



AP[®] Environmental Science 2009 Scoring Guidelines

The College Board

The College Board is a not-for-profit membership association whose mission is to connect students to college success and opportunity. Founded in 1900, the association is composed of more than 5,600 schools, colleges, universities and other educational organizations. Each year, the College Board serves seven million students and their parents, 23,000 high schools and 3,800 colleges through major programs and services in college readiness, college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT[®], the PSAT/NMSQT[®] and the Advanced Placement Program[®] (AP[®]). The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities and concerns.

© 2009 The College Board. College Board, Advanced Placement Program, AP, AP Central, SAT, and the acorn logo are registered trademarks of the College Board. PSAT/NMSQT is a registered trademark of the College Board and National Merit Scholarship Corporation.

Permission to use copyrighted College Board materials may be requested online at:
www.collegeboard.com/inquiry/cbpermit.html.

Visit the College Board on the Web: www.collegeboard.com.
AP Central[®] is the official online home for AP teachers: apcentral.collegeboard.com.

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 1

- (a) **Support Councilwoman Smith's statement that nitrogen-based fertilizers cause other environmental problems by describing one such problem.**

Two points can be earned for describing the cause and effect of one environmental problem not related to photochemical smog that is associated with the use of nitrogen-based fertilizers. One point can be earned for a description of an effect without a description of a cause.

Cause (1 point)	Effect (1 point)
Fertilizer enters surface waters or groundwater	<ul style="list-style-type: none"> • Increases algal blooms in surface waters • Decreases dissolved oxygen levels in surface waters • Promotes eutrophication in surface waters • Results in nitrate contamination of drinking water • "Blue baby syndrome"
Bacterial decomposition of fertilizer	<ul style="list-style-type: none"> • Produces nitrous oxide (N₂O), which increases global warming • Produces N₂O, which depletes stratospheric ozone
Production, transportation, and application of fertilizer	<ul style="list-style-type: none"> • Consumes fossil fuels, increasing habitat destruction during their extraction • Consumes fossil fuels, which produces carbon dioxide (CO₂) and increases global warming

- (b) **Identify a nitrogen-containing primary pollutant that contributes to the formation of photochemical smog. Describe how that primary pollutant forms and explain why Councilman Budd was wrong.**

Three points can be earned: 1 point for identifying a nitrogen-containing primary pollutant; 1 point for describing how the selected primary pollutant is formed; and 1 point for explaining why Councilman Budd was wrong.

Primary Pollutant (1 point)	Formation (1 point)
Nitric oxide (nitrogen monoxide), nitrogen dioxide, or nitrogen oxides <u>OR</u> NO, NO ₂ , or NO _x	Nitrogen reacts with oxygen ($N_2 + O_2 \rightarrow 2NO$) or ($N_2 + 2O_2 \rightarrow 2NO_2$) or nitric oxide reacts with oxygen ($2NO + O_2 \rightarrow 2NO_2$) during: <ul style="list-style-type: none"> • High-temperature combustion • Combustion in automobile engines • Combustion in fuel-burning power plants • Burning of fossil fuels

One point can be earned for a statement explaining that nitrogen-based fertilizers do not release the air pollutants that cause photochemical smog.

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 1 (continued)

(c) Identify one secondary pollutant that is a component of photochemical smog and describe the following.

- (i) How the secondary pollutant forms**
- (ii) ONE human health effect of the pollutant**
- (iii) ONE environmental effect of the pollutant**

Four points can be earned: 1 point for the identification of a correct secondary pollutant; 1 point for describing how the selected secondary pollutant is formed; 1 point for a correct human health effect; and 1 point for a correct environmental effect.

