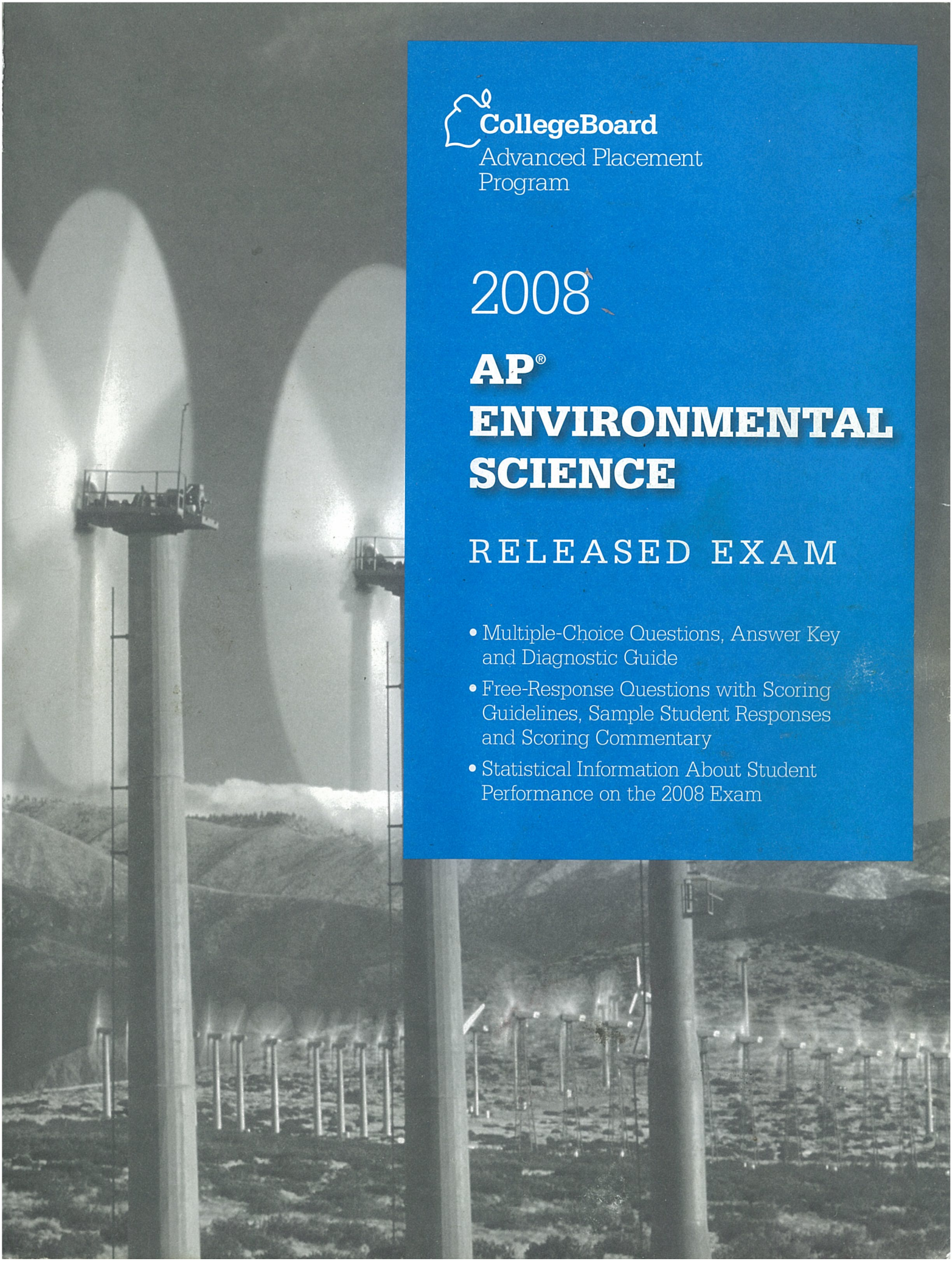


CollegeBoard
Advanced Placement Program

2008

AP® ENVIRONMENTAL SCIENCE

RELEASED EXAM

- Multiple-Choice Questions, Answer Key and Diagnostic Guide
- Free-Response Questions with Scoring Guidelines, Sample Student Responses and Scoring Commentary
- Statistical Information About Student Performance on the 2008 Exam

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 College Board is composed of more than 5,700 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 admission, 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.

For further information, visit www.collegeboard.com.

AP Equity Policy Statement

The College Board and the Advanced Placement Program encourage teachers, AP Coordinators and school administrators to make equitable access a guiding principle for their AP programs. The College Board is committed to the principle that all students deserve an opportunity to participate in rigorous and academically challenging courses and programs. All students who are willing to accept the challenge of a rigorous academic curriculum should be considered for admission to AP courses. The College Board encourages the elimination of barriers that restrict access to AP courses for students from ethnic, racial and socioeconomic groups that have been traditionally underrepresented in the AP Program. Schools should make every effort to ensure that their AP classes reflect the diversity of their student population.

For further information, visit apcentral.collegeboard.com.

The 2008 AP® Environmental Science Released Exam

Contains:

- Multiple-Choice Questions, Answer Key, and Diagnostic Guide
- Free-Response Questions with:
  - Scoring Guidelines
  - Sample Student Responses
  - Scoring Commentary
- Statistical Information About Student Performance on the 2008 Exam

Chapter I: The AP® Process

- What Is the Purpose of the AP® Environmental Science Exam?
- Who Develops the Exam?
- How Is the Exam Developed?
  - Section I—Multiple Choice
  - Section II—Free Response
- Question Types
  - Multiple Choice
  - Free Response
- Scoring the Exam
  - Who Scores the AP Environmental Science Exam?
  - Ensuring Accuracy
  - How the Scoring Guidelines Are Created
  - Training Readers to Apply the Scoring Guidelines
  - Maintaining the Scoring Guidelines
- Preparing Students for the Exam
  - Teaching Free-Response Writing

This chapter will give you a brief overview of the development and scoring processes for the AP Environmental Science Exam. You can find more detailed information at AP Central® (apcentral.collegeboard.com).

What Is the Purpose of the AP Environmental Science Exam?

The AP Environmental Science Exam is designed to allow students to demonstrate the knowledge, understanding, and analytical skills equivalent to those gained by students who have successfully completed a college-level introductory course in environmental science. The exam assesses students' understanding of the major concepts and topics that would be presented in a one-semester college introductory course usually taken by environmental science majors during their first year. A qualifying score on the AP Environmental Science Exam may allow students to begin their college careers without being required to take an introductory environmental science course.

Who Develops the Exam?

The AP Environmental Science Development Committee, working with Assessment Specialists at ETS, develops the exam. This committee is appointed by the College Board and is composed of six teachers from secondary schools, colleges, and universities in the United States. The members provide different perspectives: high school teachers offer valuable advice regarding realistic expectations when matters of content coverage, skills required, and clarity of phrasing are addressed. College and university faculty members ensure that the questions are at the appropriate level of difficulty for students planning to continue their studies at colleges and universities. Committee members typically serve for one to four years.

The Chief Reader, a college environmental science professor responsible for supervising the scoring of the free-response questions, also aids in the development process. The Chief Reader attends every committee meeting to ensure that the free-response questions selected for the exam can be scored reliably. The expertise of the Chief Reader and the committee members who have scored exams in past years is notable: they bring to bear their valuable experience from past AP Readings and suggest changes to improve the quality and the performance of the questions.

How Is the Exam Developed?

The Development Committee sets the exam specifications, determining what will be tested and how it will be tested. It also determines the appropriate level of difficulty for the exam, based on its understanding of the level of competence required for success in introductory environmental science courses in colleges and universities. Each AP Environmental Science Exam is the result of several stages of development that together span two or more years.

Section I—Multiple Choice

1. Development Committee members and other college faculty write and submit multiple-choice questions directed to the major areas outlined in the *AP Environmental Science Course Description*.
2. ETS Assessment Specialists perform preliminary reviews to ensure that the multiple-choice questions are worded clearly and concisely.
3. At the committee meetings, which are held two times a year, the committee members review, revise, and approve the draft questions for use on future exams. They ensure that the questions are clear and unambiguous, that each question has only one correct answer, and that the difficulty level of the questions is appropriate.
4. From the pool of approved questions, Assessment Specialists select an appropriate mix of materials for the multiple-choice section of an exam, making sure that

the questions are distributed across the content areas as specified by the Development Committee in the *AP Environmental Science Course Description*.

5. The committee thoroughly reviews the draft exam in various stages of its development, revising the individual questions and the mix of questions until it is satisfied with the result.
6. The difficulty level of the multiple-choice section is controlled through selection of a wide range of questions, a subset of which has been used in an earlier form of the exam.

Section II—Free Response

1. Well in advance of the exam administration, the members of the Development Committee write free-response questions for the exam. These are assembled into a free-response question pool.
2. From this pool, the committee selects an appropriate combination of questions for a particular exam. It reviews and revises these questions at all stages of the development of that exam to ensure that they are of the highest possible quality. The committee considers, for example, whether the questions will offer an appropriate level of difficulty and whether they will elicit answers that will allow Readers, the high school and college environmental science teachers who score the free-response questions, to discriminate among the responses along the scoring guidelines used for the different questions. An ideal question enables the stronger students to demonstrate their accomplishments while revealing the limitations of less-proficient students.

Question Types

The 2008 AP Environmental Science Exam contains a 90-minute multiple-choice section consisting of 100 questions and a 90-minute free-response section consisting of 4 required essay questions. The two sections are designed to complement each other and to measure a wide range of skills.

Multiple-choice questions are useful for measuring a student's level of competence in a variety of contexts. In addition, they have three other strengths:

1. They are highly reliable. Reliability, or the likelihood that students of similar ability levels taking a different form of the exam will receive the same scores, is controlled more effectively with multiple-choice questions than with free-response questions.
2. They allow the Development Committee to include a selection of questions at various levels of difficulty, thereby ensuring that the measurement of differences in students' achievement is optimized. For AP Exams, the most important distinctions are between students earning the scores of 2 and 3 and scores of 3 and 4. These distinctions are usually best accomplished by using many questions of middle difficulty.
3. They allow comparison of the ability level of the current students with those from another year. A number of questions from an earlier exam are included in the current one, allowing comparisons to be made between the scores of the earlier group of students and those of the current group. This information, along with other data, is used by the College Board to establish AP scores that reflect the competence demanded by the Advanced Placement Program® and that can be legitimately compared with scores from earlier years.

Free-response questions on the AP Environmental Science Exam are a more appropriate tool for evaluating a student's ability to use analytical and organizational skills. They allow students to express ideas in writing with clarity. These questions encompass broader topics. Usually one essay is a document-based question, requiring students to analyze material from editorials or news articles and construct or defend arguments based on scientific evidence. A second essay is data-based and requires students to calculate answers on such topics as energy use, water consumption, and pollution. Two questions involve synthesis and evaluation, requiring students to apply knowledge to particular situations. Any of these four questions may require students to analyze and interpret data or information drawn from laboratory experience and to integrate material from across the environmental science curriculum.

After each exam administration, the free-response and multiple-choice questions are analyzed both individually and collectively, and the findings are used to improve the following year's exam.

Scoring the Exam

Who Scores the AP Environmental Science Exam?

The multiple-choice answer sheets are machine scored. The teachers who score the free-response section of the AP Environmental Science Exam are known as Readers. The majority of these Readers are experienced faculty members who teach either an AP Environmental Science course in a high school or an equivalent course at a college or university

in the United States. Great care is taken to obtain a broad and balanced group of Readers. Among the factors considered before appointing someone to the role are school locale and setting (urban, rural, and so on), as well as the potential Reader's gender, ethnicity, and years of teaching experience. University and high school environmental science teachers in the United States who are interested in applying to be a Reader at a future AP Reading can complete and submit an online application via AP Central (apcentral .collegeboard.com/readers) or request more information by e-mailing apreader@ets.org.

In June 2008, approximately 250 Environmental Science teachers and professors gathered at the University of Nebraska in Lincoln to participate in the scoring session for the AP Environmental Science Exam. Some of the most experienced members of this group were invited to serve as Question Leaders and Table Leaders, and they arrived at the Reading early to help prepare for the scoring session. The remaining Readers were divided into groups, with each group advised and supervised by a Table Leader. Under the guidance of the Chief Reader, Question Leaders and Table Leaders assisted in establishing scoring guidelines, selecting sample student responses that exemplified the guidelines, and preparing for Reader training. All the free-response questions on the 2008 AP Environmental Science Exam were evaluated by the Readers at this single, central scoring session under the supervision of the Chief Reader.

Ensuring Accuracy

The primary goal of the scoring process is to have all Readers score their sets of responses fairly, consistently, and with the same guidelines as the other Readers. This goal is achieved through the creation of detailed scoring guidelines, the thorough training of all Readers, and the various checks and balances that are applied throughout the AP Reading.

How the Scoring Guidelines Are Created

1. As the questions are being developed and reviewed before the Reading, the Development Committee and the Chief Reader discuss the scoring of the free-response questions to ensure that the questions can be scored validly and reliably.
2. During the pre-Reading period, several important tasks are completed. The Chief Reader assigns the Question Leaders the task of producing draft scoring guidelines for the questions assigned to them. Then the Chief Reader, the Question Leaders, and the Table Leaders review these scoring guidelines and test them by applying them to actual student responses. The guidelines are then revised and adjusted, if necessary, to reflect the full range of actual responses that will be encountered by the Readers.
3. Once the scoring of student responses begins, no changes or modifications in the guidelines are made. Given the expertise of the Chief Reader and the analysis of many student responses by Question Leaders and Table Leaders in the pre-Reading period, these guidelines can be used to cover the whole range of student responses. Each Question Leader and Table Leader devotes the first day of the Reading to teaching the scoring guidelines for that particular question and to ensuring that everyone evaluating responses for that question understands the scoring guidelines and can apply them reliably.

Training Readers to Apply the Scoring Guidelines

Because Reader training is so vital in ensuring that students receive an AP score that accurately reflects their performance, the process is thorough:

1. On the first day of the Reading, the Chief Reader provides an overview of the exam and the scoring process to the entire group of Readers. The Readers then break into smaller groups, with each group working on a particular question or questions for which it receives specific training.
2. Each Table Leader directs a discussion of the assigned question, commenting on the question requirements and student performance expectations. The scoring guidelines for the question are explained and discussed.
3. The Readers are trained to apply the scoring guidelines by reading and evaluating samples of student answers that were selected at the pre-Reading session as clear examples of the various score points and the kinds of responses Readers are likely to encounter. Table Leaders explain why the responses received particular scores.
4. When the Table Leader is convinced the Readers understand the scoring guidelines and can apply them uniformly, the scoring of student responses begins. Readers begin by reading in teams of two. Each team member scores a set of papers and then exchanges the papers for a second reading. Scores and differences in judgment are discussed until agreement is reached, with the Table Leader, the Question Leader, or the Chief Reader acting as arbitrator when needed.
5. After a team shows consistent agreement on its scores, its members proceed to score papers individually. Readers are encouraged to seek advice from each other, the Table Leader, the Question Leader, or the Chief Reader when in doubt about a score.

6. Throughout the course of the Reading, Readers discuss with their Table Leaders any student responses that seem problematic or inappropriate. A student response that is problematic receives multiple readings and evaluations.

Maintaining the Scoring Guidelines

Throughout the Reading, the Table Leaders continue to reinforce the use of the scoring guidelines by asking their groups to review sample responses that they have already discussed as clear examples of particular scores or to score new samples and discuss their scores with them. This procedure helps the Readers to adhere to the standards of the group and helps to ensure that a student response will get the same score whether it is evaluated at the beginning, middle, or end of the Reading.

To prevent a Reader from unintentionally scoring a student response higher or lower than it deserves because that same student performed well or poorly on other questions (a phenomenon known as the "halo effect"), the following steps are taken:

- A different Reader scores each question in a given booklet, and the student's identity is unknown to the Reader. Thus, each Reader can evaluate student responses without being prejudiced by knowledge about individual students.
- No marks of any kind are made on the students' papers. The Readers record the scores on a form that is identified only by the student's AP number. Readers are unable to see the scores that have been given to other responses in the exam booklet.

Other methods help ensure that everyone is adhering closely to the scoring guidelines:

- The Table Leader rereads a subset of the student papers from each of the Readers in that Leader's group. This approach allows Table Leaders to guide their Readers toward appropriate and consistent interpretations of the scoring guidelines.
- Readers are paired, so that every Reader has a partner to check for consistency and to discuss problem cases with; Table Leaders are also paired to help each other on questionable calls.

Preparing Students for the Exam

On the AP Environmental Science Exam, students are expected to demonstrate competence in environmental science concepts, techniques, and vocabulary.

The free-response section of the exam requires the student to demonstrate an understanding of the major concepts of environmental science. Students may be asked to "plot," "predict," "discuss," "describe," "analyze," "explain," "identify," "compare and contrast," or "defend the statement that." These are obviously not identical tasks, and each requires something different of the student. Furthermore, the question may call for more than one of these activities, such as "identify and explain." Students should read each question carefully. Only when students clearly understand what is being asked of them should they begin developing and presenting their response.

Teaching Free-Response Writing

It is important for AP teachers to devote some course time to reviewing strategies for responding to free-response questions with their students. The most important elements of good free-response writing are to understand the question, to focus on developing an answer or response to what is asked, and to write the answer clearly and legibly. Some practice in "identifying factors," or "describing a relationship," or "explaining the consequences" will produce different kinds of responses for the student and the teacher to consider—responses with different content, different structures, and different lengths.

Students are required to show their work on all calculations, and factor analysis can help them avoid careless errors.

