ENVIRONMENTAL SCIENCE
SECTION II
Time—90 minutes
4 Questions

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

1. Read the article below and answer the questions that follow.

Fremont Examiner

Microalgae for Fuel Production: Can Green Goo Solve Our Energy and Climate Problems?

Scientists and investors are promoting the potential of some of the smallest, oiliest critters on Earth as a solution to our energy problems. Although the humble organisms look like green goo, some species of microalgae are over 50 percent oil. Scientists say microalgae are the most efficient organisms at converting sunlight to energy. In fact, they beat other oil crops for production per acre, hands down.

Gallons of Oil per Acre per Year	
Corn	20
Soybeans	50
Safflower	83
Sunflower	102
Rapeseed	115
Oil palm	640
Microalgae	10,000

Seventy percent of this oil can be recovered by pressing the algae; over 90 percent can be recovered by solvent extraction. The resulting oil can be used for heating, for electricity generation, or for making other fuels, like biodiesel. After the oil is removed, the remaining material can be used as animal feed or soil amendment. The Germans are even looking into using it for construction material. "In this way, we sequester that carbon indefinitely," said Dr. Klaus Mueller. Some scientists are bubbling emissions from coal-burning power plants through algae-filled tanks to remove CO_2.

Proponents claim that microalgae can be used to capture nutrients from animal feedlot waste lagoons and sewage treatment plants. Because they grow only in the top inch of water, the algae might even be grown in rooftop pools someday. But are microalgae really all they're cracked up to be? Like other monoculture crops, they may be susceptible to widespread damage from disease.

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Question 1

(a) Calculate the number of acres required to produce 1,000 gallons of oil in one year from

(i) microalgae

(One point is earned for the correct answer.)

$$\frac{10{,}000 \text{ gal}}{1 \text{ acre}} = \frac{1{,}000 \text{ gal}}{x \text{ acres}} \qquad x = \textbf{0.1 acre}$$

OR

$$1 \text{ acre} = 10{,}000 \text{ gal}; \qquad 1{,}000 \text{ gal} \times \frac{1 \text{ acre}}{10{,}000 \text{ gal}} = \textbf{0.1 acre}$$

(ii) soybeans

(One point is earned for the correct answer.)

$$\frac{50 \text{ gal}}{1 \text{ acre}} = \frac{1{,}000 \text{ gal}}{x \text{ acres}} \Rightarrow \qquad x = \textbf{20 acres}$$

OR

$$1 \text{ acre} = 50 \text{ gal}; \qquad 1{,}000 \text{ gal} \times \frac{1 \text{ acre}}{50 \text{ gal}} = \textbf{20 acres}$$

(A third point is earned in part (a) for a correct setup of <u>both</u> the microalgae and soybean calculations.)

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Question 1 (continued)

(b) Describe TWO environmental advantages that biodiesel production from microalgae offers over biodiesel production from the other crops listed in the table.

(One point is earned for each correct advantage; accept only the first two advantages given. Each advantage listed must include a corresponding description.)

Advantage	Description
Less land use	• Less habitat destruction and/or less loss of biodiversity • Protection of watersheds from agricultural runoff
Decreased tilling of soil	• Less soil erosion
Decreased pesticide and/or fertilizer use	• Less runoff of pesticides and/or fertilizers
Decreased fossil fuel consumption for tilling soil, harvesting crops, and/or manufacturing and applying fertilizers and pesticides	• Less mining and drilling for fossil fuels, resulting in less habitat destruction and less loss of biodiversity • Less air pollution (e.g., NO_x, O_3)
Decreased energy consumption for extracting oils from microalgae	• Less mining and drilling for fossil fuels, resulting in less habitat destruction and less loss of biodiversity • Less air pollution (e.g., NO_x, O_3)
Decreased irrigation of land	• Less soil salinization and/or less desertification • Less aquifer depletion
Less nutrient depletion of soil	• Less land under cultivation
Microalgae may be grown in wastewater	• Less runoff and less infiltration of wastewater

Question 1 (continued)

(c) Explain why burning biodiesel fuel has a different impact on atmospheric CO_2 concentrations than does burning fossil fuels.

(One point is earned for a correct explanation.)