Pollutant (1 point)	Formation (1 point)	Human Health Effect (1 point)	Environmental Effect (1 point)
Ozone <u>OR</u> O ₃	<ul style="list-style-type: none"> • In the light-activated reactions of nitrogen oxides and volatile organic compounds (VOCs) or hydrocarbons • In the reaction of O₂ with O 	<ul style="list-style-type: none"> • Respiratory problems • Impairs immune system • Eye irritation • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Damages plant tissues (cells, leaves, needles, stems, etc.) • Inhibits photosynthesis in plants • Suppresses plant growth • Increases plant susceptibility to diseases and pests • Causes respiratory problems in animals • Damages materials (rubber, paint, fabric, etc.) • Acts as a greenhouse gas and increases global warming
Peroxyacyl nitrates <u>OR</u> PANs	In the light-activated reactions of nitrogen oxides and volatile organic compounds (VOCs) or hydrocarbons	<ul style="list-style-type: none"> • Respiratory problems • Impairs immune system • Eye irritation • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Damages plant tissues (cells, leaves, needles, stems, etc.) • Inhibits photosynthesis in plants • Suppresses plant growth • Causes respiratory problems in animals

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 1 (continued)

Pollutant (1 point)	Formation (1 point)	Human Health Effect (1 point)	Environmental Effect (1 point)
Nitrogen Dioxide <u>OR</u> NO ₂	In the reaction of nitrogen oxide (NO) with oxygen	<ul style="list-style-type: none"> • Respiratory problems • Impairs immune system • Eye irritation • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Reduces visibility, which also impairs photosynthesis • Increases plant susceptibility to diseases • Suppresses plant growth • Causes respiratory problems in animals
Nitric Acid <u>OR</u> HNO ₃	In the reaction of nitrogen oxides (NO _x) with oxygen and water vapor	<ul style="list-style-type: none"> • Irritates eyes, nose, or throat • Damages lungs when inhaled • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Causes loss of soil fertility • Leaches nutrients from soils • Releases toxic elements in soils • Causes plant damage or death • Increases susceptibility of plants to disease or drought • Causes loss of habitat • Causes injury or death of aquatic life • Causes loss of essential elements from aquatic ecosystems • Damages materials (limestone, marble, etc.)
Sulfuric Acid <u>OR</u> H ₂ SO ₄	In the reaction of sulfur dioxide (SO ₂) with oxygen and water vapor	<ul style="list-style-type: none"> • Irritates eyes, nose, or throat • Damages lungs when inhaled • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Causes loss of soil fertility • Leaches nutrients from soils • Releases toxic elements in soils • Causes plant damage or death • Increases susceptibility of plants to disease or drought • Causes loss of habitat • Causes injury or death of aquatic life • Causes loss of essential elements from aquatic ecosystems • Damages materials (limestone, marble, etc.)

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 1 (continued)

Pollutant (1 point)	Formation (1 point)	Human Health Effect (1 point)	Environmental Effect (1 point)
Nitrates, sulfates, or fine particulate matter <u>OR</u> PM 2.5	In the reaction of nitrogen oxides (NO _x) or sulfur dioxide (SO ₂) with oxygen	<ul style="list-style-type: none"> • Irritates eyes, nose, or throat • Damages lungs when inhaled • Reduces crop yields, which may lead to poor nutrition or lack of food 	<ul style="list-style-type: none"> • Causes loss of soil fertility • Leaches nutrients from soils • Releases toxic elements in soils • Causes plant damage or death • Increases susceptibility of plants to disease or drought • Causes loss of habitat • Causes injury or death of aquatic life • Causes loss of essential elements from aquatic ecosystems • Damages materials (limestone, marble, etc.)

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 1 (continued)

(d) Earth's natural nitrogen cycle occurs in several steps. Describe one chemical transformation that occurs in the natural nitrogen cycle and discuss the importance of that transformation to an ecosystem.

Two points can be earned: 1 point for a correct natural nitrogen-cycle chemical transformation and 1 point for a corresponding discussion of its importance to an ecosystem. A discussion point can be earned without a description of the chemical transformation.

