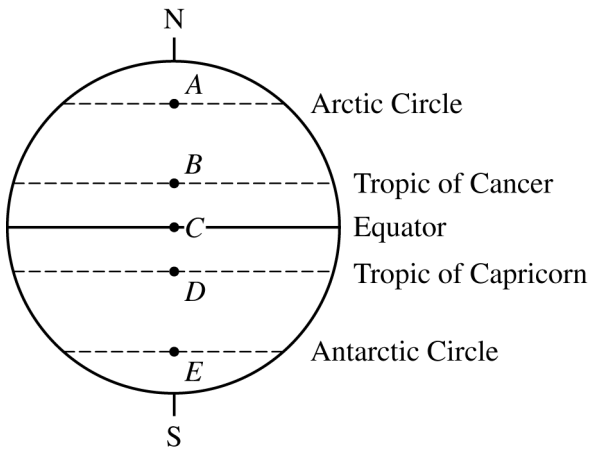
85. Which of the following would most likely reduce the concentration of ground-level ozone in the air of a city?

(A) Release of CFCs into the air of the city
(B) Occurrence of several consecutive days of sunny weather
(C) Formation of a temperature inversion
(D) Decrease in the emissions of nitrogen oxides
(E) Release of VOCs into the air of the city



86. Which latitude shown on the diagram above experiences 24 hours of daylight on December 21 ?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

87. Which of the following is the best description of bioaccumulation?

(A) The uptake of essential nutrients by plant roots
(B) The absorption of a substance by an organism at a rate greater than the rate of elimination
(C) The transfer of persistent pollutants like PCBs from one generation to the next
(D) A process that occurs exclusively in marine ecosystems
(E) A high mortality rate in organisms that have been exposed to a toxin

88. Which of the following is the human health impact most closely associated with atmospheric particulates?

(A) Cataracts
(B) Diabetes
(C) Melanoma
(D) Asthma
(E) Obesity

89. A North Carolina timber company proposes to clear-cut 45 hectares of oak-hickory deciduous forest in the Appalachian Mountains. The company has said that the forest will regrow naturally, and 50 years after the clear-cutting the company plans to harvest again, cutting all the oaks and hickories that have at least a 40-centimeter diameter. A local citizens' group claims that this is not a realistic plan. Which of the following, if true, best supports the claim of the citizens' group?

(A) Harvesting oak and hickory will disrupt the soil in the first year after clear-cutting; oaks and hickories cannot germinate that first year.
(B) Oak and hickory are late-successional species; pioneer species will dominate for many decades before the oaks and hickories are reestablished.
(C) Coniferous forests can regrow after having been clear-cut; the biome will change to a boreal forest after clear-cutting.
(D) Populations of large carnivores in the forest will decline after clear-cutting occurs; deer hunting will suffer as a result.
(E) Erosion rates on the slopes of the Appalachian Mountains will decrease after clear-cutting; many new species will move into the forest.

90. Which of the following is the best example of the tragedy of the commons?

(A) Water pollution from oil rigs concentrated in the Gulf of Mexico
(B) An increase in the concentration of a toxin as it goes through the food chain
(C) Exponential population growth as a country goes through the demographic transition
(D) The use of invasive species as a biological control
(E) The overharvesting of fish from privately owned lakes

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91. Carbon dioxide and particulates are emitted by volcanoes. Particulates form stratospheric aerosols that reflect sunlight. Which of the following best describes the impact of atmospheric carbon dioxide and stratospheric aerosols?

(A) Carbon dioxide contributes to global warming, and aerosols cause cooling.
(B) Both carbon dioxide and aerosols contribute to global warming.
(C) Carbon dioxide contributes to global warming, and aerosols have no effect on global climate.
(D) Carbon dioxide reacts to form aerosols, leading to decreased global warming.
(E) UV radiation causes carbon dioxide to break down, leading to increased stratospheric cooling.