Chapter II: The 2008 AP Environmental Science Exam

- Exam Content and Format
- Giving a Practice Exam
- Instructions for Administering the Exam
- Blank Answer Sheet
- The Exam

Exam Content and Format

The 2008 AP Environmental Science Exam is three hours in length and has two sections:

- A 90-minute multiple-choice section consisting of 100 questions accounting for 60 percent of the final score.
- A 90-minute free-response section consisting of 4 free-response questions (1 data-based, 1 document-based, and two synthesis and evaluation questions) accounting for 40 percent of the final score.

2008 Environmental Science Exam Format				
Section/Part	**Question Type**	**Number of Questions or Prompts**	**Percent of Final Score**	**Time**
Section I	**Multiple Choice**	**100 questions**	**60%**	**90 minutes**
Section II	**Free Response**	**4 questions**	**40%**	**90 minutes**

Giving a Practice Exam

The following pages contain the instructions as they appeared in the 2008 *AP Examination Instructions* for administering the AP Environmental Science Exam. Following these instructions are a blank 2008 answer sheet and the 2008 AP Environmental Science Exam. If you plan to use this released exam to test your students, you may wish to use these instructions to create an exam situation that closely resembles an actual administration. If so, read only the indented, boldface directions to the students; all other instructions are for the person administering the exam and need not be read aloud. Some instructions, such as those referring to the date, the time, and page numbers, are no longer relevant and should be ignored. Note: the term "grades," which appears in the exam and exam instructions that follow, refers to AP Exam scores of 1, 2, 3, 4, or 5.

Another publication you might find useful is the *Packet of 10*—ten copies of the 2008 AP Environmental Science Exam, each with a blank answer sheet. You can order this packet online at the College Board Store (store.collegeboard.com).

Instructions for Administering the Exam
(from the 2008 *AP Examination Instructions* book)

SECTION I: Multiple-Choice Questions

Do not begin the exam instructions below until you have completed the appropriate General Instructions for your group.

Make sure you begin the exam at the designated time. When you have completed the General Instructions, say:

> **It is Tuesday morning, May 13, and you will be taking the AP Environmental Science Exam. In a moment, you will open the packet that contains your exam materials. By opening this packet, you agree to all of the AP Program's policies and procedures outlined in the 2007-08 *Bulletin for AP Students and Parents*. You may now open your exam packet and take out the Section I booklet, but do not open the booklet or the shrinkwrapped Section II materials. Put the white seals aside. Read the statements on the front cover of Section I and look up when you have finished. . . .**
>
> **Now sign your name and write today's date. Look up when you have finished. . . .**
>
> **Now print your full legal name where indicated. Are there any questions? . . .**

Answer any questions. Then say:

> **Now turn to the back cover and read it completely. Look up when you have finished. . . .**
>
> **Are there any questions? . . .**

Answer any questions. Then say:

> **Section I is the multiple-choice portion of the exam. You may never discuss these specific multiple-choice questions at any time in any form with anyone, including your teacher and other students. If you disclose these questions through any means, your AP Exam grade will be canceled. Are there any questions? . . .**

Answer any questions. Then say:

> **You must complete the answer sheet using a No. 2 pencil only. Mark all of your responses on your answer sheet, one response per question. Completely fill in the ovals. There are more answer ovals on the answer sheet than there are questions, so you will have unused ovals when you reach the end. Your answer sheet will be scored by machine; any stray marks or smudges could be read as answers. If you need to erase, do so carefully and completely. No credit will be given for anything written in the exam booklet. Scratch paper is not allowed, but you may use the margins or any blank space in the exam booklet for scratch work. Calculators are not allowed. Are there any questions? . . .**

Answer all questions regarding procedure. Then say:

> **You have 1 hour and 30 minutes for this section. Open your Section I booklet and begin.**

Note Start Time here _____. Note Stop Time here _____. You and your proctors should make sure students are marking their answers in pencil on their answer sheets, and that they are not looking at their shrinkwrapped Section II booklets. After 1 hour and 30 minutes, say:

Stop working. Close your booklet and put your answer sheet on your desk, face up, with the fold to your left. I will now collect your answer sheet.

After you have collected an answer sheet from each student, say:

Take your seals and press one on each area of your exam booklet marked "PLACE SEAL HERE." Fold them over the open edges and press them to the back cover. When you have finished, place the booklet on your desk with the cover face up and the fold to your left. . . .

I will now collect your Section I booklet.

As you collect the sealed Section I booklets, check to be sure that each student has signed the front cover. There is a 10-minute break between Sections I and II. When all Section I materials have been collected and accounted for and you are ready for the break, say:

Please listen carefully to these instructions before we take a break. Everything you placed under your chair at the beginning of the exam must remain there. You are not allowed to consult teachers, other students, or textbooks about the exam materials during the break. You may not make phone calls, send text messages, check e-mail, access a computer, calculator, cell phone, PDA, MP3 player, e-mail/messaging device, or any other electronic or communication device. Remember, you are not allowed to discuss the multiple-choice section of this exam with anyone at any time. Failure to adhere to any of these rules could result in invalidation of your grade. Please leave your shrinkwrapped Section II package on top of your desk during the break. You may get up, talk, go to the restroom, or get a drink. Are there any questions? . . .

Answer all questions regarding procedure. Then say:

Let's begin our break. Testing will resume at _____.

SECTION II: Free-Response Questions

After the break, say:

May I have everyone's attention? Place your Student Pack on your desk. . . .

You may now open the shrinkwrapped Section II package. . . .

Read the bulleted statements on the front cover of the pink booklet. Look up when you have finished. . . .

Now place an AP number label on the shaded box. If you don't place an AP number label on this box, it may be impossible to identify your booklet, which could delay or jeopardize your AP grade. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .

Read the last statement. . . .

Using a pen with black or dark blue ink, print the first, middle, and last initials of your legal name in the boxes and print today's date where indicated. This constitutes your signature and your agreement to the conditions stated on the front cover. . . .

Turn to the back cover and read Item 1 under "Important Identification Information." Print your identification information in the boxes. Note that you must print the first two letters of your LAST name and the first letter of your FIRST name. Look up when you have finished. . . .

In Item 2, print your date of birth in the boxes. . . .

Read Item 3 and copy the school code you printed on the front of your Student Pack into the boxes. . . .

Read Item 4. . . .

Are there any questions? . . .

Answer all questions regarding procedure. Then say:

I need to collect the Student Pack from anyone who will be taking another AP Exam. If you are taking another AP Exam, put your Student Pack on your desk. You may keep it only if you are not taking any other AP Exams this year. If you have no other AP Exams to take, place your Student Pack under your chair now. . . .

While Student Packs are being collected, read the "At a Glance" column and the instructions on the back cover of the pink booklet. Do not open the booklet until you are told to do so. Look up when you have finished. . . .

Collect the Student Packs. Then say:

Are there any questions? . . .

Answer all questions regarding procedure. Then say:

Now open the Section II booklet and tear out the green insert that is in the center of the booklet. In the upper right-hand corner of the cover, print your name, your teacher's name, and your school's name. . . .

Read the information on the front cover of the green insert. Look up when you have finished. . . .

You have 1 hour and 30 minutes to complete Section II. You are responsible for pacing yourself, and may proceed freely from one question to the next. You may make notes in the green insert, but you MUST write your answers in the pink booklet using a pen with black or dark blue ink. If you need more paper during the exam, raise your hand. At the top of each extra piece of paper you use, be sure to write your AP number and the number of the question you are working on. No calculators may be used on this exam. Are there any questions? . . .

Answer any questions. Then say:

You may begin. . . .

Note Start Time here _____. Note Stop Time here _____. You and your proctors should make sure students are using pens with black or dark blue ink and that they are writing their answers in their pink Section II booklets, not in their green inserts. After 1 hour and 20 minutes, say:

> **There are 10 minutes remaining.**

After 10 minutes, say:

> **Stop working and close your exam booklet and green insert. Put your pink booklet on your desk, face up, with the fold to your left. Put your green insert next to it. Remain in your seat, without talking, while the exam materials are collected. . . .**

Collect a pink Section II booklet and a green insert from every student. **Check the front cover of each pink booklet to ensure that the student has placed an AP number label on the shaded box and printed his or her initials and today's date. Check that the student has completed the "Important Identification Information" area on the back cover, and that answers have been written in the pink booklet and not in the green insert.** The green inserts must be stored securely for no fewer than two school days. After the two-day holding time, the green inserts may be given to the appropriate AP teacher(s) for return to the students. When all exam materials have been collected and accounted for, say:

> **Your teacher will return your green insert to you in about two days. You may not discuss the free-response questions with anyone until that time. Remember that the multiple-choice questions may never be discussed or shared in any way at any time. You should receive your grade report in the mail about the third week of July. You are now dismissed.**

Exam materials should be put in locked storage until they are returned to the AP Program after your school's last administration. Before storing materials, check your list of students who are eligible for fee reductions and fill in the appropriate oval on their registration answer sheets. To receive a separate *AP Instructional Planning Report* or student grade roster for each AP class taught, fill in the appropriate oval in the "School Use Only" section of the answer sheet. See "Post-Exam Activities" in the 2008 *AP Coordinator's Manual.*

USE PENCIL ONLY FOR THE ENTIRE ANSWER SHEET.

CollegeBoard AP **Answer Sheet for May 2008, Form 4EBP** **PAGE 1**

NAME AND EXAM AREA – COMPLETE THIS AREA AT EVERY EXAM.

To maintain the security of the exam and the validity of my AP grade, I will allow no one else to see the multiple-choice questions. I will seal the multiple-choice booklet when asked to do so, and I will not discuss these questions with anyone at any time after the completion of the section. I am aware of and agree to the AP Program's policies and procedures as outlined in the 2007-08 *Bulletin for AP Students and Parents*, including using testing accommodations (e.g., extended time, computer, etc.) only if I have been preapproved by College Board Services for Students with Disabilities.

A. SIGNATURE _____
Sign your legal name as it will appear on your college applications.

PLACE YOUR AP® NUMBER LABEL OR WRITE YOUR AP NUMBER HERE AT EVERY EXAM.

B. LEGAL NAME — Omit apostrophes, Jr., or II.

Legal Last Name—first 15 letters | Legal First Name—first 12 letters | MI

C. YOUR AP NUMBER

D. ADMIN. DAY IN MAY

E. TIME OF DAY

- ○ 6 AM
- ○ 7 AM
- ○ 8 AM
- ○ 9 AM
- ○ 10 AM
- ○ 11 AM
- ○ 12 PM
- ○ 1 PM
- ○ 2 PM
- ○ 3 PM
- ○ 4 PM
- ○ 5 PM

STUDENT INFORMATION AREA—COMPLETE THIS AREA ONLY ONCE.

I. SEX
1. Male
2. Female

J. CURRENT GRADE LEVEL
1. Not yet in 9th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. No longer in high school

K. DATE OF BIRTH

Month	Day	Year
01 ○ Jan.		
02 ○ Feb.		
03 ○ Mar.	0 0	0 0
04 ○ Apr.	1 1	1 1
05 ○ May	2 2	2 2
06 ○ June	3 3	3 3
07 ○ July	4 4	4 4
08 ○ Aug.	5 5	5 5
09 ○ Sept.	6 6	6 6
10 ○ Oct.	7 7	7 7
11 ○ Nov.	8 8	8 8
12 ○ Dec.	9 9	9 9

L. SOCIAL SECURITY NUMBER (Optional, but preferred)

M. ETHNICITY/RACE
1. American Indian or Alaska Native
2. Asian, Asian American, or Pacific Islander
3. Black or African American
4. Mexican or Mexican American
5. Puerto Rican
6. Other Hispanic, Latino, or Latin American
7. White
8. Other

N. EXPECTED DATE OF COLLEGE ENTRANCE

F Fall	0 2008
W Winter/Spring	1 2009
S Summer	2 2010
U Undecided	3 2011

O. WHAT LANGUAGE DO YOU KNOW BEST?
1. English
2. English and another language about the same
3. Another language

P. Complete ONLY if you are a SOPHOMORE or a JUNIOR.

I want the College Board to send information about me to colleges, universities, and government scholarship programs interested in students like me.

○ Yes ○ No

F. AP EXAM I AM TAKING USING THIS ANSWER SHEET

Print exam name: _____ Print form code (e.g., 4EBP-R) from M-C booklet: _____

Fill in the oval below that corresponds to the exam that you are taking.

07 ○ U.S. History 4EBP-Q	43 ○ European History	78 ○ Physics B
07 ○ U.S. History 4EBP-R	48 ○ French Language	80 ○ Physics C: Mech.
13 ○ Art History	51 ○ French Literature	82 ○ Physics C: E & M
14 ○ Art: Studio Drawing	53 ○ Geography: Human	85 ○ Psychology
15 ○ Art: Studio 2-D Design	55 ○ German Language	87 ○ Spanish Language
16 ○ Art: Studio 3-D Design	57 ○ Gov. & Pol.: U.S.	89 ○ Spanish Literature
20 ○ Biology	58 ○ Gov. & Pol.: Comp.	90 ○ Statistics
25 ○ Chemistry	60 ○ Latin: Vergil	93 ○ World History
28 ○ Chinese Lang. & Culture	61 ○ Latin Literature	
31 ○ Computer Science A	62 ○ Italian Lang. & Culture	
33 ○ Computer Science AB	64 ○ Japanese Lang. & Culture	
34 ○ Economics: Micro	66 ○ Calculus AB 4EBP-Q	
35 ○ Economics: Macro	66 ○ Calculus AB 4EBP-R	
36 ○ Eng. Language & Comp.	68 ○ Calculus BC 4EBP-Q	
37 ○ Eng. Literature & Comp.	68 ○ Calculus BC 4EBP-R	
40 ○ Environmental Science	75 ○ Music Theory	

G. ONLINE PROVIDER CODE

H. MULTIPLE-CHOICE BOOKLET SERIAL NUMBER

743180

Q. PARENTAL EDUCATION LEVEL

Father / Male Guardian	Mother / Female Guardian	
○	○	Grade school
○	○	Some high school
○	○	High school diploma or equivalent
○	○	Business or trade school
○	○	Some college
○	○	Associate or two-year degree
○	○	Bachelor's or four-year degree
○	○	Some graduate or professional school
○	○	Graduate or professional degree

SCHOOL USE ONLY

Instructional Planning Report/Student Grade Roster
1 2 3 4 5 6 7 8 9

Fee Reduction Granted
○ Option 1 ○ Option 2

ETS USE ONLY

Exam	Exam
1 2	1 2

62699 • 00657 • TF127E3600 Q3121/06-09 mh07270

R. This section is for the survey questions in the AP Student Pack. (Do not put responses to exam questions in this section.) Be sure each mark is dark and completely fills the oval.

1	A	B	C	D	E	F	G	4	A	B	C	D	E	F	G	7	A	B	C	D	E	F	G
2	A	B	C	D	E	F	G	5	A	B	C	D	E	F	G	8	A	B	C	D	E	F	G
3	A	B	C	D	E	F	G	6	A	B	C	D	E	F	G	9	A	B	C	D	E	F	G

Do not complete this section unless instructed to do so.

S. If this answer sheet is for the Chinese Language and Culture, French Language, French Literature, German Language, Italian Language and Culture, Japanese Language and Culture, Spanish Language, or Spanish Literature Exam, please answer the following questions. (Your responses will not affect your grade.)

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken? ◯ Yes ◯ No

2. Do you regularly speak or hear the language at home? ◯ Yes ◯ No

Indicate your answers to the exam questions in this section. If a question has only four answer options, do not mark option E. Your answer sheet will be scored by machine. Use only No. 2 pencils to mark your answers on pages 2 and 3 (one response per question). After you have determined your response, be sure to completely fill in the oval corresponding to the number of the question you are answering. Stray marks and smudges could be read as answers, so erase carefully and completely. Any improper gridding may affect your grade. Answers written in the multiple-choice booklet will not be scored.

1	A	B	C	D	E	26	A	B	C	D	E	51	A	B	C	D	E
2	A	B	C	D	E	27	A	B	C	D	E	52	A	B	C	D	E
3	A	B	C	D	E	28	A	B	C	D	E	53	A	B	C	D	E
4	A	B	C	D	E	29	A	B	C	D	E	54	A	B	C	D	E
5	A	B	C	D	E	30	A	B	C	D	E	55	A	B	C	D	E
6	A	B	C	D	E	31	A	B	C	D	E	56	A	B	C	D	E
7	A	B	C	D	E	32	A	B	C	D	E	57	A	B	C	D	E
8	A	B	C	D	E	33	A	B	C	D	E	58	A	B	C	D	E
9	A	B	C	D	E	34	A	B	C	D	E	59	A	B	C	D	E
10	A	B	C	D	E	35	A	B	C	D	E	60	A	B	C	D	E
11	A	B	C	D	E	36	A	B	C	D	E	61	A	B	C	D	E
12	A	B	C	D	E	37	A	B	C	D	E	62	A	B	C	D	E
13	A	B	C	D	E	38	A	B	C	D	E	63	A	B	C	D	E
14	A	B	C	D	E	39	A	B	C	D	E	64	A	B	C	D	E
15	A	B	C	D	E	40	A	B	C	D	E	65	A	B	C	D	E
16	A	B	C	D	E	41	A	B	C	D	E	66	A	B	C	D	E
17	A	B	C	D	E	42	A	B	C	D	E	67	A	B	C	D	E
18	A	B	C	D	E	43	A	B	C	D	E	68	A	B	C	D	E
19	A	B	C	D	E	44	A	B	C	D	E	69	A	B	C	D	E
20	A	B	C	D	E	45	A	B	C	D	E	70	A	B	C	D	E
21	A	B	C	D	E	46	A	B	C	D	E	71	A	B	C	D	E
22	A	B	C	D	E	47	A	B	C	D	E	72	A	B	C	D	E
23	A	B	C	D	E	48	A	B	C	D	E	73	A	B	C	D	E
24	A	B	C	D	E	49	A	B	C	D	E	74	A	B	C	D	E
25	A	B	C	D	E	50	A	B	C	D	E	75	A	B	C	D	E

FOR QUESTIONS 76-151, SEE PAGE 3.