Biodiesel contains carbon that was recently present in the atmosphere rather than fossil-fuel carbon that was in the atmosphere long ago and has been sequestered beneath Earth's surface. Hence the burning of biodiesel does not contribute to a net increase in the amount of carbon dioxide currently circulating in the atmosphere, whereas the burning of fossil fuel does contribute to a net increase in the concentration of carbon dioxide in the atmosphere.

(d) Discuss TWO benefits, other than those related to atmospheric impacts, of increased reliance on biodiesel fuels over the next 50 years.

(A total of 3 points can be earned according to the following guidelines.)

- No point is earned for one correct benefit with no appropriate discussion.
- One point is earned for one correct benefit with an appropriate discussion.
- One point is earned for two correct benefits with no appropriate discussion.
- Two points are earned for two correct benefits with one appropriate discussion.
- Three points are earned for two correct benefits with two appropriate discussions.
- Only the first two benefits mentioned in the response can earn points.
- Benefits based on speculation about future energy prices do not earn points.

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Question 1 (continued)

Benefit	Sample Discussion
Biofuels are renewable resources	• Fossil fuels are nonrenewable • Renewable resources are less likely to be exhausted
Increased jobs	• More labor needed in the agricultural sector
Increased profits for companies	• Industries in the agricultural sector will increase sales
Decreased reliance on imported fossil fuels	• Decreases political instability • Results in a self-sufficient supply of energy
Increased global political stability	• Reliance on imported fossil fuels decreases • Disputes over oil are frequently the cause of disagreements among nations
Reduced transportation costs	• Fewer oil spills during transport • Fossil fuels must be transported over greater distances
Reduced land disturbance	• Result of less fossil fuel extraction
Preservation of petroleum	• For nonenergy uses (e.g., plastics, petrochemicals, medical purposes)
Reduced insecurity as fossil fuel reserves decrease	• Enhances a shift to alternate energy sources
Reduced petroleum use	• Petroleum reserves will dwindle over the next 50 years
Increased nutrient capture from wastewater	• Less escapes into the environment • Reduced eutrophication of waterways
Increased availability of waste products	• Increased availability for use as animal feed or soil amendment
Decreased disposal of used cooking oil	• Results in less waste disposal

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Question 1 (continued)

(e) Describe TWO economic or societal problems associated with producing fuel from corn.

(One point is earned for each correct response that includes a corresponding description; only the first two responses can earn points.)

Problem	Description
Increase (or decrease) in corn prices	• As corn is used for energy production, the demand for corn will become greater • Increased corn growing may flood market
Increased prices for food (e.g., beef, chicken, anything made with corn syrup)	• Result of increased corn prices • Increased demand for corn
Increased prices for commodities other than corn	• Increased corn production reduces land area for other crops, reducing supply of commodities
Shortages of food for human consumption	• Decreased supply of corn • Decreased availability of crops displaced by corn production
Cultural extinction	• Rainforest destruction for the production of crops displaced by corn production displaces indigenous cultures
Decreased aesthetic value of land	• Natural areas converted to farmland have less aesthetic value
Loss of jobs	• Lower demand for energy production jobs not associated with corn (e.g., coal mining, petroleum engineering)
Energy shortages	• Poor crop yields resulting from drought, pestilence, etc., result in less corn to produce energy
Increased land costs	• Due to increased demand for agricultural lands
Decreased availability of land for nonagricultural use leading to less land for cities	• Due to increased demand for agricultural lands

Question 1 (continued)

Problem	Description
Decreased availability of land for nonagricultural use leading to public opposition	• Due to increased demand for agricultural lands
Reduced water supply for cities	• Due to increased agricultural water consumption
Increased societal risks associated with exposure to agricultural chemicals	• Increased pesticide and fertilizer use
Higher costs to cultivate and maintain agricultural land	• Increased use of marginal lands to grow more corn
Overuse of agricultural land	• Loss of productive land
Increased taxes or unavailable public money	• Subsidies that divert public money to pay for corn production.
The need to convert combustion engines to burn ethanol or biodiesel	• Using corn for fuel will result in fuel that is not compatible with current engines
More expensive than alternatives	• Higher cost for resources (e.g., fertilizer, pesticides, land, water) needed to produce fuel from corn as compared with producing other fuels