# 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 | |
| 1997 | 10 million hectares | |
| 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 |
| 5 years | 10 million hectare increase/yr | 50 million hectares |
| 2004 | | 80 million hectares (*must have units*) |

***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**<br>**(Score only the first advantage provided by student)** |
|---|
| Higher yields per acre and hence less acreage needed/impacted by agriculture<br><br>Permits low-tillage agriculture (due to herbicide resistance in GM crops), which:<br>• Reduces soil exposure/erosion<br>• Reduces energy consumption associated with farm machinery (plowing, harrowing, etc.)<br>• Can reduce evaporative water loss<br><br>GM crops may exhibit:<br>• Lower fertilizer requirements, which reduces negative impacts of fertilizers<br>• Insect resistance and the associated reduced impact of insecticide/pesticide use/production/exposure<br>• Drought resistance and the associated decreased need for irrigation<br>• Disease resistance and the associated decreased need for fungicide applications<br>• Salinity tolerance, which decreases the need for flushing of soils with water<br>• Frost resistance, which extends seasonal productivity and decreases crop loss<br>• Perennial life span (rather than annual), which reduces the need for tillage (see above)<br>• 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) | • For optimum nutrient availability<br>• Less-soluble/mobile nutrients in organic fertilizer |
| Monitoring or adjusting | • Doing soil tests<br>• Balancing soil nutrients | • Optimum nutrient (N, P, K, Ca, Fe, etc.)/pH balance |
| Contouring or terracing | Building/installing water bars, terraces, etc. | • Reduces soil erosion |
| Crop rotation | Planting different crops in subsequent planting periods | • Lower herbicide/insecticide requirements<br>• Adds nutrients back to the soil<br>• Takes advantage of nitrogen-fixers (e.g., legumes) |
| Cover crops | • Interspersing crops/planting between the rows<br>• Planting cover vegetation during a fallow period | • Adds nutrients<br>• Reduces erosion |
| Windbreaks | Planting rows of trees or shrubs | • Lowers soil loss to wind erosion<br>• Traps moisture of winter snows |
| Mulching | Applying organic matter to the surface of the field/soil | • Lowers water loss<br>• Increases water-holding capacity<br>• Increases nutrient availability<br>• Increases permeability/infiltration |
| Reduced or no tillage | Planting with reduced or no mechanical turning of the soil | • Decreases evaporation<br>• Decreases soil erosion |
| Fallowing | Allowing soil to rejuvenate with a noncrop year; resting soil | • Rests/recharges soil<br>• Adds nutrients<br>• Lowers erosion |

# AP® ENVIRONMENTAL SCIENCE
# 2009 SCORING GUIDELINES

## Question 4 (continued)

| Practice | Description | Advantage |
|---|---|---|
| Small-scale, slash-and-burn agriculture (*milpa*; swidden) | • Forest is cut in small patches<br>• Some shrubs/herbaceous plants remain<br>• Crops planted together among existing vegetation | • Conserves soil nutrients<br>• Allows nutrients time to replenish<br>• Erosion losses are minimized |
| Tiling | Installing underground drainage | • Reduces water saturation<br>• Reduces capillary rise of salts |
| Polyculture/inter-cropping | Use of a diversity of species to take advantage of beneficial interactions | • Lowers soil exposure<br>• Takes advantage of different root depths<br>• Breaks monoculturing and its negative effects<br>• Takes advantage of attributes of multiple species (nitrogen-fixer, insect resistance) |
| Rotational grazing | Moving cattle to benefit grassland health | • Ensures healthy regeneration of grasslands |
| GM crops | Planting GM crops (must suggest soil improvement) | • 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 | • Removes products that compromise soil ecology or health |
| Tillage or soil structure alteration | • Mechanical or physical alteration<br>• Harrowing, plowing in loam, sand, clay, organic matter to improve soil attributes | • Aerates soil<br>• Increases permeability<br>• Increases water/nutrient holding capacity, permeability, workability |
| Irrigation | Distribution of water (pumps, piping, wells, center pivot) | • Increases effectiveness of fallowing<br>• Increases decay/composting of vegetation<br>• 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) | • Increases ecological diversity associated with cropping landscape<br>• 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**<br>**(Score only the first advantage provided by student)** |
|---|
| Decreased transportation of food, which results in:<br>• Decreased fossil fuel consumption<br>• Decreased greenhouse gases, climate impacts, or carbon footprint<br>• Decreased combustion-related air pollutants/emissions (GHG, VOCs, ozone, particulates, smog)<br>• Decreased extraction impacts (drilling, transport, spills)<br>• Decreased transport impacts (oil spills)<br>• Decreased transport of pest species with crops<br>Consumers can more easily influence environmental choices of growers by:<br>• Supporting organic or permacultural practices and community-supported agriculture (CSA)<br>• Knowing what farming strategies are used (encouraging low pesticide or herbicide use)<br>Consumers can avoid packaging waste<br>Not exporting nutrients—nutrients remain locally compostable |

| **Economic Advantages: 1 point**<br>**(Score only the first advantage provided by student)** |
|---|
| Lower cost associated with:<br>• Transportation (fossil fuels, vehicle maintenance)<br>• Storage (warehousing, refrigeration, ripening agents, preservation)<br>Boost in local economy with:<br>• Revenues remaining in local area<br>• Support for local labor or increased number of jobs<br>• Use of community-supported agriculture (CSA)<br>Lower health-care costs associated with local food because it can be more nutritious (less time in transit, picked in riper condition) |