DO NOT WRITE IN THIS AREA.

Be sure each mark is dark and completely fills the oval. If a question has only four answer options, do not mark option E.

76	A	B	C	D	E	101	A	B	C	D	E	126	A	B	C	D	E
77	A	B	C	D	E	102	A	B	C	D	E	127	A	B	C	D	E
78	A	B	C	D	E	103	A	B	C	D	E	128	A	B	C	D	E
79	A	B	C	D	E	104	A	B	C	D	E	129	A	B	C	D	E
80	A	B	C	D	E	105	A	B	C	D	E	130	A	B	C	D	E
81	A	B	C	D	E	106	A	B	C	D	E	131	A	B	C	D	E
82	A	B	C	D	E	107	A	B	C	D	E	132	A	B	C	D	E
83	A	B	C	D	E	108	A	B	C	D	E	133	A	B	C	D	E
84	A	B	C	D	E	109	A	B	C	D	E	134	A	B	C	D	E
85	A	B	C	D	E	110	A	B	C	D	E	135	A	B	C	D	E
86	A	B	C	D	E	111	A	B	C	D	E	136	A	B	C	D	E
87	A	B	C	D	E	112	A	B	C	D	E	137	A	B	C	D	E
88	A	B	C	D	E	113	A	B	C	D	E	138	A	B	C	D	E
89	A	B	C	D	E	114	A	B	C	D	E	139	A	B	C	D	E
90	A	B	C	D	E	115	A	B	C	D	E	140	A	B	C	D	E
91	A	B	C	D	E	116	A	B	C	D	E	141	A	B	C	D	E
92	A	B	C	D	E	117	A	B	C	D	E	142	A	B	C	D	E
93	A	B	C	D	E	118	A	B	C	D	E	143	A	B	C	D	E
94	A	B	C	D	E	119	A	B	C	D	E	144	A	B	C	D	E
95	A	B	C	D	E	120	A	B	C	D	E	145	A	B	C	D	E
96	A	B	C	D	E	121	A	B	C	D	E	146	A	B	C	D	E
97	A	B	C	D	E	122	A	B	C	D	E	147	A	B	C	D	E
98	A	B	C	D	E	123	A	B	C	D	E	148	A	B	C	D	E
99	A	B	C	D	E	124	A	B	C	D	E	149	A	B	C	D	E
100	A	B	C	D	E	125	A	B	C	D	E	150	A	B	C	D	E
												151	A	B	C	D	E

ETS USE ONLY			
	R	W	FS
PT1			
PT2			
PT3			
PT4			
TOT			
EQ			
TA1			
TA2			

DO NOT WRITE IN THIS AREA.

T. YOUR MAILING ADDRESS

HOME ADDRESS AND SCHOOL AREA—COMPLETE THIS AREA ONLY ONCE.

- Your grade report will be mailed to this address in July.
- Using the abbreviations given in your AP Student Pack, print your address in the boxes below. If your international address does not fit, see item V, below.
- Indicate a space in your address by leaving a blank box — do not grid that column. Only one oval is to be filled in for each column.

Street

City

STATE

1 AL 2 AK 3 AZ 4 AR 5 CA 6 CO 7 CT 8 DE 9 DC 10 FL 11 GA 12 HI 13 ID 14 IL 15 IN 16 IA 17 KS 18 KY 19 LA 20 ME 21 MD 22 MA 23 MI 24 MN 25 MS 26 MO 27 MT 28 NE 29 NV 30 NH 31 NJ 32 NM 33 NY 34 NC 35 ND 36 OH 37 OK 38 OR 39 PA 40 RI 41 SC 42 SD 43 TN 44 TX 45 UT 46 VT 47 VA 48 WA 49 WV 50 WI 51 WY 52 Puerto Rico 53 Other

ZIP OR POSTAL CODE

U. COUNTRY CODE

W. TELEPHONE NUMBER

Area Code

INTERNATIONAL TELEPHONE

If your international telephone number is longer than 10 digits, write the entire number below.

FOR STUDENTS OUTSIDE THE UNITED STATES ONLY

V. If the address gridded above is not complete enough for delivery of your grade report, please fill in this oval and print your complete address below. ⟶ ○

Address

Address

City State or Province

Country ZIP or Postal Code

X. SCHOOL YOU ATTEND

School Code

School Name, City, and State

← Make sure you have correctly entered your School Code, filled in the appropriate ovals, and completed the information below.

School Name

City

State

Y. COLLEGE TO RECEIVE YOUR AP GRADE REPORT

College Code

College Name and Address

Using the College Code list in the AP Student Pack, indicate the **one** college that you want to receive your AP Grade Report by writing in the college code number, gridding the appropriate ovals, and completing the information below.

College Name

City

State

AP® Environmental Science Exam

SECTION I: Multiple-Choice Questions

2008

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 Grade
60%
Writing Instrument
Pencil required
Electronic Device
None allowed

Instructions

Section I of this exam contains 100 multiple-choice questions. Fill in only the ovals 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 oval 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.

About Guessing

Many students wonder whether or not to guess the answers to questions about which they are not certain. In this section of the exam, as a correction for random guessing, one-fourth of the number of questions you answer incorrectly will be subtracted from the number of questions you answer correctly. If you are not sure of the best answer but have some knowledge of the question and are able to eliminate one or more of the answer choices, your chance of answering correctly is improved, and it may be to your advantage to answer such a question.

ENVIRONMENTAL SCIENCE

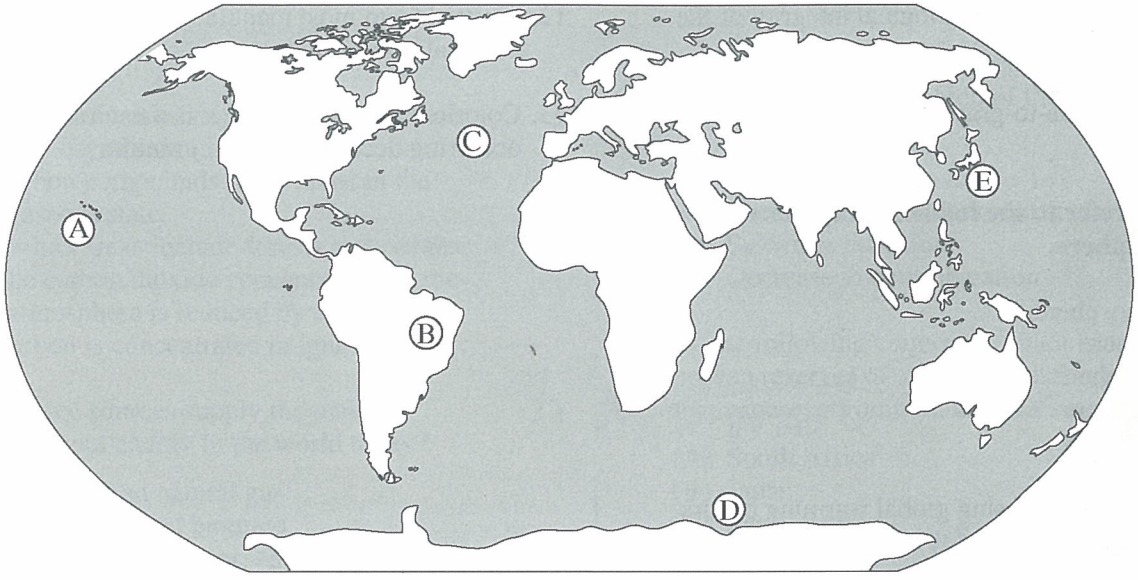
Section I

Time—1 hour and 30 minutes

Part A

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement and then fill in the corresponding oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-3 refer to the locations marked by letters on the world map below.



1. The location where new crust is being created at a divergent plate boundary

2. The location where one tectonic plate is being forced beneath another, creating a volcanic arc.

3. The intraplate location where hot-spot volcanism is occurring

Questions 4-6 refer to the following.

(A) Safe Drinking Water Act
(B) Clean Water Act
(C) Comprehensive Environmental Response Compensation and Liability Act (CERCLA)
(D) Resource Conservation and Recovery Act
(E) Toxic Substances Control Act

4. Requires minimum safety standards for community water supplies

5. Mandates the restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters

6. Establishes cradle-to-grave tracking of hazardous waste

Questions 7-9 refer to the following regions of Earth's atmosphere.

(A) Thermosphere
(B) Exosphere
(C) Troposphere
(D) Mesosphere
(E) Stratosphere

7. The phenomenon causing global warming occurs primarily in this region of the atmosphere.

8. The beneficial ozone layer is in this region of the atmosphere.

9. Most oxygen is found in this layer of the atmosphere.

Questions 10-13 refer to the substances listed.

(A) Asbestos
(B) Radon
(C) Lead
(D) Carbon monoxide
(E) Formaldehyde

10. Found in old plumbing pipes and fixtures and some ceramic glazes

11. Composed of fibers known to cause lung disease

12. Emitted from most manufactured building materials and furniture

13. Colorless, odorless gas that is a naturally occurring decay product of uranium

GO ON TO THE NEXT PAGE.

Part B

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

14. The greatest amount of fresh water is found in which of the following?
    (A) The atmosphere
    (B) Estuaries
    (C) Lakes
    (D) Rivers and streams
    (E) Polar ice caps and glaciers

15. Which of the following is true of carbon as it cycles in nature?
    (A) Carbon dioxide is released during photosynthesis.
    (B) Carbon compounds rarely exist in the gaseous state.
    (C) Carbon sinks include forests and oceans.
    (D) The carbon dioxide concentration in the atmosphere is reduced by cutting trees.
    (E) Carbon is concentrated in igneous rocks.

16. Which three sources supply the majority of commercial energy in the world today?
    (A) Coal, oil, and natural gas
    (B) Solar, wind, and biomass
    (C) Nuclear, hydropower, and photovoltaics
    (D) Wood, dung, and charcoal
    (E) Fuel cells, geothermal, and tidal power

17. By the year 2050, world population is expected to approach 10 billion. If the current population trends continue, which region of the world will most likely experience the majority of the growth?
    (A) North and Central America
    (B) Central and South America
    (C) Eastern and Western Europe
    (D) Africa and Asia
    (E) Australia and New Zealand

18. Which of the following human activities is most closely associated with depletion of the stratospheric ozone layer?
    (A) Mining of coal
    (B) Disposal of refrigerators and air conditioners
    (C) Heating of homes and factories
    (D) Generation of electricity
    (E) Agricultural irrigation

19. Overuse of groundwater in coastal areas would most likely result in which of the following?
    (A) Rise in water table
    (B) Increase in stream flow
    (C) Bacterial contamination of surface water
    (D) Saltwater intrusion
    (E) Decrease in eutrophication

20. Of the following countries, which has the largest proven reserves of strategic metals such as manganese, chromium, and platinum?
    (A) South Africa
    (B) Japan
    (C) Saudi Arabia
    (D) The United States
    (E) France

21. In 2007 in the United States there were approximately 480 cars for every 1,000 people. The total number of cars in the United States in 2007 was closest to
    (A) 150,000
    (B) 30,000,000
    (C) 150,000,000
    (D) 300,000,000
    (E) 3,000,000,000

22. Which of the following world regions contain the greatest area of rain forest?
(A) Canada and the United States
(B) Eastern and Western Europe
(C) Russia and China
(D) Australia and New Zealand
(E) Brazil and Indonesia

23. Which of the following best exemplifies population momentum?
(A) Continued growth of a population after fertility drops to replacement level
(B) Continued growth of a population due to emigration
(C) Decreased population due to increase in the death rate
(D) Decreased population due to a reduced death rate and an increased fertility rate
(E) Growth of a population after the fertility rate doubles

24. Of the following strategies to decrease the landfill volume of packaging material from food and other consumer products, the most energy efficient is
(A) recovering plastic packaging material from the waste stream and recycling it
(B) recovering metal packaging material from the waste stream and recycling it
(C) limiting the size of individual beverage containers made from metal, glass, or plastic
(D) using more packaging materials that are manufactured from raw materials that are renewable
(E) promoting the use of reusable containers for consumer goods

25. An integrated pest-management approach to pest control emphasizes which of the following?
(A) Eradication of the pest population
(B) Reliance on spraying broad-spectrum pesticides
(C) Reduction of crop damage to an economically tolerable level
(D) Use of plant monocultures to simplify spraying
(E) Elimination of the use of second-generation pesticides

26. Of the following, which is true of noise pollution?
(A) Noise pollution is an insignificant occupational hazard.
(B) Noise at 100 decibels has twice the energy of noise at 50 decibels.
(C) Hearing damage occurs most quickly when the intensity level of the sound is low.
(D) In urban areas, few individuals are exposed to noise pollution.
(E) Sudden or persistent noise may lead to permanent hearing loss.

27. If a country has a crude birth rate of 24 per 1,000 and a crude death rate of 8 per 1,000, the natural annual percent increase of its population is
(A) 0.6%
(B) 1.6%
(C) 3%
(D) 16%
(E) 32%

28. Which of the following shows the approximate concentration of CO_2, N_2, and O_2 in dry air?

	CO_2	N_2	O_2
(A)	78%	< 1%	21%
(B)	43%	< 1%	56%
(C)	36%	8%	56%
(D)	10%	70%	20%
(E)	< 1%	78%	21%

29. Which of the following best illustrates an abiotic component of the environment affecting a biotic component of the environment?
(A) Composted manure is added to agricultural soil during spring tilling.
(B) Coral reefs modify the direction of an ocean current.
(C) Plants release O_2 into the atmosphere during photosynthesis.
(D) Low phosphorus content in soil limits the growth of vegetation.
(E) A thick planting of ground cover reduces soil erosion on a hillside.

GO ON TO THE NEXT PAGE.

30. Of the following cities, which regularly experiences the worst levels of photochemical smog that is enhanced by thermal inversions?
    (A) New York City, New York
    (B) Los Angeles, California
    (C) Portland, Oregon
    (D) Atlanta, Georgia
    (E) Philadelphia, Pennsylvania

31. Which of the following best describes the first law of thermodynamics?
    (A) Energy always changes from a more useful, more concentrated form to a less useful, less concentrated form.
    (B) In a closed system of constant mass, the energy involved in any physical or chemical change is neither created nor destroyed, but merely changed from one form to another.
    (C) Heat always flows from a hot body to a cold body.
    (D) Entropy of a system increases as the state of disorganization in the system increases.
    (E) In a reversible process, the entropy of the system is constant, whereas in an irreversible process, the entropy of the system increases.

32. What two main factors would best indicate the quality of life of a country's population?
    (A) The total fertility rate and the death rate
    (B) The crude birth rate and crude death rate
    (C) The birth rate and the infant mortality rate
    (D) The replacement-level fertility rate and the total fertility rate
    (E) The life expectancy and the infant mortality rate

33. Rachel Carson's contributions to the environmental movement include which of the following?
    (A) Alerting the public to the hazardous waste problem at Love Canal
    (B) Increasing public awareness of the risks of using pesticides
    (C) Starting the first Earth Day in 1970
    (D) Discovering the thinning of the ozone layer in polar regions
    (E) Being the first female administrator of the EPA

34. In a typical forest ecosystem, dead trees and fallen trees are most important because of their role in which of the following?
    (A) Providing a valuable source of timber
    (B) Providing habitats for wildlife
    (C) Contributing to soil erosion
    (D) Increasing water runoff
    (E) Removing carbon dioxide from the air

35. Possible effects of a warmer atmosphere include which of the following?
    I. Expanded ranges of tropical diseases
    II. More intense hurricanes and typhoons
    III. Increased crop damage from pests and diseases
    (A) I only
    (B) II only
    (C) I and III only
    (D) II and III only
    (E) I, II, and III

36. When a rain forest is slashed and burned, the local concentration of carbon dioxide in the atmosphere increases. This is primarily due to
    (A) changes in the local climate
    (B) oxidation of carbon compounds
    (C) cellular respiration of rain-forest plants
    (D) erosion of exposed soil
    (E) carbon dioxide being released by anaerobic organisms

37. Pollution is considered an external cost when
    (A) it has harmful effects borne only by the people who purchase the products that cause the pollution
    (B) the cost to the environment is not reflected in the price of the products that produce the pollution
    (C) it has a significant impact on the consumer's decision to buy a product that pollutes
    (D) it is a hidden cost that would result in a greater demand for the product if the consumer were aware of the hidden cost
    (E) it is produced in the external environment by a malfunction in the operation of the product

38. A sustainable society would emphasize

(A) maintaining the current rates of energy flow and resource use
(B) converting the world's high-quality energy resources to low-quality heat
(C) recycling both matter and high-quality energy
(D) using energy efficiently and reusing and recycling matter
(E) quickly expanding nuclear power, because it is a renewable resource

39. A large forested area is fragmented into small forest tracts separated by agricultural areas. This change will most likely lead to

(A) an increase in the population of top carnivores
(B) an improvement in the dispersal mechanisms of forest species
(C) a more stable regional climate
(D) a decrease in the amount of edge habitat
(E) a decrease in the gene flow within species of the original forest

40. Which of the following is a greenhouse gas that is produced by domestic livestock?

(A) NO_2
(B) CH_4
(C) O_3
(D) CO
(E) SO_2

Questions 41-42

In 1997 the World Resources Institute estimated the world's proven oil reserves to be 1,000 billion barrels and the ultimately recoverable reserves to be 2,000 billion barrels. The table below shows the world consumption of oil from 1986 to 1997.

Year	Consumption (million barrels per day)
1986	62
1987	63
1988	65
1989	66
1990	66
1991	67
1992	67
1993	67
1994	68
1995	70
1996	72
1997	74

41. At the 1997 rate of consumption, about how long will the estimated 2,000 billion barrels of oil last?

(A) 25 years
(B) 50 years
(C) 75 years
(D) 200 years
(E) 500 years

42. What was the approximate percent increase in consumption from 1986 to 1997 ?

(A) 10%
(B) 20%
(C) 30%
(D) 50%
(E) 80%

GO ON TO THE NEXT PAGE.