Chemical Transformation (1 point)	Discussion (1 point)
<p>Nitrogen is converted to ammonia, ammonium, or nitrate</p> <p><u>OR</u></p> <p>$N_2 \rightarrow NH_3$ or NH_4^+ or NO_3^-</p>	<ul style="list-style-type: none"> • Converts atmospheric nitrogen into terrestrial nitrogen • Converts nitrogen to a biologically usable form • Provides plants with biologically available (fixed) nitrogen
<p>Ammonia or ammonium is converted to nitrite, which is converted to nitrate (a description of only one of the steps is acceptable)</p> <p><u>OR</u></p> <p>NH_3 or $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$ NH_3 or $NH_4^+ \rightarrow NO_3^-$ $NO_2^- \rightarrow NO_3^-$ (a description of only one of the steps is acceptable)</p>	<ul style="list-style-type: none"> • Provides plants with nitrates that can be taken up and used • Nitrates, along with ammonia and ammonium, are the most useful forms of nitrogen to plants
<p>Nitrate, ammonia, or ammonium is converted to nitrogen-containing molecules (e.g., proteins, nucleic acids)</p> <p><u>OR</u></p> <p>NH_3 or NH_4^+ or $NO_3^- \rightarrow$ proteins or nucleic acids</p>	<ul style="list-style-type: none"> • Converts nitrogen to proteins, nucleic acids, and other molecules essential to life
<p>Nitrate is converted to nitrogen gas</p> <p><u>OR</u></p> <p>$NO_3^- \rightarrow N_2$</p>	<ul style="list-style-type: none"> • Converts terrestrial nitrogen into atmospheric nitrogen to continue the cycle
<p>Nitrogen-containing molecules (e.g., nitrates, urea, uric acid, proteins, nucleic acids) are converted to ammonia or ammonium</p> <p><u>OR</u></p> <p>NO_3^-, urea, uric acid, proteins or nucleic acids $\rightarrow NH_3$ or NH_4^+</p>	<ul style="list-style-type: none"> • Converts the nitrogen in nitrogen-containing wastes and dead organisms back into biologically useful forms • Provides plants with nitrogen in a biologically usable form

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 2

(a) Describe the steps by which methane produced in the digester can be used to generate electricity.

Two points can be earned: 1 point for stating that methane can be burned and 1 point for describing how this generates electricity:

- By producing steam to turn a turbine (to rotate coils in a magnetic field), OR
- Through use in internal combustion engine to turn a turbine (to rotate coils in a magnetic field).

(b) Discuss TWO environmental benefits that may result from the installation of an anaerobic methane digester.

One point is earned for each of two environmental benefits discussed. (Only the first two answers are scored.)

Benefit	Discussion
Reduction in the amount of methane released to the atmosphere	<ul style="list-style-type: none"> • Methane contributes to climate change (greenhouse gas)
Reduction in runoff or spills of manure in local waterways	<ul style="list-style-type: none"> • Manure contains nutrients that lead to eutrophication/nutrient loading • Fecal coliform contamination may spread disease
Reduction in amount of manure/waste that needs to be disposed of	<ul style="list-style-type: none"> • Takes up less space in landfills/waste lagoons
Reduction in use of fossil fuels for electricity generation	<ul style="list-style-type: none"> • Fewer contaminants such as mercury/sulfur/particulates in atmosphere • Extends the supply of fossil fuels • Less land disturbance from the extraction (mining) of fossil fuels • Unlike fossil fuels, manure is a renewable resource that can be regenerated, avoiding depletion of natural resources • No net increase in CO₂ emissions (CO₂ released by burning methane comes from plants removing CO₂ through photosynthesis now, rather than from fossil fuels formed millions of years ago)

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 2 (continued)

- (c) Assuming that the cost of electricity remains constant and the farmer starts using the manure from the cows in an anaerobic digester to produce electricity on the farm, calculate:**

- (i) The number of kWh of electricity that can be produced in one year**

One point is earned for the correct setup and 1 point for the correct answer. (Units are not required, but the student must show calculations in order to receive the answer point.)

$$\frac{500 \text{ cows}}{\text{year}} \times \frac{3.0 \text{ kWh}}{\text{cow-day}} \times \frac{365 \text{ days}}{\text{year}} = 547,500 \text{ kWh/year}$$

or

$$\frac{1500 \text{ kWh}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} = 547,500 \text{ kWh/year}$$

- (ii) The amount of money the farmer can save in one year, NOT counting the installation cost of the digester. (You may round your answer to the nearest \$1,000.)**