92. Recent studies have found that fine particulate matter with a diameter of 2.5 μm or less can have negative human health effects. Which of the following correctly links a negative human health effect to an anthropogenic source of fine particulate matter?

(A) High rates of respiratory disease from power plant emissions
(B) High rates of skin cancer in urban areas with sewage treatment plants
(C) High rates of asthma from salt spray in coastal communities
(D) High rates of genetic deformities from additives in food supplies
(E) High rates of obesity from exposure to waste from meatpacking

93. Water vapor is a greenhouse gas and is produced by burning fossil fuels. However, anthropogenic water vapor does not contribute significantly to global warming because water vapor

(A) is naturally occurring and therefore will not harm the environment
(B) does not absorb energy
(C) has a short residence time in the atmosphere
(D) does not contain carbon
(E) has no global-warming potential (GWP)

94. The spread of infectious diseases is expected to increase with climate change, mainly because

(A) the world population growth rate is increasing very rapidly
(B) warmer temperatures allow disease-carrying insects to survive in areas that were once too cold
(C) disease-carrying microbes are migrating more rapidly into the tropics and subtropics
(D) the rain forests are rapidly expanding to cover more of Earth's surface
(E) techniques and efforts to combat infectious diseases have not been successful globally

95. As part of a school project, a group of high school students will attempt to determine whether increasing the species diversity of the edible plants in pastures used for grazing livestock will provide an economic benefit to ranchers. Which of the following hypotheses, if supported by experimental results, best demonstrates an economic benefit to the ranchers?

(A) Pastures with the highest diversity of plant species will have the highest net primary productivity.
(B) Pastures with the highest diversity of plant species will have the lowest water infiltration rate.
(C) Pastures with the highest diversity of plant species will have the highest soil pH.
(D) Pastures with the lowest diversity of plant species will have the lowest rate of insect predation.
(E) Pastures with the highest diversity of plant species will have the lowest diversity of bird species.

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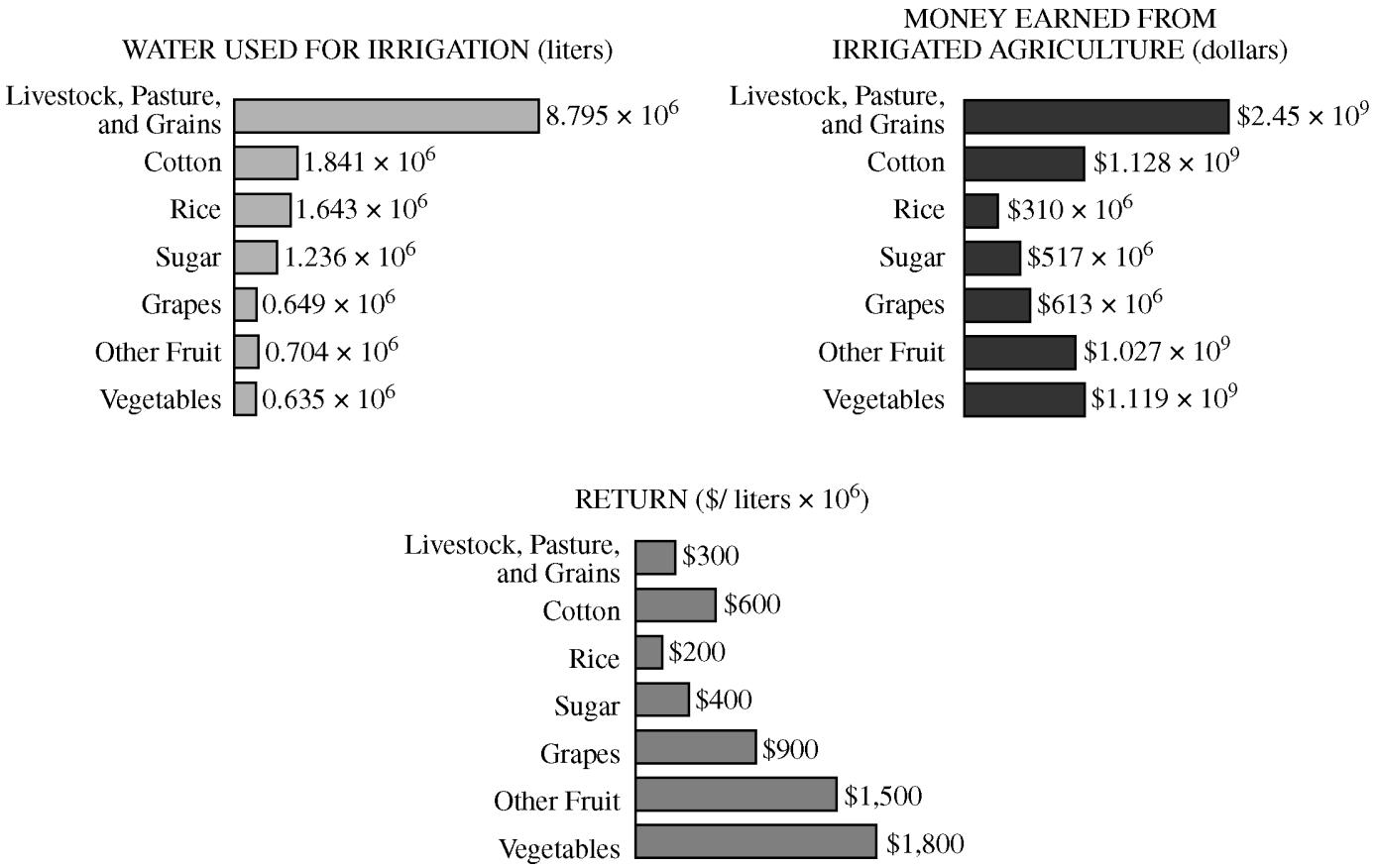