43. Which of the following is most typically associated with the transition from a rural to an urbanized society?

(A) Reduced birth rates
(B) Reduced need for sewage-treatment facilities
(C) Increased rates of population growth
(D) Increased air quality in urban areas
(E) Increased stabilization of microclimate in urban areas

44. Five islands, *A*, *B*, *C*, *D*, and *E*, differ only in distance from the mainland, area, and species diversity. Which island would be predicted to have the highest species diversity?

Island	Distance from Mainland (kilometers)	Area (hectares)
(A) *A*	50	1×10^2
(B) *B*	50	1×10^6
(C) *C*	500	1×10^2
(D) *D*	1,000	1×10^2
(E) *E*	1,000	1×10^6

45. Which of the following best illustrates point-source pollution?

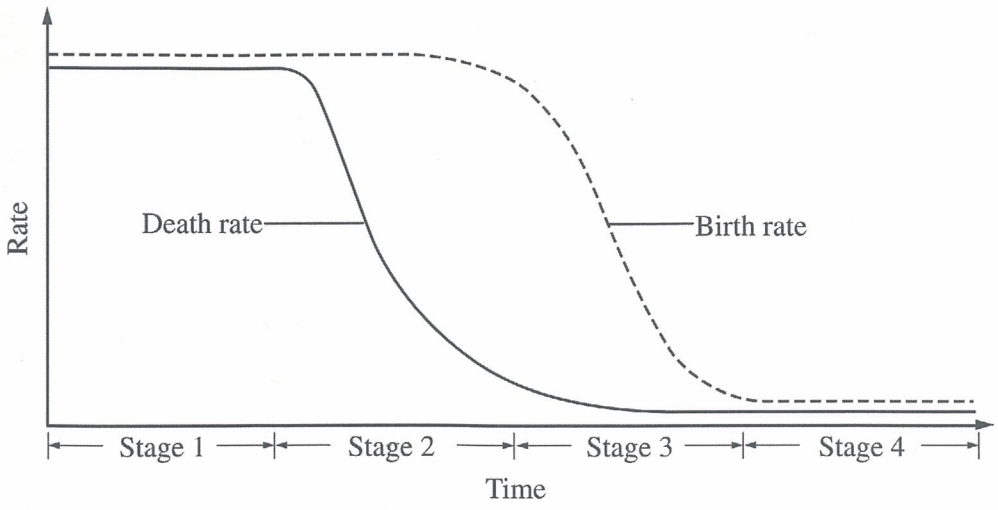
(A) Toxic sediments in the delta of a major river
(B) Increase in NO_x in a traffic-clogged city
(C) Dust blowing off unpaved roads
(D) Smoke emitted from forest fires
(E) Smokestack emissions from a large smelting company

46. The net annual primary productivity of a particular wetland ecosystem is found to be 8,000 kcal/m^2 per year. If respiration by the aquatic producers is 12,000 kcal/m^2 per year, what is the gross annual primary productivity for this ecosystem, in kcal/m^2 per year?

(A) 4,000
(B) 8,000
(C) 12,000
(D) 20,000
(E) 96,000

47. The three main anthropogenic sources of gaseous air pollutants in the United States are

(A) soil erosion, volcanoes, and forest fires
(B) soil erosion, volcanoes, and energy production
(C) industry, construction, and agriculture
(D) industry, transportation, and energy production
(E) industry, transportation, and agriculture



48. During which stage of the demographic transition shown above does a population begin to experience an explosive increase in growth?

(A) Stage 1
(B) Stage 2
(C) Stage 3
(D) Stage 4
(E) After stage 4

---

49. Most municipal solid waste in the United States is disposed of in

(A) the oceans
(B) sanitary landfills
(C) deep wells
(D) open dumps
(E) abandoned mines

50. Which of the following would likely reduce the threats posed by exotic species to native species?

I. Increasing inspections of goods coming into a country
II. Mandating that bilgewater from vessels be emptied in ports instead of in the open ocean
III. Enforcing legislation that restricts imported materials such as untreated wooden packing crates

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

51. Which of the following is a measure of the amount of suspended material in water?

(A) Salinity
(B) Turbidity
(C) Trace-metal concentration
(D) Leachate concentration
(E) pH

52. Acid deposition would most likely result in which of the following?

(A) The release of aluminum ions from soil
(B) An increase in populations of mollusks
(C) The death of species tolerant of low pH levels
(D) An increase in buffering of lake water by sulfates
(E) An increase in the pH of unbuffered water

53. Which of the following are the three major sources of nutrients and calories for the global human population?

(A) Potatoes, fish, and barley
(B) Wheat, beef, and potatoes
(C) Oats, soybeans, and poultry
(D) Corn (maize), wheat, and rice
(E) Rye, beef, and eggs

GO ON TO THE NEXT PAGE.

54. If Earth had no atmosphere, the mean surface temperature would be approximately −15°C. With our present atmosphere, Earth's mean surface temperature is approximately +15°C. Which of the following is the best explanation for this difference?

(A) Reflection of incident solar radiation by clouds
(B) Scattering of visible radiation by aerosols
(C) Absorption of ultraviolet radiation by the ozone layer
(D) Absorption of infrared radiation by atmospheric gases
(E) The breakdown of oxygen molecules in the thermosphere

55. Which of the following can be used to assess the biological diversity of an area?

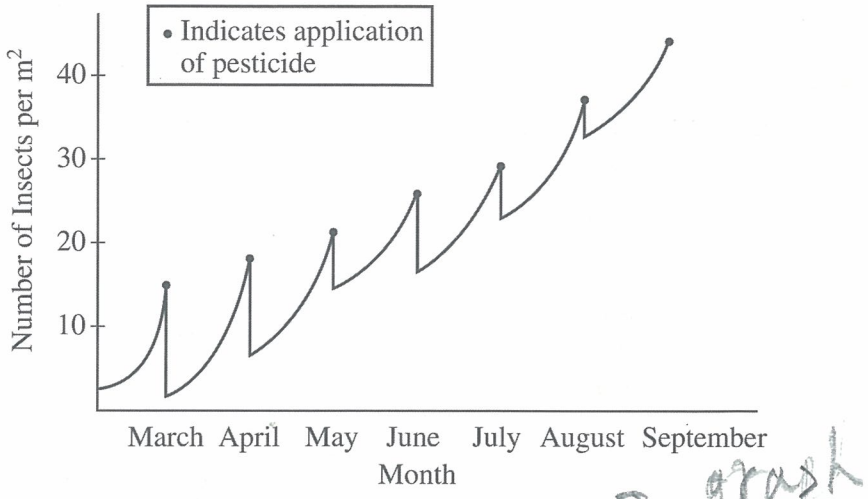
(A) Population size of each species and area occupied by each population
(B) Minimum population area and minimum viable population size
(C) Ratio of *r*-strategists to *K*-strategists and life expectancy of *K*-strategists
(D) Number of individuals under fifteen years old and number of individuals over sixty-five years old
(E) Genetic variation within each species and number of species present

56. Which of the following is a way for the government to encourage efficient energy use?

(A) Requiring higher fuel economy standards for new cars
(B) Implementing government subsidies to keep gasoline prices low
(C) Raising the speed limit from 55 to 70 miles per hour
(D) Limiting the development of public transportation systems
(E) Removing all taxes from gasoline at the fuel pump

57. Ground-level ozone in most major United States cities results primarily from

(A) burning coal
(B) burning fuel for cooking
(C) producing electric power
(D) industrial emissions
(E) motor-vehicle exhaust



58. An insect population in an agricultural field is affected by monthly applications of a pesticide, as shown in the graph above. A likely cause of the overall increase in the insect population over time is

(A) an increase in the population of insect predators
(B) an increase in average temperature over the summer
(C) an increase in soil salinity
(D) a decrease in the moisture content of the soil
(E) the survival of increasing numbers of resistant insects

---

59. The process in the hydrologic cycle in which water vapor is released from leaves into the atmosphere is called

(A) infiltration
(B) transpiration
(C) sublimation
(D) reflection
(E) percolation

60. Which of the following terms applies to the economic approach of including external costs in the price of goods and services?

(A) Optimal-cost pricing
(B) Cost-benefit pricing
(C) Full-cost pricing
(D) Green pricing
(E) Subsidized pricing

61. Global warming is most likely to directly cause which of the following?

(A) Shifting of grain belts toward the equator
(B) Falling sea levels in the Southern Hemisphere
(C) Coastal flooding and submersion of low-lying areas
(D) A decrease in the amount of water vapor in the atmosphere
(E) An increase in the number and size of glaciers

62. Which of the following would encourage recycling?

(A) Decreasing government purchases of recycled materials
(B) Decreasing subsidies for recycling
(C) Decreasing taxes on resource-extracting industries
(D) Decreasing taxes on recycled material
(E) Decreasing fees for using landfills

GO ON TO THE NEXT PAGE

63. Which of the following is a true statement about passive solar heating?

(A) It is effective only during the summer months.
(B) It is based in part on the principle of the greenhouse effect.
(C) It is not used to heat commercial buildings.
(D) It is not efficient because it cannot produce high-quality energy.
(E) It produces more pollution than heating with an electric heat pump.

64. Which of the following is a common characteristic of lakes undergoing cultural eutrophication?

(A) Decreased rates of sediment accumulation
(B) Decreased amounts of green and blue-green algae
(C) Increased levels of oxygen throughout the water column
(D) Increased water clarity in the epilimnion
(E) Increased levels of plant nutrients

65. An advantage of using natural gas, rather than oil, as a fuel is that natural gas is

(A) less of a contributor to global warming because it does not release CO_2 when it burns
(B) less expensive because most reserves are in the United States
(C) more abundant because it is a by-product of photosynthesis
(D) cleaner because it burns more completely
(E) safer to store because it is a gas

66. Which of the following best explains why the maximum sustainable yield for ocean fisheries has been exceeded?

(A) Populations of fish-eating birds such as the albatross have increased.
(B) Too many fish of reproductive age are harvested.
(C) Too many marine fish farms have been created.
(D) Everything trapped by large bottom trawl nets is used for food.
(E) For every calorie of fish caught, a ship uses only about 0.5 calorie of fuel energy.

67. Although the fertility rate for women in the United States has declined in recent years to a value below replacement level, the United States population is still increasing because of

(A) lower average age at first marriage
(B) lower infant death rates
(C) increased longevity
(D) improved health care
(E) immigration

Item 68 was not scored.

69. Which of the following is an important contributor to both global warming and ozone depletion?

(A) An increase in the concentration of carbon dioxide to higher-than-preindustrial levels
(B) A buildup of methane in the stratosphere to higher-than-preindustrial levels
(C) An increase in the levels of ultraviolet radiation reaching Earth's surface
(D) An increase in the amount of infrared solar radiation absorbed in the troposphere
(E) A release of chlorofluorocarbons to the atmosphere

70. The most populous countries in the world are China, India, and

(A) Indonesia
(B) Russia
(C) the United States
(D) Japan
(E) Mexico

71. Lakes that are characterized by high water clarity and low concentrations of dissolved nutrients are classified as
    (A) buffered
    (B) climax
    (C) eutrophic
    (D) oligotrophic
    (E) stratified

72. Smoke from forest fires is most likely to affect air quality over larger areas for many days when
    (A) smog is produced due to chemical reactions in the atmosphere
    (B) a persistent atmospheric inversion exists in the region
    (C) oak trees are burned, releasing terpenes into the atmosphere
    (D) primary, rather than secondary, forests are burned
    (E) vegetation in the region is green and burns more slowly

73. In the majority of less developed countries, the major source of energy for domestic use is which of the following?
    (A) Oil
    (B) Coal
    (C) Biomass
    (D) Nuclear
    (E) Geothermal

74. When logging is carried out in a watershed, a likely effect on the local streams is
    (A) mitigation of anoxia
    (B) decreased nutrient levels
    (C) decreased input of sediments
    (D) increased oligotrophic conditions
    (E) increased water temperature

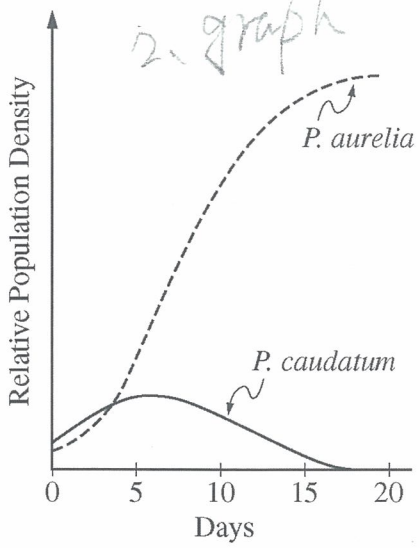
75. When scientists discover the existence of an emerging infectious disease such as SARS (severe acute respiratory syndrome), they must take immediate steps to determine the cause of the disease and the method of transmission. These initial steps would include which of the following?
    (A) Developing a vaccine to eliminate the disease
    (B) Beginning a program to eradicate insect vectors for the disease
    (C) Acquiring recent medical and travel histories of the disease victims
    (D) Testing methods to block airborne transmission of the disease
    (E) Estimating the cost of eradicating the disease

76. In a river ecosystem, dissolved oxygen concentrations drop quickly downstream from a point-source input of organic matter into the river. This effect is due to
    (A) increasing populations of mayfly and stonefly larvae
    (B) increasing activity of trout and black bass
    (C) increasing bacterial activity as organic matter decays
    (D) decreasing bacterial activity as turbidity increases
    (E) decreasing water temperature as surface evaporation increases

77. What is the population doubling time in years for a country with an annual growth rate of 3.5 percent?
    (A) 0.5
    (B) 3.5
    (C) 20
    (D) 24.5
    (E) 70

GO ON TO THE NEXT PAGE.

78. The graph below shows the results obtained when two species of *Paramecium* were grown together in the same medium.



The graph above best exemplifies

(A) the demographic transition
(B) sustained logarithmic growth
(C) the edge effect
(D) competitive exclusion
(E) the normal distribution

79. In a cost-benefit analysis of the risks associated with an environmental hazard involving human health and safety, which of the following concerns is NOT typically taken into account?

(A) Lower worker productivity resulting from health-related time lost on the job
(B) Higher production costs resulting from the installation of expensive pollution-control devices
(C) The long-term value and peace of mind to society resulting from a cleaner, healthier environment
(D) The initial capital investment required to purchase pollution-control devices
(E) The need to remove pollutants from factory effluents

80. Three common methods employed in the cleanup of oil spills are

(A) aeration of water, skimmer boats, and genetically engineered bacteria
(B) aeration of water, phytoremediation, and genetically engineered bacteria
(C) skimmer boats, high temperature incineration, and phytoremediation
(D) large floating booms, high temperature incineration, and phytoremediation
(E) large floating booms, skimmer boats, and genetically engineered bacteria

81. Ticks are vectors for various diseases. The ticks acquire the disease-causing organisms from

(A) polluted water
(B) feeding on host animals
(C) contact with other ticks
(D) trees and plants in a forest
(E) gene changes as they go through metamorphosis

82. Which of the following is most likely to increase both the nutrient levels and the bacterial content of lake water?

(A) Runoff from a nearby hog farm
(B) Thermal pollution from a nearby power plant
(C) Increased aeration of the lake water
(D) Percolation of the water through soil to groundwater
(E) Acidification of the lake water by acid deposition

83. Which of the following is a major goal of the program begun in 1995 to reintroduce the gray wolf into Yellowstone National Park?

(A) Decrease the number of grizzly bears, because they were becoming a nuisance
(B) Enable the removal of the gray wolf from the endangered species list
(C) Increase the dwindling numbers of tourists that visit the park each year
(D) Upset the natural predator-prey balance between coyotes and elk
(E) Decrease the number of sheep and cattle that wander into the park and overgraze the vegetation

84. The half-life of radon gas is approximately four days. Four weeks after the introduction of radon into a sealed room, the fraction of the original amount remaining is closest to

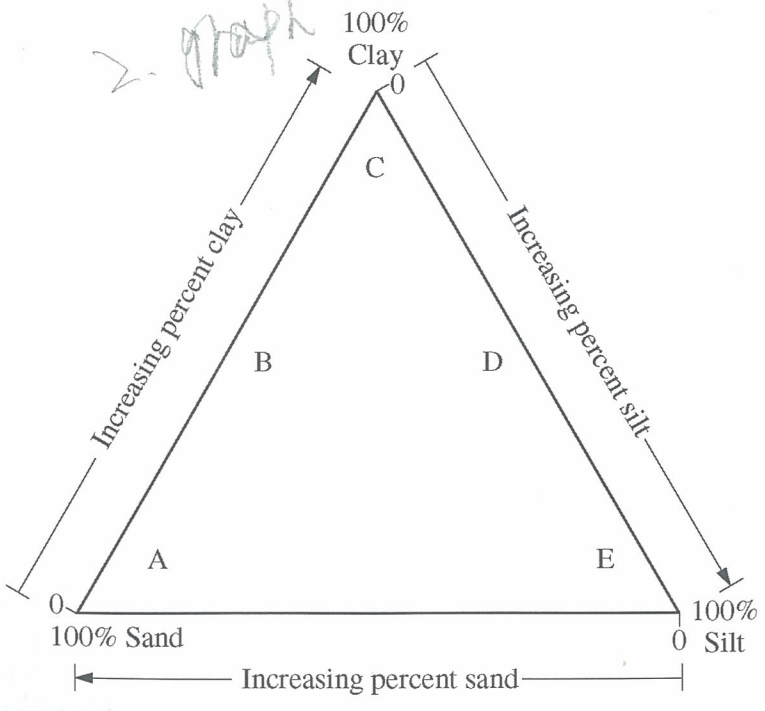
(A) 1/2
(B) 1/8
(C) 1/32
(D) 1/64
(E) 1/128

85. The consumption of mosquitoes by bats and the control of flooding provided by tropical forests in mountainous areas of Central America are examples of

(A) adaptive radiation
(B) ecosystem services
(C) evolution by natural selection
(D) ecological equilibrium
(E) positive feedback loops

86. Which of the following best explains why it is predicted that ozone depletion over the poles will be at its worst between 2010 and 2019 ?