One point is earned for the correct setup and 1 point for the correct answer. (Units are not required, but the student must show calculations in order to receive the answer point.) Incorrect answers transferred from (c)(i) can still earn full credit if used correctly.

$$547,500 \text{ kWh} \times \$0.10 = \$54,750 \text{ } (\$55,000)$$

or

$$800,000 \text{ kWh} - 547,500 \text{ kWh} = 252,500 \text{ kWh needed from a utility}$$

$$800,000 \times \$0.10 = \$80,000$$

$$252,500 \times \$0.10 = \$25,250$$

$$\$80,000 - \$25,250 = \$54,750 \text{ or } \$55,000 \text{ saved}$$

- (iii) The amount of time, in years, that it will take to recover the cost of installing an anaerobic digester on the farm. (You may round your answer to the nearest whole number of years.)**

One point is earned for the correct setup AND correct answer. (Units are not required, but the student must show calculations in order to receive the point). Incorrect answers transferred from (c)(ii) can still earn full credit if used correctly.

$$\$400,000 / \$55,000 = 7.2 \text{ years (or 7 years)}$$

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 2 (continued)

(d) Calculate the minimum number of cows the farm would need to produce 800,000 kWh of electricity per year.

One point is earned for the correct setup and 1 point for the correct answer. (Units are not required, but the student must show calculations in order to receive the answer point.) Incorrect answers transferred from (c)(i) can still earn full credit if used correctly.

$$\frac{3.0 \text{ kWh}}{\text{cow-day}} \times \frac{365 \text{ days}}{\text{year}} = \frac{1095 \text{ kWh}}{\text{cow-year}}$$

or

$$\frac{800,000 \text{ kWh}}{\text{year}} \times \frac{1 \text{ year}}{365 \text{ days}} \times \frac{\text{cow-day}}{3 \text{ kWh}} = 730.5 \text{ cows} = 731 \text{ cows}$$

or

$$\frac{800,000 \text{ kWh/year}}{1095 \text{ kWh/cow-year}} = 730.5 = 731 \text{ cows}$$

or

$$\frac{500 \text{ cows}}{547,500} = \frac{x \text{ cows}}{800,000} = 730.5 = 731 \text{ cows}$$

AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES

Question 3

(a) Multiple dams have been erected along the Colorado River. Identify TWO benefits other than agriculture and recreation that people derive from that system of dams.

A total of 2 points can be earned, 1 for each correct response. (Only the first two responses are scored.)

- Hydroelectric power/affordable (inexpensive) electricity
- Flood control
- Storage of water for domestic/nonagricultural use; municipal water supply (must specify a nonagricultural use)
- Provision of/increase in navigable waterways
- Employment/stimulation of local economy (dam construction, maintenance, operation)
- Reduced air pollution as hydroelectric power replaces electrical generation from fossil fuels

(b) Discuss TWO potential environmental consequences of damming a major river.

A total of 2 points can be earned, 1 for each correct response. (Only the first two responses are scored.)

- Habitat alteration; displacement or death of native species (e.g., fish, plants, birds)
- Population decline of migratory fish (salmon, etc.) or disruption of fish migrations
- Risk of flood from catastrophic failure of dam
- Sedimentation behind dam
- Downstream ecosystems deprived of sediments, nutrients, or water
- Reduction in amount of agricultural land
- Reduction of available water because of increased evaporative loss
- Scouring of channel downstream from dam alters habitat or destabilizes banks
- Increased risk of diseases associated with reservoir (e.g., Aswan dam and schistosomiasis)
- Release of mercury or other toxins from flooded soils
- Accumulation of toxins behind dam
- Methane produced by biomass decomposing in lake
- Humans displaced/local inhabitants forced to move, due to inundation/lake formed behind dam

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 3 (continued)

- (c) Competition for access to Colorado River water has increased dramatically due to increased population size and intensive agricultural use. Describe TWO conservation strategies for reducing agricultural water consumption.**

A total of 2 points can be earned, 1 for each correct response. (Only the first two responses are scored.)

Note: Correct answers must detail how agricultural water-use efficiency can be improved. Answers suggesting incentives or regulations to spur conservation are insufficient, unless they are linked to one of the strategies listed below.