96. Which of the following statements best explains the graphs above?

(A) The price of cotton is high because cotton growing uses a lot of water.
(B) Fruits and vegetables give the greatest monetary return per water usage.
(C) Raising cattle for consumption uses few resources.
(D) The amount of livestock exceeds the amount of fruits and vegetables grown.
(E) People consume more vegetables than they do rice.

---

97. Increased atmospheric CO_2 concentration over the next 50 years is expected to cause which of the following global changes?

(A) A decrease in the severity of storms
(B) A significant loss of biodiversity in the tropics
(C) Fewer significant heat waves
(D) A delay in the spring migration of many birds
(E) Later blooming of many mountain flowers

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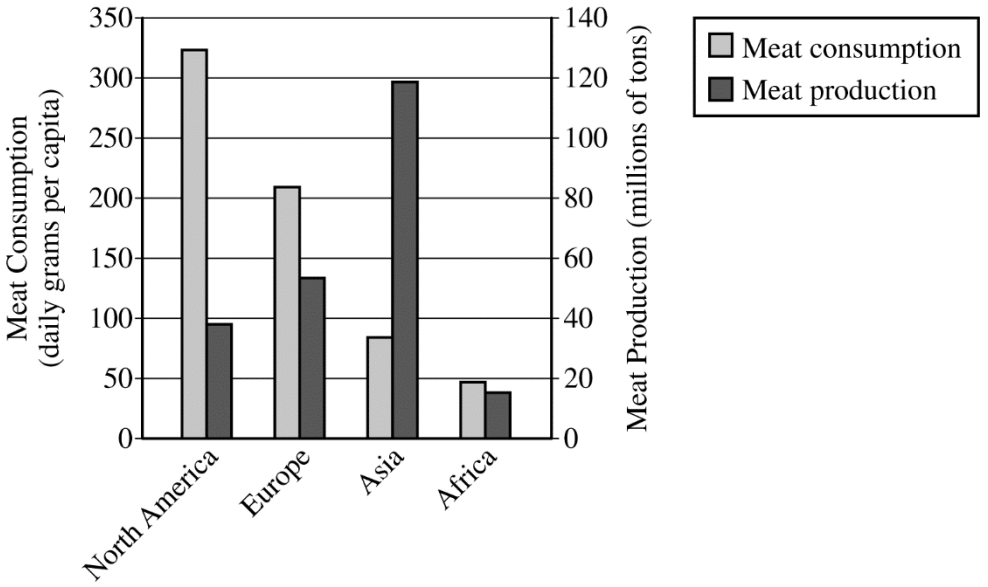
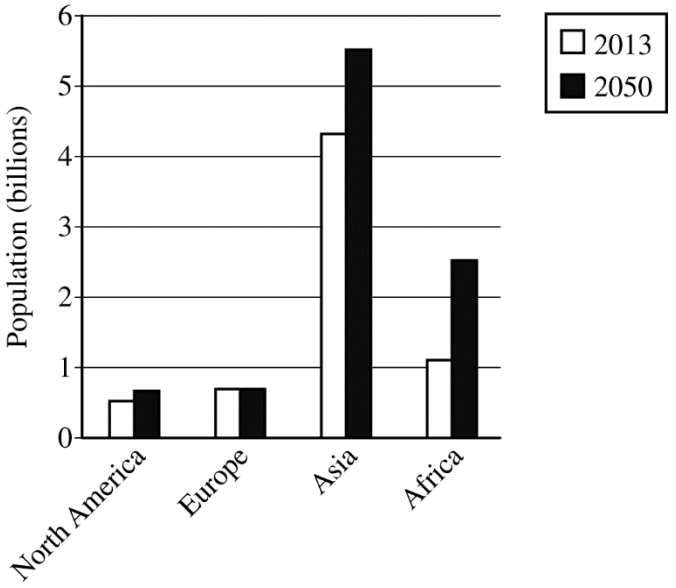
2013 MEAT PRODUCTION AND CONSUMPTION
IN SELECTED REGIONS



PROJECTED HUMAN POPULATION
IN SELECTED REGIONS



98. Which of the following statements is consistent with the graphs above?

(A) Per capita meat consumption in Africa will increase as the population in Africa increases.
(B) North American meat production is expected to decrease as population increases.
(C) Per capita meat consumption in Europe will decline because population in Europe is projected to decrease.
(D) People in North America consume more meat per capita than people in other regions of the world do.
(E) By 2050 Asia will have the greatest per capita meat consumption because Asia has the greatest projected increase in population.

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99. Which of the following describes a potential human health effect most likely to be associated with a thermal inversion?

(A) Increase in respiratory irritation due to increased levels of fine airborne particulates