(A) Projected global warming from carbon dioxide emissions is expected to reach a peak during those years.
(B) Ozone-depleting chemicals produced before their use was banned will take that long to reach peak concentrations in the stratosphere.
(C) Deforestation in tropical regions is expected to reach a peak during the second decade of the twenty-first century.
(D) Increased global population will lead to an increase in per capita CO_2 production.
(E) Acid deposition will continue to increase, reaching a peak in approximately 2015.



87. Which soil indicated on the soil triangle above would most likely have the highest water-holding capacity?

(A) Soil A
(B) Soil B
(C) Soil C
(D) Soil D
(E) Soil E

GO ON TO THE NEXT PAGE.

88. Which of the following is a true statement concerning the production of electricity in conventional nuclear power plants using fission reactors?

(A) New nuclear power plants will be built without containment structures, due to the increased insulation in the reactor core.
(B) Thermal energy is converted into mechanical energy and then to electrical energy, as in coal-burning power plants.
(C) Regularly scheduled releases of radioactive gases during production are well below the maximum contamination levels set by the EPA (Environmental Protection Agency).
(D) Nuclear production of electricity is much less expensive per kilowatt-hour than production of electricity at a coal-burning or natural-gas-fueled power plant.
(E) Storage of nuclear waste is no longer an issue, because power plants are now storing all wastes on-site in specialized containment units.

89. Alligators in a Florida lake polluted by high levels of dioxins (chlorinated hydrocarbons) had low testosterone levels and failed to reproduce. Scientists came to the conclusion that the dioxins were acting as which of the following?

(A) Endocrine disrupters
(B) Growth hormones
(C) Carcinogens
(D) Immune-system suppressors
(E) Mutagens

90. Factors that affect the total fertility rate of a human population include which of the following?

I. Cultural traditions
II. Government policies and economic incentives
III. Education level and economic opportunities for females

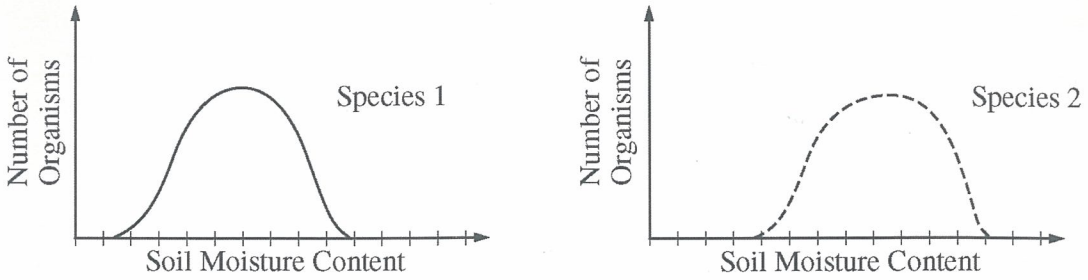
(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

91. Sustainable use of forests in the United States would likely be encouraged by

(A) cutting small groups of medium- and large-sized trees in uneven-aged forests
(B) clear-cutting old-growth forests to allow for secondary succession
(C) allowing road building in wilderness areas so that older, clear-cut forests have time to regenerate
(D) logging on steep slopes in designated wilderness areas
(E) enforcing all provisions of the Resource Conservation and Recovery Act (RCRA)

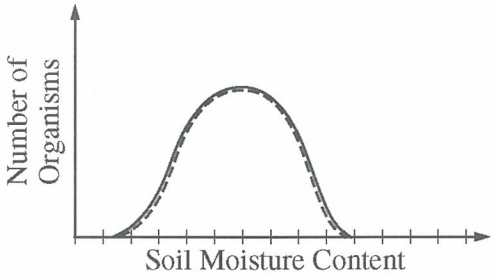
92. The use of which of the following to control agricultural insect pests is most likely to have a negative and persistent impact on an ecosystem?

(A) *Bacillus thuringiensis*, a soil organism that kills insect larvae
(B) *Braconid sp.*, a parasitic wasp
(C) Insecticidal soap, a surfactant that kills through suffocation
(D) Lindane, a chlorinated hydrocarbon
(E) Rotenone, a toxic plant derivative

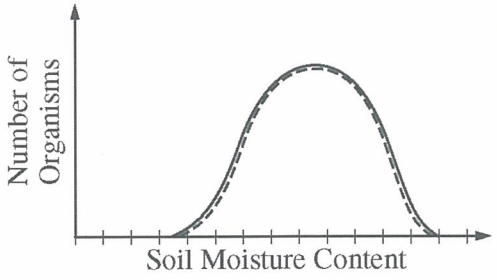


93. The diagrams above show the range of tolerance for soil moisture content for two different species of terrestrial invertebrate: Species 1 and Species 2. The ranges represented are for each species where it occurs alone. Soil moisture content is a limiting factor for both species. If populations of both species are placed together in a new location, which of the following diagrams represents the most likely actual (realized) ranges of the species' distribution of individuals with respect to soil moisture content after five generations?

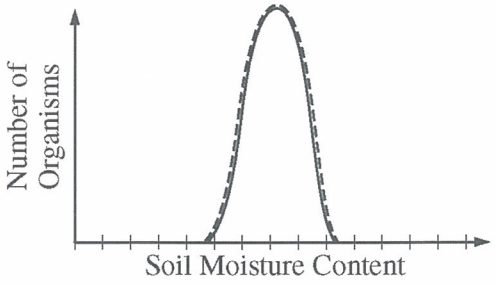
(A)



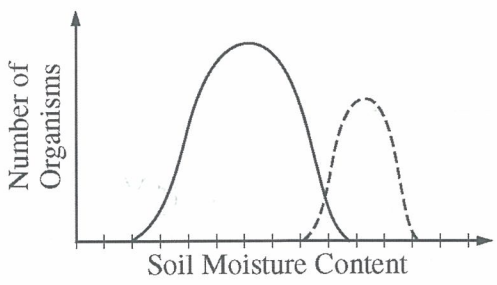
(B)



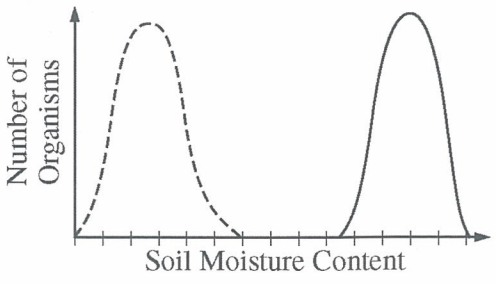
(C)



(D)



(E)



GO ON TO THE NEXT PAGE.

94. Overgrazing of grasslands can lead to reduced range quality. Two of the major effects of overgrazing are
(A) erosion and desertification
(B) higher fire potential and increased productivity
(C) eutrophication and increased methane production
(D) higher primary productivity and ammonification
(E) soil compaction and subsidence

95. Which of the following describes the heat-island effect?
(A) Urban areas trap more heat than rural areas do.
(B) Tropical islands reflect heat back into the atmosphere.
(C) Warm water in the Pacific causes excessive evaporation into the atmosphere.
(D) Lakes retain heat and provide warmth for landmasses nearby.
(E) Rapid decomposition in swamps releases a large amount of heat.

96. Losses of usable energy between successive trophic levels in an ecosystem are best accounted for by which of the following?
(A) The first law of thermodynamics
(B) The second law of thermodynamics
(C) The law of conservation of matter
(D) The process of ecological succession
(E) Limiting factors in the ecosystem

97. Which of the following actions would reduce global greenhouse emissions?
(A) Increasing the use of automobiles
(B) Decreasing the number of nuclear power plants
(C) Replacing coal-burning power plants with wind farms
(D) Converting tropical forests to rice paddies
(E) Switching from hydroelectric power generation to power generation using natural gas as the primary fuel

98. A home uses ten 100-watt lightbulbs for five hours per day. Approximately how many kilowatt-hours of electrical energy are consumed in one year by using the lightbulbs?
(A) 365
(B) 1,825
(C) 5,000
(D) 10,500
(E) 365,000

99. During an El Niño–Southern Oscillation event, which of the following best describes conditions in the eastern part of the tropical Pacific Ocean (e.g., near Peru and Ecuador) ?

	Sea Surface Temperature	Rainfall
(A)	Low	Low
(B)	Low	High
(C)	High	Low
(D)	High	High
(E)	High	Normal

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

I. It is a pollutant in the troposphere.
II. It filters out most of the UVC radiation in the stratosphere.
III. Most of it is formed in the stratosphere by reaction between carbon dioxide and free oxygen atoms.

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

STOP

END OF SECTION I

AP® Environmental Science Exam

SECTION II: Free-Response Questions

2008

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 Grade
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
3. Six-digit school code
   ☐☐☐☐☐☐
4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.
   No, I do not grant the College Board these rights. ☐

Instructions

The questions for Section II are printed in the green insert and in this pink booklet. You may use the insert to organize your answers and for scratch work, but you must write your answers in the pink Section II booklet. No credit will be given for any work written in the insert.

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. Extra examples will not earn points. Diagrams may be used to supplement discussion, but diagrams alone will not suffice.

Write clearly and legibly. Cross out any errors you make; crossed-out work will not be graded.

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.

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.

GO ON TO THE NEXT PAGE.

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

(i) microalgae

(ii) soybeans

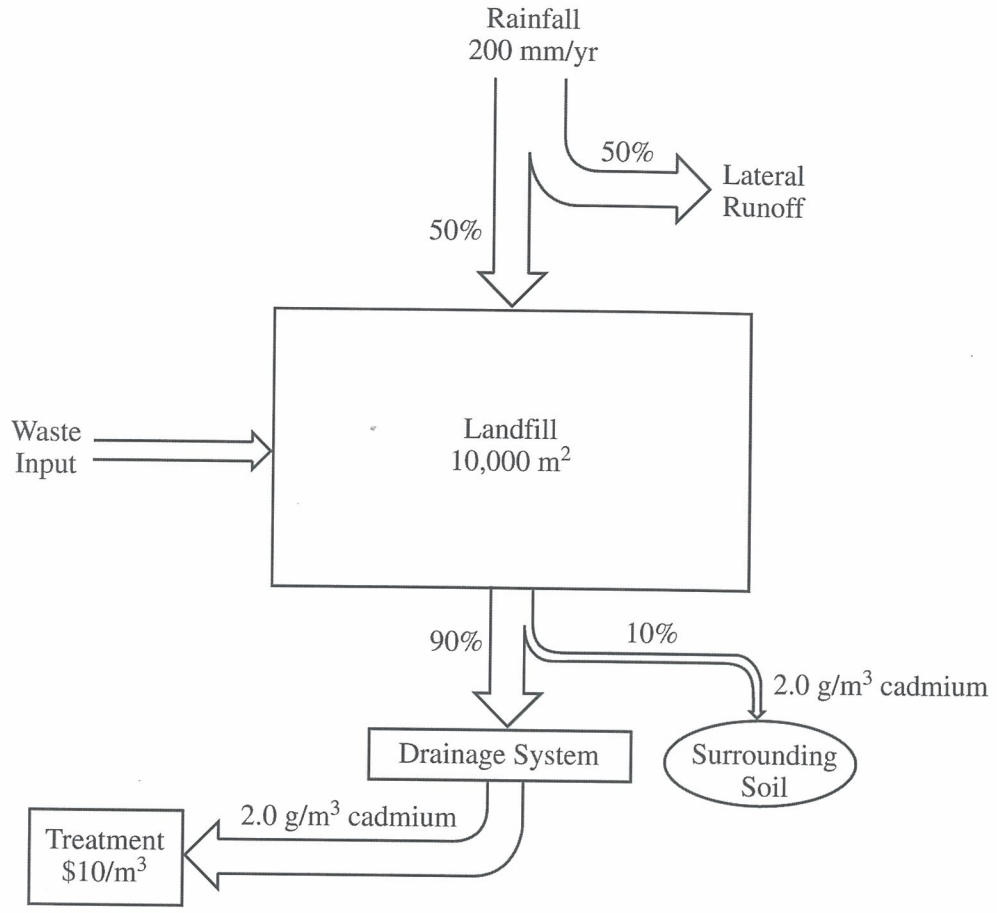
(b) Describe TWO environmental advantages that biodiesel production from microalgae offers over biodiesel production from the other crops listed in the table.

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

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

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

Section II



2. The city of Fremont operates a municipal solid-waste landfill. As represented in the diagram above, the annual precipitation in Fremont is 200 mm/year: 50 percent of this water infiltrates through the landfill cover soil into the waste, and 50 percent drains off the landfill. A drainage system withdraws 90 percent of the leachate generated within the landfill for treatment. The rest of the leachate travels through the bottom liner of the landfill into the surrounding soil. Most of the cadmium disposed of in the landfill remains in the landfill; the leachate withdrawn from the landfill by the drainage system has an average cadmium concentration of 2.0 g/m^3. Pumped to a treatment station, the leachate is treated at a cost of \$10/m^3.

   (a) Calculate the volume, in m^3, of each of the following:

      (i) The water infiltrated through the landfill per year

      (ii) The leachate that is treated per year

   (b) Given that the cadmium concentration in the water draining from the landfill is 2.0 g/m^3, calculate the mass, in kg, of cadmium that is released into the surrounding soil per year.

   (c) What is the annual cost of treating the leachate from the drainage system?

   (d) Discuss TWO viable methods for reducing the amount of cadmium entering the municipal waste input.

   (e) Explain a shortcoming of ONE of the methods that you identified in part (d).

GO ON TO THE NEXT PAGE.

3. For decades, forest fires in the United States have been suppressed. In 2003 legislation was passed under the Healthy Forests Initiative (HFI) in response to the record-breaking wildfires that had occurred in the early 2000s. Some environmental and conservation groups fear that negative impacts could result if timber companies are encouraged to harvest medium- and large-size trees in federally owned forests while clearing away the smaller trees and underbrush.

   (a) Identify TWO characteristics of forests that develop when fires are suppressed, and explain why the practice of fire suppression does not reduce, but actually increases, the risk of intense and extensive forest fires.

   (b) The effects of the HFI are expected to extend beyond fire reduction. Excluding fire reduction, describe ONE positive and ONE negative effect likely to result from the implementation of the provisions of the HFI.

   (c) Describe TWO ecosystem services provided for humans by forests. Explain how clear-cutting would affect each ecosystem service you describe.

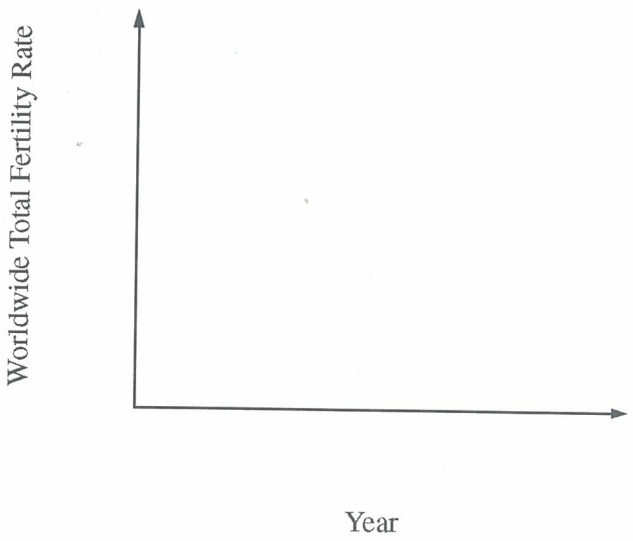
   (d) Identify a specific type of plant community or biome (other than a forest) that is naturally maintained by fire. Explain how the fire maintains the community or biome.

4. Answer the following regarding world human population.

(a) Create a graph of the data from table 1 below on the axes provided.

Table 1: Worldwide Total Fertility Rate (TFR)

Year	TFR
1950	5.0
1960	4.9
1970	4.7
1980	3.7
1990	3.4
2000	3.0



(b) Identify and discuss TWO of the causes for the trend in the worldwide TFR that you graphed in part (a).

Table 2: Population Data for Selected Nations (2005)

Country	TFR	Crude Birth Rate*	Crude Death Rate*	Infant Mortality Rate*	Per Capita Income (U.S. dollars)
China	1.6	12	7	27	6,500
Japan	1.3	9	8	2.8	31,400
Kenya	5.9	43	19	100	1,000
United States	2.0	14	8	6.7	42,000

* rates are per thousand per year

(c) Consider the data in table 2 above. Identify and discuss TWO economic or societal factors that account for the difference between the TFR of Kenya and that of the United States.

(d) Describe TWO human activities related to the rapidly growing world population that are having an impact on Earth's biodiversity.

GO ON TO THE NEXT PAGE.

STOP

END OF EXAM

Chapter III: Answers to the 2008 AP Environmental Science Exam

- Section I: Multiple Choice
  - Section I Answer Key and Percent Answering Correctly
  - Analyzing Your Students' Performance on the Multiple-Choice Section
  - Diagnostic Guide for the 2008 AP Environmental Science Exam
- Section II: Free Response
  - Comments from the Chief Reader
  - Scoring Guidelines, Sample Student Responses, and Commentary
    - Question 1
    - Question 2
    - Question 3
    - Question 4

Section I: Multiple Choice

Listed below are the correct answers to the multiple-choice questions, the percent of AP students who answered each question correctly by AP score, and the total percent answering correctly.