- Employ microirrigation (drip irrigation; trickle irrigation)
- Choose crops that do not require irrigation in that climate
- Breed/select/develop crops for more efficient water use or drought tolerance
- Irrigate when evaporative loss is lower (e.g., at night)
- Level fields to improve delivery efficiency
- Carefully monitor soil moisture levels to reduce unnecessary irrigation
- Transport irrigation water in pipes or lined channels
- Direct sprinkler heads downward or place near soil
- Increase soil organic (matter) content
- Incorporate shelterbelts or windbreaks
- Use measures to reduce or slow runoff: contour planting, strip cropping, terracing, etc.
- Cover surface with mulch to reduce evaporative water loss
- Reduce meat consumption, because more water is used in animal production than in plant production

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 3 (continued)

(d) Identify TWO possible environmental consequences of climate change on the hydrology of the Colorado River system.

A total of 2 points can be earned, 1 for each correct response. The specific climate change must be paired with its effect on the hydrologic cycle. (Only the first two responses are scored.)

Specific Climate Change Phenomenon	Effect on Hydrologic Cycle
Warmer temperatures	<ul style="list-style-type: none">• Reduced snow(pack) in (Rocky) Mountains• Increased evaporation from bodies of water• Increased evaporation from soil• Altered plant transpiration rates• Timing of snow/melt
Increased precipitation	<ul style="list-style-type: none">• Increased surface water or groundwater inputs• Increased sedimentation in bodies of water• Increased aquifer recharge
Decreased precipitation	<ul style="list-style-type: none">• Decreased surface water or groundwater inputs• Decreased sedimentation in bodies of water• Decreased aquifer recharge
Increased frequency or severity of storms	<ul style="list-style-type: none">• Increased sedimentation• Increased flooding• Increased runoff volume

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 3 (continued)

(e) In addition to impacts on the Colorado River system, climate change is impacting the hydrology of coastal ecosystems. Identify and describe TWO possible consequences of climate change on coastal ecosystems.

A total of two points can be earned, one for each correct response. A correct response both identifies a climate change phenomenon and describes how that change affects the coastal ecosystem. (Only the first two responses are scored.) A single phenomenon may be paired with two different effects on ecosystems.

Climate Change Consequence	Effect on Coastal Ecosystem
Rising sea levels	<ul style="list-style-type: none"> • Terrestrial ecosystems are inundated, affecting biota • Shallow aquatic systems become deepwater habitats • Saltwater intrusion of water table inland • Saltwater intrusion into rivers/estuaries/wetlands
More frequent and/or severe storms	<ul style="list-style-type: none"> • Destruction of habitat • Increased mortality of coastal species
Warming/cooling of coastal waters	<ul style="list-style-type: none"> • Affects aquatic ecological tolerances or interactions • Disrupts spawning • Altered nutrient cycling dynamics • Reduced dissolved oxygen levels (in warmer water) • Increased dissolved oxygen levels (in colder water)
Increased or decreased rate of water cycling (change in precipitation or evaporation/transpiration)	<ul style="list-style-type: none"> • Riparian habitats altered (scouring, temperature, etc.) due to new flow regime • Altered inputs of freshwater, sediments, nutrients
Atmospheric circulation (winds) change	<ul style="list-style-type: none"> • Air or ocean currents are changed (new patterns) • Affects aquatic ecological tolerances or interactions • Disrupts spawning • Altered nutrient cycling dynamics • Changes in dissolved oxygen levels
Increased carbon dioxide (CO ₂) concentration in atmosphere	<ul style="list-style-type: none"> • Carbon dioxide dissolves in ocean, lowering pH (increasing acidity), which affects biota • Altered nutrient cycling dynamics

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4

(a) Reply to the following questions based on the data in the graph.

Four points can be earned: 1 point for the correct answer in each section.