(B) Increase in skin cancer due to increased ozone levels
(C) Increase in allergies due to increased household mold
(D) Increase in infant mortality due to increased atmospheric CO_2 levels
(E) Increase in heart attacks due to increased barometric pressure

100. Which of the following annual population growth rates is paired with the correct doubling time?

(A) 1% . . 700 years
(B) 2% . . 35 years
(C) 3.5% . . 12 years
(D) 5% . . 350 months
(E) 7% . . 70 months

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 DONE THE FOLLOWING.

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

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AP® Environmental Science Exam

SECTION II: Free Response

2016

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
4
Percent of Total Score
40%
Writing Instrument
Pen with black or dark blue ink
Electronic Device
None allowed
Weight
The questions are weighted equally, but the parts of a question are not necessarily given equal weight.

IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name ☐☐
   First letter of your first name ☐
2. Date of birth
   ☐☐ Month ☐☐ Day ☐☐☐☐ Year
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Instructions

The questions for Section II are printed in this booklet. You may use the blank page 3 to organize your answers and for scratch work, but you must write your answers on the lined pages provided for each question.

Each answer should be organized, comprehensive, and in prose form; outline form is not acceptable. Do not spend time restating the questions or providing more than the number of examples called for. For instance, if a question calls for two examples, you can earn credit only for the first two examples you provide. Diagrams may be used to supplement discussion, but diagrams alone will not suffice.