Section I Answer Key and Percent Answering Correctly

Item No.	Correct Answer	Percent Correct by Score					Total Percent Correct
		5	4	3	2	1	
1	C	69	51	42	35	27	42
2	E	59	42	33	29	25	35
3	A	73	62	57	53	45	56
4	A	89	81	74	68	56	71
5	B	89	79	71	63	48	67
6	D	35	22	15	11	9	16
7	C	64	54	46	39	31	44
8	E	96	89	79	68	48	72
9	C	83	71	61	53	40	58
10	C	93	85	78	72	57	74
11	A	91	77	65	55	37	61
12	E	73	55	42	35	24	42
13	B	87	72	59	49	33	56
14	E	93	88	83	77	63	78
15	C	89	72	57	43	22	52
16	A	100	99	99	97	88	96
17	D	98	95	90	84	67	84
18	B	78	51	33	24	17	36
19	D	96	87	73	58	34	65
20	A	52	42	34	28	20	33
21	C	71	52	40	32	25	41
22	E	99	97	95	91	77	90
23	A	66	49	40	33	24	39
24	E	84	77	70	60	40	63
25	C	52	36	27	23	22	30
26	E	92	83	75	68	50	70
27	B	91	78	65	54	35	61
28	E	75	56	42	31	16	39
29	D	97	87	73	59	35	66
30	B	92	85	78	72	52	73
31	B	91	85	80	74	59	76
32	E	95	87	78	67	42	70
33	B	84	72	63	53	37	58
34	B	97	91	84	75	51	76
35	E	94	85	76	66	45	69
36	B	70	51	41	36	30	43
37	B	82	66	52	42	29	50
38	D	96	93	89	85	68	84
39	E	90	79	69	59	40	64
40	B	92	77	61	46	28	56
41	C	56	31	21	17	17	26
42	B	81	60	47	38	29	47
43	A	50	39	30	24	14	29
44	B	71	62	55	50	37	53
45	E	98	93	88	81	57	80
46	D	66	50	40	32	21	38

continued on the next page

Section I Answer Key and Percent Answering Correctly *(continued)*

Item No.	Correct Answer	Percent Correct by Score					Total Percent Correct
		5	4	3	2	1	
47	D	80	72	65	62	52	64
48	B	96	88	79	68	51	73
49	B	91	88	85	82	68	81
50	D	77	64	56	49	36	53
51	B	89	79	68	55	34	61
52	A	47	24	14	10	9	18
53	D	96	90	81	72	53	75
54	D	76	51	34	25	17	37
55	E	86	79	71	62	39	64
56	A	99	98	96	92	69	88
57	E	60	53	53	55	46	52
58	E	99	99	97	95	70	89
59	B	98	95	90	84	64	84
60	C	70	54	43	34	24	41
61	C	98	94	90	84	63	83
62	D	98	95	91	84	62	83
63	B	74	59	47	38	31	47
64	E	88	70	53	41	24	51
65	D	82	68	57	49	31	54
66	B	85	73	62	55	40	60
67	E	76	65	56	51	40	55
68*	–	–	–	–	–	–	–
69	E	81	68	56	46	27	52
70	C	54	48	46	46	41	46
71	D	77	59	45	34	19	43
72	B	64	44	30	22	15	32
73	C	72	53	39	29	18	38
74	E	35	20	12	9	7	15
75	C	95	90	85	77	52	76
76	C	94	80	66	52	37	62
77	C	86	68	53	43	31	53
78	D	97	92	84	73	43	73
79	C	75	65	55	46	31	51
80	E	49	36	28	23	17	28
81	B	90	88	86	85	73	83
82	A	95	83	70	58	35	64
83	B	84	80	77	71	55	71
84	E	90	77	64	48	21	55
85	B	70	51	38	28	18	37
86	B	87	61	38	24	14	40
87	C	54	48	44	40	34	43
88	B	73	48	32	22	17	35
89	A	86	72	62	53	38	59
90	E	99	96	92	86	61	84
91	A	60	42	31	24	14	31
92	D	69	53	41	30	18	39
93	D	58	41	32	25	18	32
94	A	97	94	91	85	61	83
95	A	85	67	52	39	21	48
96	B	87	72	59	48	30	55
97	C	100	99	96	91	64	87
98	B	82	60	45	37	24	45
99	D	55	48	47	43	34	44
100	D	55	38	28	21	15	29

*Although 100 multiple-choice items were administered in Section I, item #68 was not used in scoring.

Analyzing Your Students' Performance on the Multiple-Choice Section

If you give your students the 2008 exam for practice, you may want to analyze the results to find overall strengths and weaknesses in their understanding of AP Environmental Science. The following diagnostic worksheet will help you do this. You are permitted to photocopy and distribute it to your students for completion.

1. In each section, students should insert a check mark for each correct answer.
2. Add together the total number of correct answers for each section.
3. To compare the student's number of correct answers for each section with the average number correct for that section, copy the number of correct answers to the "Number Correct" table at the end of the Diagnostic Guide.

In addition, under each question, the percent of AP students who answered correctly is shown, so students can analyze their performance on individual questions. This information will be helpful in deciding how students should plan their study time. Please note that one question may appear in several different categories, as questions can cross over different topics.

Diagnostic Guide for the 2008 AP Environmental Science Exam

Earth Systems and Resources (Average number correct = 6.7)

Question #	1	2	3	7	8	9	14	19	28	51	54	87	99
Correct/Incorrect													
Percent of Students Answering Correctly	*42*	*35*	*56*	*44*	*72*	*58*	*78*	*65*	*39*	*61*	*37*	*43*	*44*

The Living World (Average number correct = 7.1)

Question #	15	22	29	34	46	55	59	71	78	85	93	96
Correct/Incorrect												
Percent of Students Answering Correctly	*52*	*90*	*66*	*76*	*38*	*64*	*84*	*43*	*73*	*37*	*32*	*55*

Population (Average number correct = 8.5)

Question #	17	21	23	27	32	43	44	48	67	70	75	77	81	90
Correct/Incorrect														
Percent of Students Answering Correctly	*84*	*41*	*39*	*61*	*70*	*29*	*53*	*73*	*55*	*46*	*76*	*53*	*83*	*84*

Land and Water Use (Average number correct = 5.1)

Question #	20	25	33	53	58	66	74	91	92	94
Correct/Incorrect										
Percent of Students Answering Correctly	*33*	*30*	*58*	*75*	*89*	*60*	*15*	*31*	*39*	*83*

Energy Resources and Consumption (Average number correct = 7.7)

Question #	16	31	38	41	42	56	57	63	65	73	80	84	88	98
Correct/Incorrect														
Percent of Students Answering Correctly	*96*	*76*	*84*	*26*	*47*	*88*	*52*	*47*	*54*	*38*	*28*	*55*	*35*	*45*

Pollution (Average number correct = 13.8)

Question #	4	5	6	10	11	12	13	24	26	30	37	45
Correct/Incorrect												
Percent of Students Answering Correctly	*71*	*67*	*16*	*74*	*61*	*42*	*56*	*63*	*70*	*73*	*50*	*80*

Question #	47	49	52	60	62	64	72	76	79	82	89	95
Correct/Incorrect												
Percent of Students Answering Correctly	*64*	*81*	*18*	*41*	*83*	*51*	*32*	*62*	*51*	*64*	*59*	*48*

Global Change (Average number correct = 6.8̄)

Question #	18	35	36	39	40	50	61	69	83	86	97	100
Correct/Incorrect												
Percent of Students Answering Correctly	*36*	*69*	*43*	*64*	*56*	*53*	*83*	*52*	*71*	*40*	*87*	*29*

Quantitative/Calculations (Average number correct = 3.8)

Question #	21	27	41	42	44	77	84	98
Correct/Incorrect								
Percent of Students Answering Correctly	*41*	*61*	*26*	*47*	*53*	*53*	*55*	*45*

Graph/Data Interpretation (Average number correct = 4.4)

Question #	41	42	44	48	58	78	87	93
Correct/Incorrect								
Percent of Students Answering Correctly	*26*	*47*	*53*	*73*	*89*	*73*	*43*	*32*

Diagnostic Guide for the 2008 AP Environmental Science Exam *(continued)*

Number Correct

	Earth Systems and Resources	The Living World	Population	Land and Water Use	Energy Resources and Consumption
Number of Questions	13	12	14	10	14
Average Number Correct	6.7 (51.5%)	7.1 (59.2%)	8.5 (60.7%)	5.1 (51.0%)	7.7 (55.0%)
My Number Correct					

	Pollution	Global Change	Quantitative/ Calculations	Graph/Data Interpretation
Number of Questions	24	12	8	8
Average Number Correct	13.8 (57.5%)	6.8 (56.7%)	3.8 (47.5%)	4.4 (55.0%)
My Number Correct				

Section II: Free Response

Comments from the Chief Reader

Art Samel
Bowling Green State University
Bowling Green, Ohio

Below are some observations and suggestions arising from the scoring of the four free-response questions on the 2008 AP Environmental Science Exam, gleaned from discussions with Readers and Table and Question Leaders at the AP Reading.

Question 1, the document-based question, concerned alternative energy sources, the carbon cycle, and the use of food products to produce energy. Students performed fairly well on this question.

In part (a) most calculated the correct acreage required to produce 1,000 gallons of oil in one year from microalgae and soybeans. In parts (b) and (c) many students began, but did not complete, thorough descriptions of the environmental advantages of biodiesel production from microalgae (part [b]) and the impact of burning biodiesel fuel on atmospheric CO_2 (part [c]); and in part (e) many did not include two complete discussions of two economic or societal problems associated with producing fuel from corn.

The most striking lack of accomplishment on this question was in part (c). Few students indicated an understanding of the difference between the impact of biodiesel fuel and fossil fuels on CO_2 concentrations. Many students wrote that biodiesel fuel releases no CO_2 when burned or that biodiesel fuel reduces CO_2 concentration in the atmosphere. Students also confused photosynthesis and respiration in their explanations.

In part (e) many students did not demonstrate an understanding of the problems of using a food commodity as fuel.

Question 2 required students to analyze environmental information in a schematic diagram, as well as in text, and to make computations of landfill values for infiltrated water, cadmium containing leachate, cadmium released into surrounding soil, and the annual costs associated with treating the leachate. The question also measured students' knowledge of viable methods of waste stream reduction for cadmium and the inherent shortcomings associated with the implementation of these methods.

A significant number of students chose not to answer this question. Integrating the questions with the schematic and the descriptive text appeared difficult for many, perhaps due to the time constraints of the exam.

In parts (a), (b), and (c), students often omitted calculations or had difficulty with the calculations. Mathematicall many students struggled with deciphering the correct formulas and setup from the schematic and text; showing correct dimensional analysis; and carrying correct units through the problem(s). They also had difficulty with metr units and the final computation. When students elected to answer the computational parts of the question (parts [a], [b], and [c]) with prose, the prose did not indicate a clear understanding of the setup.

In part (d) many students confused municipal waste input with cadmium-bearing leachate already in the waste stream, and they inappropriately suggested filtering as a method. Students were often vague in descriptions of methods (e.g., screening waste).

Question 3 was on fire-suppressed forests, the impact of th Healthy Forests Initiative upon forests, ecosystem services provided by forests, and the effect of clear-cutting upon those services. Additionally, students were asked to identify another plant community or biome maintained by fire other than forests. Performance was good, with almost all students attempting to answer the question, and some even writing several pages.

Many students in part (a) indicated "dry" as a condition of suppressed forests. Fire-suppressed forests are not dry bu have an accumulation of combustible materials, increased understory growth, stored terpenes in older trees, and othe conditions that cause fire risk to increase. Dryness is due to local climate, not forest conditions. Other students thought fire suppression followed a forest fire or the act of putting out a forest fire.

In part (b) students may not have read the question carefully, as many responded with fire-reduction methods, which the question specifically excluded, when describing positive and negative effects of implementing the Healthy Forests Initiative.

Students who did not receive full credit in part (c) failed to identify an ecosystem service benefiting humans—in order to earn credit for the suggestion of clear-cutting, the response had to link it to an ecosystem service. Students also had difficulty explaining the carbon/oxygen cycle and omitted the human service of carbon dioxide reduction reducing climate change impact. Many students incorrectly stated that oxygen is released from carbon dioxide during photosynthesis.

Some students did not read the question for part (d) carefully or else they did not know a specific plant community, other than forests, maintained by fire; they did not earn points by responding with forest biomes or other forested plant communities.

Question 4 assessed students' knowledge of contemporary issues related to human population growth and its impact on the environment. Overall, students performed well.

Lack of care in plotting the data was a common error in part (a), where students had to create a graph of worldwide total fertility rate (TFR) on the axes provided in the exam booklet. In part (b) students often did not specify the role played by increasing educational opportunities for women—instead, they simply gave "increasing education" as a cause of the trend in TFR identified in part (a). Another common error was to link the end of the baby boom to the Korean, Vietnam, and Iraq Wars to explain decreased worldwide TFR since 1950.

In part (c), where student were asked to discuss factors accounting for the difference in TFR between Kenya and the United States, students sometimes did not qualify their statements by stating which country they were describing and therefore did not earn points. Students often stated causes without responding with an adequate discussion—they were required to discuss causes in part (b) and factors in part (c), but they often only identified them.

In part (d) students had difficulty identifying how human population growth impacts biodiversity. Many students gave answers that related to human health and human biodiversity, rather than to the biodiversity of nonhuman species. Often, students mentioned marriage between people of two different races as a factor that would increase biodiversity, or they used answers that would have been appropriate in parts (b) or (c).

To improve students' performance on the AP Exam, teachers are encouraged to:

- Teach students to read questions carefully and note where linkage and exclusions are specified within the questions. When students miss this subtlety, they may earn no points on one or more parts of a question.
- Encourage students to follow through on their ideas when answering questions, even when it may seem that the discussion point is an obvious outcome of the cause or factor being discussed. A list is not the same thing as a discussion or a description. Teach students to write complete descriptions and discussions.
- Remind students to answer the questions that have been asked. For example, when asked to describe an *environmental* advantage in Question 1, students did not earn points for descriptions of *nonenvironmental* advantages.
- Provide students with opportunities to practice writing explanations of environmental concepts (when answering Question 1, many students were largely unable to explain the difference between old and new carbon).
- Give students opportunities to discuss and write about environmental issues in the news. Exam questions occasionally cover subject matter inspired by recent world events.
- Teach students about the ecological services provided by ecosystems and the impact of humans on ecosystems.
- Give students practice with answering sample questions in class, and ensure that their responses are thorough and specific to the question asked.
- Remind students that when calculations are required on the exam, they must clearly show how they arrived at their answer. Encourage them to show all computational work on the pages of the exam booklet. Teach students to complete all computational sets, so that they can earn points where possible.
- Work with students on organizing computational problems using a variety of methods to include dimensional analysis.
- Remind students to review their computational answers to determine if they have produced realistic results, with the right order of magnitude.
- Encourage development of analytical skills: work with students on data analysis and the application of quantitative analysis of environmental problems.
- Train students to accurately plot data on a graph, and be sure that they know how to plot points and bars and how to draw pie charts. Stress attention to detail. Focus on the interpretation of drawn graphs.

Scoring Guidelines, Sample Student Responses, and Commentary

The responses on the following pages are actual student responses, reproduced with the permission of the writers at the time they took the exam. Each essay was read and scored by the Chief Reader, Question Leader, and Table Leaders. Each one appeared in the sample responses used for the training of Readers during the AP Reading. Each question is represented by three responses that illustrate three distinct score points at upper and lower ranges.

A copy of the scoring guideline for each question precedes the samples. Following each response is commentary that explains how the response met the criteria for the assigned score.

Question 1—Overview

This was the document-based question. After reading a newspaper article, students were asked a series of questions related to the subject of the article, biodiesel fuel. The questions required students to demonstrate knowledge of alternative energy sources, the carbon cycle, and the issues surrounding the use of food products to produce energy. Students performed fairly well, with most attempting to answer the question. The mean score was 4.10 out of a possible 10 points. (For a discussion of student performance and suggestions for improving scores, see Comments from the Chief Reader beginning on page 46.)

Scoring Guidelines for 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.)

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

OR

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

(ii) soybeans

(One point is earned for the correct answer.)

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

OR

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

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

coring Guidelines for Question 1 *(continued)*

) **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
ess land use	▪ Less habitat destruction and/or less loss of biodiversity ▪ Protection of watersheds from agricultural runoff
)ecreased tilling of soil	▪ Less soil erosion
)ecreased pesticide and/or fertilizer use	▪ Less runoff of pesticides and/or fertilizers
)ecreased fossil fuel consumption for tilling soil, ıarvesting crops, and/or manufacturing and applying ertilizers 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)
)ecreased energy consumption for extracting oils from nicroalgae	▪ 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)
)ecreased irrigation of land	▪ Less soil salinization and/or less desertification ▪ Less aquifer depletion
ess nutrient depletion of soil	▪ Less land under cultivation
Aicroalgae may be grown in wastewater	▪ Less runoff and less infiltration of wastewater

) **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.

Scoring Guidelines for Question 1 *(continued)*

(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.

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

Scoring Guidelines for 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
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

Sample Student Responses for Question 1
Student Response 1 (Score: 9)

A i. $10000 \frac{\text{gallons}}{\text{acre year}} \times \text{acre} = 1000 \frac{\text{gallons}}{\text{year}}$

$x \text{ acre} = \frac{1}{10} = .1$

.1 acres are required to produce 1000 gallons/year using microalgae

ii. $50 \frac{\text{gallons}}{\text{acre year}} \times \text{acre} = 1000 \frac{\text{gallons}}{\text{year}}$

$x \text{ acre} = 20 \text{ acre}$

20 acres of soybeans are required to produce 1000 gallons/year

B. According to the article microalgae are the "most efficient organism at converting sunlight to energy". As such, they offer the largest oil per acre ratio of any biodisel production. This means that more oil can be produced in a smaller space using microalgae. Thus microalgae is more energy efficient and space efficient. This allows for less crop land and less intrusion upon native habitats.