- (i) Calculate the increase in the area of land used for growing GM [genetically modified] crops in developing countries from 1999 to 2003. Express your answer as a percentage of the 1999 value.**

1999 (10 million hectares) to 2003 (20 million hectares)
Increase of 10 million hectares = 100 percent increase

- (ii) Calculate the annual rate of increase in land area used for growing GM crops in industrialized countries from 1997 to 1999.**

1999	30 million hectares	
<u>1997</u>	<u>10 million hectares</u>	
2 years	20 million hectares	20 million ha/2yr = 10 million ha/yr

Must have units of “hectares” or “hectares/yr”

Note: Percentage answer accepted only if both years are calculated as independent percentages.

First year 100 percent Second year 50 percent Ave. Ann. 75 percent

- (iii) Using the rate you calculated in part (ii), project the area of land that would have been expected to be used for GM crops in industrialized countries in 2004.**

1999	-----	30 million hectares
<u>5 years</u>	<u>10 million hectare increase/yr</u>	<u>50 million hectares</u>
2004		80 million hectares (<i>must have units</i>)

Note: Students who incorrectly calculate (ii) can still get points if the solution is correct in (iii).

For example: 5 million hectares/year in (ii)

5 years @ 5 million hectares/year = 25 million hectares, for a total 55 million hectares.

- (iv) Identify one likely cause for the difference between the projected land area for GM crops in industrialized countries in 2004 and the actual land area for GM crops in industrialized countries in 2004.**

Genetically modified crops faced:

- Increased public resistance (toward perceived risks, due to increased awareness following labeling of products)
- Decreasing market demand for products containing genetically modified organisms (GMOs)
- Governmental regulation/controls/limitations/bans that limited the planting/use of GM crops

Note: “Decrease in available land” is not acceptable.

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

(b) Describe one environmental advantage and one environmental disadvantage of using GM crops.

Two points can be earned: 1 point for a description of a viable advantage and 1 point for a description of a viable disadvantage.

**Environmental Advantages: 1 point
(Score only the first advantage provided by student)**

Higher yields per acre and hence less acreage needed/impacted by agriculture

Permits low-tillage agriculture (due to herbicide resistance in GM crops), which:

- Reduces soil exposure/erosion
- Reduces energy consumption associated with farm machinery (plowing, harrowing, etc.)
- Can reduce evaporative water loss

GM crops may exhibit:

- Lower fertilizer requirements, which reduces negative impacts of fertilizers
- Insect resistance and the associated reduced impact of insecticide/pesticide use/production/exposure
- Drought resistance and the associated decreased need for irrigation
- Disease resistance and the associated decreased need for fungicide applications
- Salinity tolerance, which decreases the need for flushing of soils with water
- Frost resistance, which extends seasonal productivity and decreases crop loss
- Perennial life span (rather than annual), which reduces the need for tillage (see above)
- Firmer tissues/peels/shells reduce waste as a result of increased shelf life and reduced spoilage

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

**Environmental Disadvantages: 1 point
(Score only the first disadvantage provided by student)**

Low-tillage agriculture often depends on:

- High dosage/frequent application of herbicides to control competitive weeds that are normally controlled by tillage

GM crops with:

- Insect resistance (e.g., Bt gene) may impact beneficial insects (e.g., pollen toxic to monarch butterflies)
- Drought-resistance gene may lead to agricultural use of currently marginal, semi-arid areas, leading to increased human pressures/loss of natural landscape
- Salinity-tolerance gene may lead to agricultural use of currently marginal, saline soils, leading to increased human pressures/loss of natural landscape
- Altered genes may impact human health with altered proteins and/or subsequent toxins

Native plant diversity may be impacted by the spread of genes to nonengineered crops.

Higher yields per acre often require higher inputs (fertilizer, etc.) and often lead to greater soil depletion and erosion.

GM crops are often engineered to have lower genetic variability than non-GM crops, thereby making GM crop monocultures more vulnerable to mass mortality than non-GM crop monocultures exposed to disease or pest outbreaks or severe environmental changes. (*Note:* To earn this point, the student must clearly contrast GM and non-GM crops and emphasize genetic variability and monoculture agriculture.)

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

(c) Describe one economic advantage and one economic disadvantage of using GM crops.

Two points can be earned: 1 point for a description of a viable economic advantage and 1 point for a description of a viable economic disadvantage.