Write clearly and legibly. Do not skip lines. Cross out any errors you make; crossed-out work will not be scored.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

Form O
Form Code 4MBP

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 this book. 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 New Tribune*.

Fremont New Tribune **May 2, 2016**

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces.

The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*).

Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

"Little brown bats provide tremendous value to the United States economy every year by the essential services they provide to farmers and other people. We need to understand how this deadly disease spreads and attempt to help reduce its impact on the little brown bat and other bat species," said Dr. Duke Serach of the Fremont office of the United States Fish and Wildlife Service. Dr. Serach concluded with, "It may yet be possible to save the little brown bats, but the remaining population will be alarmingly small."

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(a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.

(b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.

(i) **Describe** TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.

(ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.

(c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.

(d) The Eastern deciduous forest in which the little brown bats live is an important ecosystem. **Identify** TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades.

(e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.

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2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
1.2 billion tons of pig iron are produced each year.
Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

(i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

(ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

(iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

(b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

(c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

(d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

(e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

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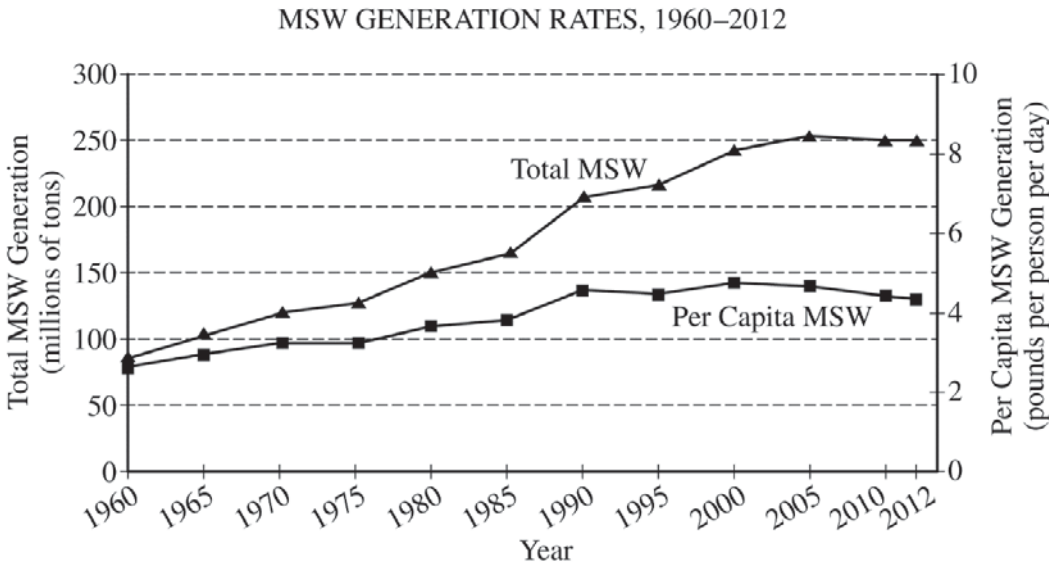
3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



(a) Use the data provided in the graph above to respond to the following.

(i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.

(ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.

(b) Two ways of managing MSW are incineration and disposal in landfills.

(i) **Identify** one disadvantage of waste incineration.

(ii) **Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

(c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.

(d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.

(e) Composting is one way to reduce the amount of waste that enters a landfill.

(i) Other than reducing the volume of waste, **identify** one advantage of composting.

(ii) **Identify** one disadvantage of composting.

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4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

   (a) **Describe** how TWO climate factors affect the rate of soil formation.

   (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.

      (i) **Identify** one specific biotic component of the A horizon.

      (ii) **Identify** one abiotic component of the A horizon.

   Resources such as soil and water can be degraded by human activities.

   (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.

      (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.

      (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.

   (d) Acid deposition has affected soil quality in many parts of the northeastern United States.

      (i) **Explain** one way acid deposition onto soil can affect plant health.

      (ii) **Describe** one method for remediating soil affected by acid deposition.

   (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

STOP

END OF EXAM

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