Additionally, microalgae has several alternate uses that other methods of biofuel production do not. After being pressed for oil, microalgae can be used as "animal feed or soil amendment". These alternate uses allow microalgae to be substituted for land-intensive feed crops thus enabling the use of less land.

Microalgae also provides a possible means of carbon

B. Sequestration. By housing the carbon in the microalgae and then permanently using it as construction material, the carbon ~~remains in the~~ cannot enter the atmosphere and further global warming.

C. Biodiesel fuel's carbon was taken from the atmosphere and placed into the fuel. ~~The~~ When it is burned only carbon that was originally in the atmosphere is released and there is ~~not~~ no net shift in ~~carbon dioxide~~ CO_2 levels. Fossil fuels however are sequestered carbon resources. Burning these releases carbon that was not previously in the atmosphere.

D. Biodiesel is a renewable energy supply; ~~the~~ oil is not. ~~There~~ Eventually the oil ~~supply~~ and coal supplies will be depleted, but biodiesel presents a permanent replacement that will never be used up. ~~Biodiesel will continue to be supply~~

Biodiesel allows us to be independent of foreign oil distributors. ~~and~~ This independence ensures a more stable economy and society.

E. Use of corn [redacted] for biodiesel will cause a drastic increase in corn prices. This increase will [redacted] translate to increased food prices. Increased food prices cause economic [redacted] hardship for the impoverished.

Corn can only be efficiently grown in specific climates. Many countries and parts of the world [redacted] cannot [redacted] efficiently grow corn and thus would not be able to take advantage or use the fuel produced from it.

[redacted] Corn is not an efficient producer of fuel and would require [redacted] a considerable amount of energy and land for a small amount of fuel.

Commentary

In part (a) 3 points were earned: 1 point each for the correct answers and 1 point for the two correct setups.

In part (b) 1 point was earned for the indication that there is "less crop land and less intrusion upon native habitats." The second description, that "microalgae has several alternate uses," does not involve an environmental advantage of microalgae over the other listed crops. The third description, "Microalgae also provides a possible means of carbon sequestration," was not scored as the question asked for only two advantages.

In part (c) 1 point was earned for the correct explanation that carbon in biodiesel "was originally in the atmosphere" and "there is no net shift in CO_2 levels," while fossil fuels "are sequestered carbon resources."

In part (d) 3 points were earned for correctly identifying and discussing two benefits: "Biodiesel is a renewable energy supply; oil is not," and "[b]iodiesel allows us to be independent of foreign oil distributors. This independence ensures a more stable economy and society."

In part (e) 1 point was earned for indicating that "[u]se of corn for biodiesel will cause a drastic increase in corn prices."

Student Response 2 (Score: 7)

a) microalgae: gallons of oil per acre: 10,000
1,000 gallons ÷ 10,000 gallons = .1 acres
soybeans: gallons of oil per acre: 50
1,000 gallons ÷ 50 gallons = 20 acres

b) Making biodiesel fuels from microalgae instead of corn and other food products eliminates the concern of interfering with food production. Many people advertise the global food shortage as a reason why biodiesel fuels can never become a significant ~~part~~ energy source but using microalgae counters this argument.
Since microalgae requires fewer acres than any other known biodiesel contributer, if using it proves far more efficient and less detrimental to the land.

c) Biodiesel fuels do not have the sulfur and other toxic compound content that fossil fuels like coal do. They burn much cleaner without releasing harmful emissions in the atmosphere. This eases the problem of CO_2 emissions, making biodiesel use very beneficial.

d) Since biodiesel fuels are a mostly renewable source of energy, we would not have to worry so much about depleting our natural releases. Coal, oil and other fossil fuels are nonrenewable and therefore we are running out of them very quickly. ~~AF~~ It is crucial that we switch our reliance on nonrenewables to a reliance on renewables so that we can become a sustainable society.

Not only do biodiesel fuels offer a cleaner method of energy production but they also eliminate the need for mining. Mining is expensive, as well as detrimental to the environment. It produces a mass amount of waste, contributes to erosion, increases sediment run off and decreases biodiversity through the fragmentation of habitats. Since biodiesel use is not based off the burning of materials from the earth's crust, it does not require such harmful measures.

e) Producing fuel from corn contributes to the problem of food shortages. Both ~~people, tir~~ people and animals rely on ~~food~~ corn as an important source of food. Limiting the production of corn for food and using it instead for fuels such as ethanol could certainly contribute to a global food shortage.

Corn also has a relatively low yield per acre of oil. In one acre, you only get 20 gallons of oil. This lack of efficient production could cause economical problems.

Commentary

In part (a) 3 points were earned: 1 point each for the correct answers and 1 point for the two correct setups.

No points were earned in part (b). The first advantage the student describes ("Making biodiesel fuels from microalgae instead of corn and other food products eliminates the concern of interfering with food production") is not environmental, and the second advantage listed is not clearly described; "less detrimental to the land" is not an adequate description.

No points were earned in part (c) because the answer confuses sulfur and CO_2.

In part (d) 3 points were earned for correctly identifying and discussing each of two benefits: "biodiesel fuels are a mostly renewable source of energy," "[c]oal, oil and other fossil fuels are nonrenewable," and "biodiesel fuels . . . also eliminate the need for mining . . . [which is] detrimental to the environment."

In part (e) 1 point was earned for the correct observation that "[p]roducing fuel from corn contributes to the problem of food shortages." The second description, that "low yield . . . could cause economical problems," is not adequately described and did not earn a point.

Student Response 3 (Score: 3)

(a) .10 acres are required to produce 1,000 gallons of oil in one year from microalgae whereas 200 acres are required to produce that from soybeans.

(b) If only .10 ares are needed to produce 1,000 gallons of oil from microalgae, then one obvious advantage of biodiesel production from microalgae is the small amount of land needed for production. By not needing alot of land for production, concerns over extensive land use, pollution, and living near the production land is avoided. Another environmental advantage to using this microalgae to produce biofuel is that after the oil is removed, the remaining material can be used as animal feed or soil amendment.

(d) If reliance on biodiesel increased over the next 50 years then people wouldn't have to pay so much money to fuel their cars (like they are using gasoline). Also, if people understood the positive impact that using biodiesel has on the thviroment, they would begin to be more thvironmentaly conscious and therefore may take steps to protect the thvironment in other ways.

Student Response 3 *(continued)*

(e) One problem associated with producing fuel from corn is the fear that by using this corn, we would be taking a food resource from people who rely on corn for nutrition. An economic problem associated w/ producing fuel from corn is that corn isn't cost efficient.

→ Calculations for (a)

(i) microalgae

$$\frac{10{,}000 \text{ gal}}{1 \text{ acre}} = \frac{1{,}000 \text{ gal}}{x \text{ acre}}$$

$$\frac{10{,}000x}{10{,}000} = \frac{1{,}000}{10{,}000}$$

$$x = .10 \text{ acres}$$

(ii) soybeans

$$\frac{50 \text{ gal}}{1 \text{ acre}} = \frac{1000}{x \text{ acre}}$$

$$\frac{50x}{50} = \frac{1000}{50}$$

$$x = 200 \text{ acres}$$

Commentary

In part (a) 2 points were earned: 1 point for correctly answering that .10 acre of land would be required and 1 point for two correct setups. (The work is shown on the second page of the response.)

No points were earned in part (b). The student lists one environmental advantage ("the small amount of land needed for production"), but the description of why this is an environmental advantage is too vague to earn a point. The second advantage ("the remaining material can be used as animal feed") is not, as presented, an environmental advantage.

The student does not attempt part (c) and thus earned no points.

No points were earned in part (d). It is not clear that biodiesel will be cheaper than gasoline, nor that its use will change people's environmental consciousness.

In part (e) 1 point was earned for the correct statement that using corn for fuel "would be taking a food resource from people who rely on corn for nutrition."

Question 2—Overview

The question assessed the students' abilities to analyze environmental information from a schematic diagram as well as from text. The outcome of these analyses should have been a correct computation of landfill values for infiltrated water, cadmium-containing leachate, cadmium released into surrounding soil, and the annual costs associated with treating the leachate. The question also measured students' abilities to recognize viable methods of waste stream reduction for cadmium and the inherent shortcomings associated with the implementation of these methods. Overall, performance was fair: the mean score was 2.27 out of a possible 10 points. (For a discussion of student performance and suggestions for improving scores, see Comments from the Chief Reader beginning on page 46.)

Scoring Guidelines for Question 2

(a) Calculate the volume, in m^3, of each of the following:

(Two points can be earned in each of parts (a)(i) and (a)(ii): 1 point for a correct setup and 1 point for the correct answer.)

(i) The water infiltrated through the landfill per year

$$200 \text{ mm rain} \times \frac{1 \text{ m}}{1{,}000 \text{ mm}} = 0.2 \text{ m rain}$$

$$\frac{10{,}000 \text{ m}^2 \mid 0.2 \text{ m} \mid 50\% \text{ infiltrated water}}{\mid \mid 100\% \text{ water}} = \mathbf{1{,}000 \text{ m}^3}$$

(ii) The leachate that is treated per year

$$1{,}000 \text{ m}^3 \times 0.9 \ (90\%) = \mathbf{900 \text{ m}^3}$$

Note: If the answer to (a)(i) is incorrect, then 0.9 times that answer still earns full credit in (a)(ii).

(b) Given that the cadmium concentration in the water draining from the landfill is 2.0 g/m^3, calculate the mass, in kg, of cadmium that is released into the surrounding soil per year.

(Two points can be earned: 1 point for the correct setup and 1 point for the correct answer.)

Note: The student can either begin with the difference between the answers for (a)(i) and (a)(ii) or take 10 percent of the answer from (a)(i). Metric conversions do not necessarily have to be shown.

$$\frac{100 \text{ m}^3 \text{ drainage water} \mid 0.2 \text{ g Cd} \mid 1 \text{ kg}}{1 \text{ year} \mid 1 \text{ m}^3 \mid 1{,}000 \text{ g}} = \mathbf{0.2 \text{ kg Cd/year}}$$

(c) What is the annual cost of treating the leachate from the drainage system?

(Two points can be earned: 1 point for the correct setup and 1 point for the correct answer.)

Note: The student must use the answer from (a)(ii).

$$\frac{900 \text{ m}^3 \text{ treatable leachate} \mid \$10}{\mid 1 \text{ m}^3 \text{ leachate}} = \mathbf{\$ 9{,}000 \text{ per year}}$$

Scoring Guidelines for Question 2 *(continued)*

(d) Discuss TWO viable methods for reducing the amount of cadmium entering the municipal waste input.

(Two points can be earned: 1 point for a discussion of each viable method. Only the first two methods are scored.)

Category of Reduction	Method or Action
Disposal options	▪ Sort waste stream for cadmium-containing products (batteries, e-waste, paints and pigments, stabilizers, pesticides) headed to landfills ▪ Deposit these materials at a dropoff site or recycling facility, or return to manufacturer
New/substitute technology or alternate materials	Avoid use of cadmium-containing products by: ▪ using rechargeable batteries (e.g., lithium rechargeable) ▪ applying new technology and/or alternate materials that do not use cadmium
Incentives and/or disincentives	▪ Place restrictions on disposal of materials that contain cadmium (batteries, e-waste, paints and pigments, stabilizers, pesticides) ▪ Pass cradle-to-grave (RCRA) legislation ▪ Provide rebate incentives for using cadmium-free products ▪ Provide incentives for manufacturing cadmium-free products (e.g., research grants) ▪ Place a deposit (payable on return) or surcharge on cadmium-containing products
Education	Make the public aware of (any one of the following): ▪ concerns (health, environmental) associated with cadmium ▪ methods of cadmium-containing product/battery reduction/recycling ▪ availability of new/substitute technology

(e) Explain a shortcoming of ONE of the methods that you identified in part (d).

(One point is earned for an explanation that is linked to an accepted method described in part (d).)

Difficulty and/or expense identified with:

- educating the public about benefits of recycling waste that contains cadmium
- providing efficient systems for cadmium waste pickup (recycling/reuse)
- sorting
- achieving 100 percent cadmium removal from waste or 100 percent replacement
- safe disposal, new technology, and substitute material development
- enforcement/regulations/compliance
- recycling (e.g., energy requirements)
- determining if a product contains cadmium

Sample Student Responses for Question 2

Student Response 1 (Score: 10)

a) i: $200\,mm/year \times \frac{50\ percent}{100\ percent} \times \frac{1\ m}{1000\ mm} \times 10{,}000\,m^2 = 1000\,m^3$

$1000\,m^3$ of water infiltrates through the landfill each year.

ii: $1000\,m^3 \times \frac{90\%\ treated}{100\%} = 900\,m^3$

The amount of leachate treated is $900\,m^3$ per year.

b) $1000\,m^3 \times \frac{10\%\ not\ treated}{100\%} \times \frac{2.0\,g}{1\,m^3} \times \frac{1\,kg}{1000\,g} = .2\ kg$ of

There is .2 kg of cadmium released into the soil each year.

c) $1000\,m^3 \times \frac{90\%\ treated}{100\%} \times \frac{\$10}{m^3} = \$9000$ spent

The annual cost of treatment is $9000.

d) One way to reduce cadmium is to not allow batteries into the landfill. Batteries contain cadmium, like other e-waste, and this is then released as the batteries corrode and enters the leachate and possibly ground water. Another possible solution is a MRF or Material Recovery Facility. This can be used to separate out not only cadmium containing products but recycleables as well then the recycleables can be recycled and the cadmium wastes can be properly disposed.

e) A shortfall of preventing batteries is enforcement. How will you know if a truck has batteries or other e-waste? You won't! This makes prevention of dumping cadmium-containing products into the landfill very difficult and even nearly impossible.

Commentary

In part (a) 2 points were earned for correct setups for parts (i) and (ii), and 2 points were earned for the correct answers in cubic meters (1000 m^3 of water and 900 m^3 of leachate).

In part (b) 1 point was earned for the setup, using 1/10 of the value in part (a)(i), and 1 point was earned for the correct final value in kg of Cd (0.2 kg).

In part (c) 1 point was earned for the setup of multiplying cost per meter times the amount of treatable leachate from part (a)(ii), and 1 point was earned for the correct value in dollars ($9,000 annual cost).

In part (d) 1 point was earned for the statement that "[o]ne way to reduce cadmium is to not allow batteries into the landfill. Batteries contain cadmium . . . and this is then released as the batteries corrode." Another point was earned for the discussion about a Material Recovery Facility separating out cadmium wastes for proper disposal.

If 10 points had not already been earned, the student also could have earned 1 point in part (e) for citing the difficulty of enforcement and explaining that it is virtually impossible to know if trucks contain batteries or other e-waste, since this discussion relates to a viable method of reduction from part (d).

Student Response 2 (Score: 7)

a)i) $50\% \times \frac{200\ mm}{yr} = \frac{100\ mm}{yr}$

$\frac{100\ mm}{1\ yr} \cdot \frac{1\ m}{1000\ mm} = \frac{.1\ m}{yr}$

$\frac{.1\ m}{yr} \times 10{,}000\ m^2 = \boxed{\frac{1000\ m^3}{yr}}$

ii) $90\% \times \frac{1000\ m^3}{yr} = \boxed{\frac{900\ m^3}{yr}}$

b) $\frac{2.0\ g}{m^3} \cdot \frac{kg}{1000\ g} = \frac{200\ kg}{m^3}$

$\frac{200\ kg}{m^3} \cdot \frac{900\ m^3}{yr} = \boxed{\frac{180{,}000\ kg}{yr}}$

c) $\frac{\$10}{m^3} \cdot \frac{900\ m^3}{yr} = \boxed{\$9{,}000/yr}$

d) Two viable methods for reducing the amount of reducing the amount of cadium waste input could be setting laws to limit the amount of cadium allowed in products and screening the waste before it enters the municipal waste input.

The first method could be like the clean water Act, where limits are set for the amount of allowed cadium. That way, with the lesser amount in products, the waste would not have so much.

The second method would cost more, in that there has to be a screening device that blocked the entering of cadium into the municipal waste input. Also at the screening process, there can be bacterias that are

Student Response 2 *(continued)*

genetically modified to eat away the cadium. This way, almost all of the cadium would be reduced by the time it hits the land fill.

(e) One of the short comings of using a screening and bacteria method to reduce the amount of cadium is the cost. It would take a lot of money to make sure the intricate screen will indeed detect the cadium. Also, the bacteria that will be genetically-modified will be expensive and will take time to create them.

Commentary

In part (a) 2 points were earned for correct setups for parts (i) and (ii), and 2 points were earned for the correct answers in cubic meters (1000 m^3 of water and 900 m^3 of leachate).

No points were earned in part (b). The setup is incorrectly based on the amount of treated leachate rather than the amount released to the surrounding soil, and the calculation is incorrect.

In part (c) 1 point was earned for the setup of multiplying cost per meter times the amount of treatable leachate from part (a)(ii), and 1 point was earned for the correct value in dollars ($9,000 per year).

In part (d) 1 point was earned for the statement "setting laws to limit the amount of cadmium allowed in products." As described, the second proposed method ("screening") is not viable.

No points were earned in part (e) because the shortcomings are associated with a nonviable method of reduction from part (d).

Student Response 3 (Score: 4)

(a) The volume of water filtrated through the landfill per year is 1000 m^3, the leachate is 900 m^3 (b) The mass in kg of cadmium released into the surrounding soil is 0.2kg. (c) The annual cost of treating the leachate from the drainage system will be $9000. (d) A methed for reducing the cadmium would be to create a filter at the drainage system. (e) A short coming of the filtrations method is that it would need to be replaced maybe monthly or more.

Commentary

In part (a) 2 points were earned for correct answers in cubic meters (1000 m^3 of water and 900 m^3 of leachate). The student does not show how the numbers are calculated, so no setup points were earned.