**Economic Advantage: 1 point
(Score only the first advantage provided by student)**

For farmers specifically

Permits low/reduced-tillage agriculture resulting in:

- Reduced soil erosion
- Retention of soil nutrients
- Reduced energy consumption associated with farm machinery (plowing, harrowing, spraying, etc.)
- Reduced water loss that lowers associated costs
- Reduced greenhouse gas emissions from agricultural activities and associated costs (carbon sequestration)

Increased profits/reduced costs due to use of GM crops that have:

- Higher yields per acre
- Lower fertilizer/pesticide/herbicide requirements
- Insect resistance, resulting in reduced insecticide cost
- Disease resistance, resulting in reduced fungicide/viral control cost
- Healthier appearance (e.g., reduced viral spotting of skin of papaya)
- Drought resistance, resulting in lower costs for irrigation or expanded land area under cultivation
- Saline resistance, resulting in lower cost for irrigation/mitigation or increased use of marginal lands
- Less worker exposure to fertilizer/pesticides/herbicides and lower associated health-care costs
- Increased nutritional value
- Pharmacological value
- Frost resistance—extends seasonal productivity
- Firm tissue/peels/shells—less spoilage of crops in transit

For society in general

- Decreased health-care costs:
 - Due to reduced worker exposure to pesticides
 - Better-nourished people (“golden rice”)

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

**Economic Disadvantages: 1 point
(Score only the first disadvantage provided by student)**

For farmers specifically

Higher yields per acre often lead to greater soil depletion, requiring higher costs of mitigation.

Low-tillage agriculture often depends on:

- Costly high dosage/frequent application of herbicides to control competitive weeds that are normally controlled by tillage

Decreased profits/increased costs due to use of GM crops that:

- Have increased fertilizer demand to reach yield potential
- Require investment in a new generation of pesticides because the GM crop has promoted target insect pest resistance
- Increase the amount and frequency of pesticide applications to mitigate nontarget pests whose virulence increases (when pests targeted by the GM crops are suppressed)
- Have patented seeds (which commit the farmer to annual purchase of seeds that are often too expensive for poor farmers)
- Have sterile seeds, committing the farmer to annual seed purchases
- Risk consumer rejection/import restrictions that result in lower demand for GM crops

For society in general

Costs of/for:

- Tracking and labeling GM crops in the food supply
- Litigation surrounding use of GM crops
- Controlling pest species to which the new gene has been inadvertently transferred
- Unexpected health issues related to GM crops
- Research and development

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

(d) A healthy soil ecosystem is of primary importance in sustainable agriculture. Describe TWO viable agricultural practices that farmers can use to maintain or improve soil quality.

Two points can be earned: 1 point for each description of a viable agricultural practice. Score only the first two answers provided by the student; answers must provide a description of the practice or/and include a linked advantage.

Practice	Description	Advantage
Fertilizing or supplementing	Application of nutrients (compost, organic, inorganic)	<ul style="list-style-type: none"> • For optimum nutrient availability • Less-soluble/mobile nutrients in organic fertilizer
Monitoring or adjusting	<ul style="list-style-type: none"> • Doing soil tests • Balancing soil nutrients 	<ul style="list-style-type: none"> • Optimum nutrient (N, P, K, Ca, Fe, etc.)/pH balance
Contouring or terracing	Building/installing water bars, terraces, etc.	<ul style="list-style-type: none"> • Reduces soil erosion
Crop rotation	Planting different crops in subsequent planting periods	<ul style="list-style-type: none"> • Lower herbicide/insecticide requirements • Adds nutrients back to the soil • Takes advantage of nitrogen-fixers (e.g., legumes)
Cover crops	<ul style="list-style-type: none"> • Interspersing crops/planting between the rows • Planting cover vegetation during a fallow period 	<ul style="list-style-type: none"> • Adds nutrients • Reduces erosion
Windbreaks	Planting rows of trees or shrubs	<ul style="list-style-type: none"> • Lowers soil loss to wind erosion • Traps moisture of winter snows
Mulching	Applying organic matter to the surface of the field/soil	<ul style="list-style-type: none"> • Lowers water loss • Increases water-holding capacity • Increases nutrient availability • Increases permeability/infiltration
Reduced or no tillage	Planting with reduced or no mechanical turning of the soil	<ul style="list-style-type: none"> • Decreases evaporation • Decreases soil erosion
Fallowing	Allowing soil to rejuvenate with a noncrop year; resting soil	<ul style="list-style-type: none"> • Rests/recharges soil • Adds nutrients • Lowers erosion

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

Practice	Description	Advantage
Small-scale, slash-and-burn agriculture (<i>milpa</i> ; swidden)	<ul style="list-style-type: none"> • Forest is cut in small patches • Some shrubs/herbaceous plants remain • Crops planted together among existing vegetation 	<ul style="list-style-type: none"> • Conserves soil nutrients • Allows nutrients time to replenish • Erosion losses are minimized
Tiling	Installing underground drainage	<ul style="list-style-type: none"> • Reduces water saturation • Reduces capillary rise of salts
Polyculture/intercropping	Use of a diversity of species to take advantage of beneficial interactions	<ul style="list-style-type: none"> • Lowers soil exposure • Takes advantage of different root depths • Breaks monoculturing and its negative effects • Takes advantage of attributes of multiple species (nitrogen-fixer, insect resistance)
Rotational grazing	Moving cattle to benefit grassland health	<ul style="list-style-type: none"> • Ensures healthy regeneration of grasslands
GM crops	Planting GM crops (must suggest soil improvement)	<ul style="list-style-type: none"> • Environmental advantage must refer to improving soil quality, such as the nitrogen-fixing quality of GM crops
Pesticide reduction	Eliminate overuse of pesticides or fertilizers or herbicides	<ul style="list-style-type: none"> • Removes products that compromise soil ecology or health
Tillage or soil structure alteration	<ul style="list-style-type: none"> • Mechanical or physical alteration • Harrowing, plowing in loam, sand, clay, organic matter to improve soil attributes 	<ul style="list-style-type: none"> • Aerates soil • Increases permeability • Increases water/nutrient holding capacity, permeability, workability
Irrigation	Distribution of water (pumps, piping, wells, center pivot)	<ul style="list-style-type: none"> • Increases effectiveness of fallowing • Increases decay/composting of vegetation • Drip irrigation avoids oversaturation/waterlogging and/or salinization problems
Permaculture	Designing the agricultural system to mimic a healthy soil ecosystem (includes many other practices, e.g., composting, intercropping)	<ul style="list-style-type: none"> • Increases ecological diversity associated with cropping landscape • Reduces erosion/nutrient loss and/or increases nutrient retention, soil biota, humus

**AP[®] ENVIRONMENTAL SCIENCE
2009 SCORING GUIDELINES**

Question 4 (continued)

(e) Identify and describe one environmental advantage and one economic advantage of consuming locally grown produce.

Two points can be earned: 1 point for an environmental advantage and 1 point for an economic advantage.

**Environmental Advantages: 1 point
(Score only the first advantage provided by student)**

Decreased transportation of food, which results in:

- Decreased fossil fuel consumption
- Decreased greenhouse gases, climate impacts, or carbon footprint
- Decreased combustion-related air pollutants/emissions (GHG, VOCs, ozone, particulates, smog)
- Decreased extraction impacts (drilling, transport, spills)
- Decreased transport impacts (oil spills)
- Decreased transport of pest species with crops

Consumers can more easily influence environmental choices of growers by:

- Supporting organic or permacultural practices and community-supported agriculture (CSA)
- Knowing what farming strategies are used (encouraging low pesticide or herbicide use)

Consumers can avoid packaging waste

Not exporting nutrients—nutrients remain locally compostable

**Economic Advantages: 1 point
(Score only the first advantage provided by student)**

Lower cost associated with:

- Transportation (fossil fuels, vehicle maintenance)
- Storage (warehousing, refrigeration, ripening agents, preservation)

Boost in local economy with:

- Revenues remaining in local area
- Support for local labor or increased number of jobs
- Use of community-supported agriculture (CSA)

Lower health-care costs associated with local food because it can be more nutritious (less time in transit, picked in riper condition)