In part (b) 1 point was earned for the correct final value in kg of Cd (0.2 kg). The student does not show how the numbers are calculated, so no setup point was earned.

In part (c) 1 point was earned for the correct final value in dollars ($9,000 annual cost). The student does not show how the numbers are calculated, so no setup point was earned.

No points were earned in part (d). As described, the proposed method (filtering) is not viable.

The student earned no points in part (e) because the shortcoming is associated with a nonviable method of reduction from part (d).

Question 3—Overview

The intent of this question was to determine the level of students' understanding of fire-suppressed forests, the impact of the Healthy Forests Initiative upon forests, ecosystem services provided by forests, and the effect of clear-cutting upon those services. In addition, students were asked to identify another plant community or biome maintained by fire, other than forests. Almost all students attempted to answer the question, and overall performance was good. The mean score was 4.61 out of a possible 10 points. (For a discussion of student performance and suggestions for improving scores, see Comments from the Chief Reader beginning on page 46.)

Scoring Guidelines for Question 3

(a) **Identify TWO characteristics of forests that develop when fires are suppressed, and explain why the practice of fire suppression does not reduce, but actually increases, the risk of intense and extensive forest fires.**

(Three points can be earned: 1 point for each correct characteristic and 1 point for a correct explanation. Only the first two characteristics given are scored.)

Characteristics of Forests
▪ Accumulation of combustible materials (layer of leaf litter and debris on forest floor, dead trees, etc.)
▪ Increase in understory growth (grasses, shrubs, brush, ladder trees)
▪ Larger trees develop
▪ Even-aged stands develop
▪ Tree density increases
▪ Fire-intolerant species increase in number in the understory
▪ Fire-tolerant species that need fire to germinate seeds decrease in population
▪ Increased canopy coverage eliminates understory growth
▪ Increase or decrease in the rate of nutrient cycling (e.g., release of nutrients of litter, lack of nutrient-rich ash)
▪ No loss of nutrients to burning in intense fires
▪ Increased susceptibility to disease/parasites

Explanations for Increased Fire Risk
Adds to fuel load [intensity]
▪ Increased leaf litter
▪ Increased density of large trees
▪ Increased size of trees
▪ Increase in brush and small trees
▪ Species composition change
Adds to spreading of fire [extent]
▪ Increased density of trees
▪ Increased density of understory growth
▪ Ladder trees leading to crown fires

Scoring Guidelines for Question 3 *(continued)*

(b) The effects of the HFI are expected to extend beyond fire reduction. Excluding fire reduction, describe ONE positive and ONE negative effect likely to result from the implementation of the provisions of the HFI.

(Two points can be earned: 1 point for a correct positive effect and description; 1 point for a correct negative effect and description.)

Positive Effect and Description	Negative Effect and Description
Increased removal of medium and large trees/small tree brush removal will: ▪ lead to economic growth in the lumber industry Increased removal of medium and large trees will: ▪ allow understory to develop into larger trees, potentially enhancing forest habitat ▪ make additional timber available to use (must indicate usage) ▪ result in thinned trees resistant to pests and disease/ impede spread of diseases and pests ▪ enhance economic value of the surrounding areas (housing, lower insurance) ▪ lower the cost of timber ▪ result in a change of aesthetics (with explanation)	The removal of medium and large trees/small tree brush removal will: ▪ reduce available habitat for other organisms in the forest biome ▪ allow timber companies to cut in areas remote from forest communities not threatened by forest fires ▪ cause a reduction in biodiversity (must include a specific example: reduction in nest sites, decrease in seed trees, etc.) ▪ increase soil erosion ▪ increase logging practices (e.g., roads providing access to new areas) ▪ reduce public input ▪ result in a change in aesthetics (with explanation)

Scoring Guidelines for Question 3 *(continued)*

(c) Describe TWO ecosystem services provided for humans by forests. Explain how clear-cutting would affect each ecosystem service you describe.

(Four points can be earned: 1 point for each correct ecosystem service and 1 point for each correct link that describes the impact of clear-cutting. Only the first two characteristics given are scored.)

Ecosystem Service	Impact of Clear-Cutting
Carbon that is removed from the atmosphere by trees helps to limit the magnitude of the atmospheric greenhouse effect.	▪ Some carbon will be released to the atmosphere or will not be removed
Forests provide oxygen (via photosynthesis).	▪ Some loss of oxygen, without which we cannot live
Forests provide food products for human consumption (deer, nuts, fungi).	▪ Can change available browsing places and sighting of animals due to species composition change, increasing their availability for humans (e.g., deer)
Forests provide habitat for many species, some of which provide food and goods for humans, some of which cause harm.	▪ Loss of habitat (biodiversity)
Forests provide wood (e.g., construction material, paper).	▪ Increase in the short-term availability of wood, but potential long-term loss of availability
Forests provide wood for fuel.	▪ Increase in the short-term availability of wood, but potential long-term loss of availability
Many products, such as glue, rubber, and medicines, are produced with forest products.	▪ Increase in the short-term availability of these products, but potential long-term loss of availability
Forests influence the local microclimate affecting humans (change in temperature, shade, UV, wind breaks).	▪ Change in the microclimate
Forests have aesthetic value (hiking, camping, photography, tourism, etc.).	▪ Decreases in natural beauty
Forests improve the quality of soil and water used by humans. (Soil and water must be linked to a specific human use.)	▪ Increases in erosion and runoff and decreases in groundwater recharge, changing water quality
Forests maintain watershed integrity (e.g., flood control with specific human application).	▪ Decreases in watershed integrity

Scoring Guidelines for Question 3 *(continued)*

(d) Identify a specific type of plant community or biome (other than a forest) that is naturally maintained by fire. Explain how the fire maintains the community or biome.

(Two points can be earned; 1 point for identification of biome; 1 point for correct explanation of how fire maintains biome.)

Grasslands (savannah, steppe, veldt, pampas, prairie, maquis, garigue—regional descriptions should include mention of grasslands):

- Fire destroys invasive plant species (e.g., other grasses and trees) that compete for resources with native grasses.
- Fire removes cover and allows sunlight penetration.
- Fire helps the seeds of native grasses to germinate.
- Fires enhance cycling of nutrients back into the soil.

Chaparral (Mediterranean scrubland, Mediterranean shrubland—regional descriptions should include mention of location):

- Fire removes brush, reducing competition for resources.
- Fire helps plants that require fire or lack of brush cover to germinate.
- Species that vigorously stump sprout quickly regenerate themselves.
- Fires enhance cycling of nutrients back into the soil.

Note: Any forest biome earns no credit.

Sample Student Responses for Question 3

Student Response 1 (Score: 10)

a. When forest fires do not occur, dead trees are left standing and large amounts of dry, decomposing material accumulate on the Forest floor. These piles can be subject to spontaneous combustion due to the natural heat of decomposition, and when fires do start, there is enough fuel accumulated to make them extremely intense and ~~long~~ persistent.

b. Clearing underbrush and some larger trees can give saplings a chance to grow and help protect mature trees from competition, but if too much open space is left, invasive species can take over and out-compete native ones, destroying natural biodiversity.

c. Forests limit erosion, keeping rivers ~~dead~~ clear enough for use as a water source, for fishing, and for transportation. They also act as carbon sinks, reducing the amount of carbon in the atmosphere and helping to counteract the greenhouse effect. Clear cutting would ~~cause~~ increase erosion into water bodies, limiting their usefullness to humans, and increase the amount of carbon dioxide in the atmosphere, ~~expediating global warming~~ contributing to global warming. ~~Fire can for many conifers, seeds can only~~

d. Grasslands depend on fire to enrich the soil with nutrients from ash, and to give new generations of plants a chance to grow.

Commentary

In part (a) 2 points were earned: 1 point for the characteristic "large amounts of dry, decomposing material accumulate on the forest floor" and 1 point for the explanation that this accumulated fuel makes fires "extremely intense and persistent."

In part (b) 1 point was earned for the statement "can give saplings a chance to grow" (positive) and 1 point was earned for "if too much open space is left, invasive species can take over and out-compete native ones, destroying natural biodiversity" (negative).

In part (c) 1 ecosystem service point was earned for this statement: "Forests limit erosion, keeping rivers clear enough for use as a water source, for fishing, and for transportation." An additional ecosystem service point was earned for stating, "They also act as carbon sinks, reducing the amount of carbon in the atmosphere and helping to counteract the greenhouse effect." A clear-cutting point was earned for explaining that "[c]lear cutting would increase erosion into water bodies, limiting their usefullness [*sic*] to humans," and a second point was earned for the statement that clear-cutting would "increase the amount of carbon dioxide in the atmosphere, contributing to global warming."

In part (d) 1 point was earned for identifying grasslands as a biome maintained by fire and 1 point for the explanation that "[g]rasslands depend on fire to enrich the soil with nutrients from ash."

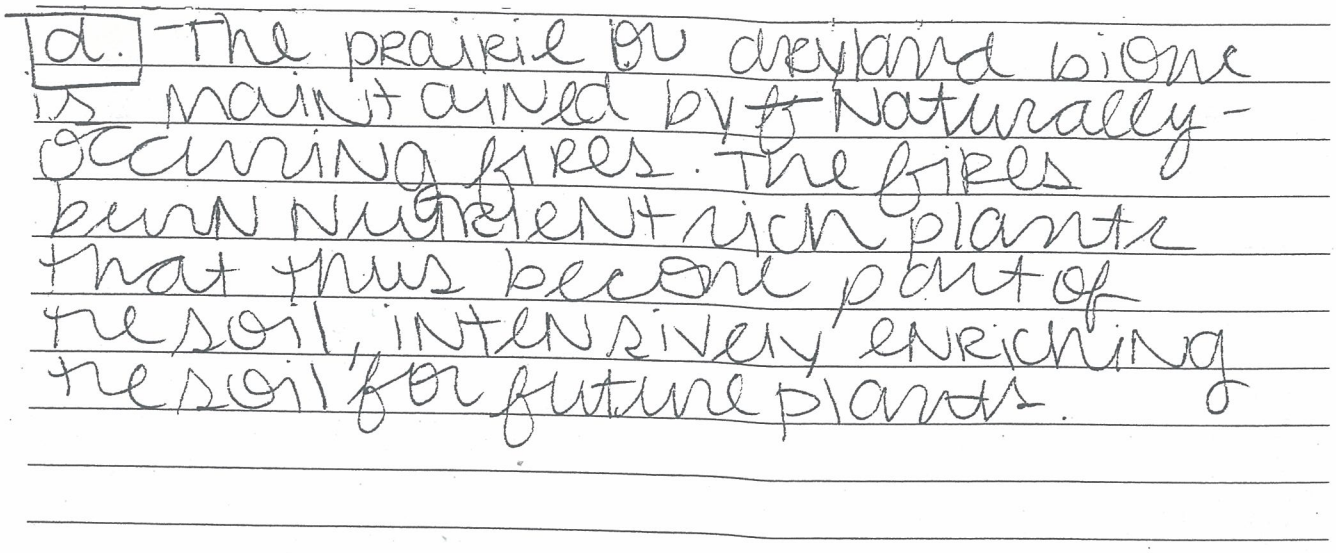
Student Response 2 (Score: 8)

a. Fire suppression by humans disrupts the natural ecosystem; artificial fire suppression alters the balance of the ecosystem, putting additional chemicals likely to react with others in the forest. Furthermore, when ~~forests~~ fires are suppressed, trees ~~with~~ dry leaves even further litter the ground, making eventual fires likely to be worse because of artificially extensive dry leaf accumulation

b. On the positive side, ~~this~~ HFI helps maintain the growth of moisture-rich plants. However, HFI artificially and unpredictably alters the ecosystems in the forests.

c. The plants in forests provide oxygen for animals (including humans) livelihood. Clearcutting would reduce this oxygen concentration. In addition, forest-grown bees pollinate crops that humans eat. If their habitat is cut down, they will decrease in population.

Student Response 2 *(continued)*



Commentary

In part (a) 2 points were earned: 1 point for the characteristic "dry leaves even further litter the ground" and 1 point for the explanation "making eventual fires likely to be worse because of artificially extensive dry leaf accumulation."

No points were earned in part (b). The explanation of a positive effect, "helps maintain the growth of moisture-rich plants," is incorrect, and the negative effect, "artificially and unpredictably alters the ecosystems," is too vague to earn a point.

In part (c) 1 ecosystem service point was earned for this statement: "The plants in forests provide oxygen for animal (including human) livlihood [*sic*]." A clear-cutting point was earned for the statement that "clearcutting would reduce this oxygen concentration." An ecosystem service point was earned for the statement that "forest-grown bees pollinate crops that humans eat." A clear-cutting point was earned for the explanation that "[i]f their habitat is cut down, they will decrease in population."

In part (d) 1 point was earned for identifying the prairie as a biome maintained by fire and 1 point for the explanation that "fires burn nutrient rich plants that thus become part of the soil, intensively enriching the soil."

Student Response 3 (Score: 4)

(a) A characteristic that developed when fires are suppressed includes a ~~disruption~~ disrupted natural flow of organisms in the forest. Another characteristic influenced by suppressed fires includes a weak dispersal of seeds of trees, which brings many tall and old trees, but no or little new ones. Suppressing fires increase the risk of a serious fire because of the intermediate disturbance hypothesis, which states that a little disturbance naturally every now and then, say for instance a natural forest fire, will benefit the ecosystem and stabilize it as well.

(b) A positive effect resulting from the HFI includes less pollution ~~by human activities~~ on forests, yielding a more stable forest ecosystem. However, as stated above in the question, if timber companies are encouraged to harvest medium and large size trees, that is a negative effect of the HFI on the forests.

(c) One ecosystem service provided by forests for humans is the production of oxygen, which we need to live. Another ecosystem service is that it provides flood control and stoppage, including mud and landslide protection. Clear-cutting would slow down oxygen production b/c they are being cut down. As for flood control and landslide prevention, since they are being cut down, floods and landslides will occur more frequently.

(d) A biome that is naturally maintained by fire is the grasslands. If not for fire, the ecosystem would become more susceptible to larger fires. Due to the intermediate disturbance hypothesis, ~~fires~~ natural fires benefit and maintain the biome and prevent a serious disaster from occuring.

Commentary

No points were earned in part (a) because "disrupted natural flow of organisms in the forest" is too vague an explanation for a characteristic, and "weak dispersal of seeds" is not valid.

No points were earned in part (b) because "less pollution by human activities" is not an effect likely to result from the implementation of the Healthy Forests Initiative.

In part (c) 1 ecosystem service point was earned for describing "the production of oxygen, which we need to live." A clear-cutting point was earned for the statement that "[c]lear-cutting would slow down oxygen production." A second clear-cutting point was earned for stating that "floods and landslides will occur more frequently." No ecosystem service point was earned for the reference to flood control as no human service is identified.

In part (d) 1 point was earned for identifying grasslands as a biome maintained by fire. The explanation proposed ("the ecosystem would become more susceptible to larger fires") does not explain how fire maintains the biome.

Question 4—Overview

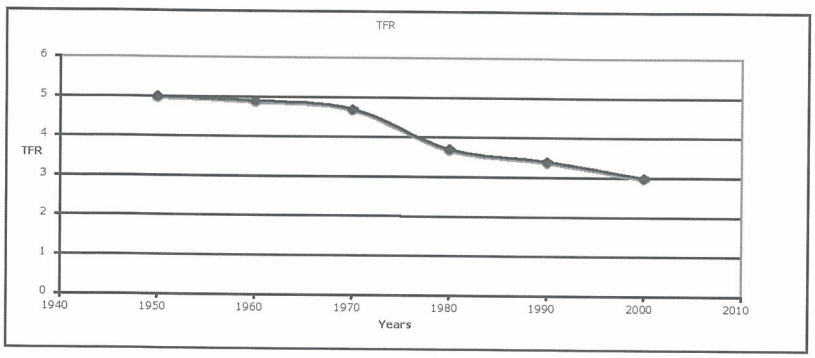
The aim of this question was to assess students' knowledge of contemporary issues related to human population growth and its impact on the environment. Students were required to graph and analyze Total Fertility Rate data (TFR), which should have shown a decreasing trend, and then to give two causes for this decrease over the past 50 years. Students were then asked to compare the TFR for a developed country (the United States) and a less-developed country (Kenya) and to discuss two factors that would account for the difference. Lastly, students were required to relate two effects of rapid human population growth on the biodiversity of the Earth. Overall, students performed well: the mean score was 5.81 out of a possible 10 points. (For a discussion of student performance and suggestions for improving scores, see Comments from the Chief Reader beginning on page 46.)

Scoring Guidelines for Question 4

(a) Create a graph of the data from table 1 below on the axes provided.

(Two points can be earned: 1 point for correctly plotting the data [no more than one data point may be misaligned] and 1 point for correctly setting up BOTH axes with a consistent scale interval.)

Notes: Bar graphs are acceptable. Students need not connect the data points. Award no credit for flipped axes.



Scoring Guidelines for Question 4 *(continued)*

(b) Identify and discuss TWO of the causes for the trend in the worldwide TFR that you graphed in part (a).

(Three points can be earned: 1 point for each valid cause and 1 point for discussion of a valid cause—cause and discussion MUST BE LINKED. Two points maximum may be earned for causes; 1 point maximum for discussion. A single discussion point may be earned by itself.)

Cause	Discussion
Increased/improved family planning	▪ Fewer pregnancies/control of fertility/choice in number of children born
Increased education for women (stay in school longer)/ improved social status of women	▪ Delay having children/choosing to have fewer children
More women enter the workforce	▪ Delay having children
Reduced need for children in workforce/on farm	▪ More industrialization/less agriculture/increased urbanization
More industrialization/less agriculture/increased urbanization	▪ Reduced need for children in workforce/on farm
Improved health care (lower infant mortality)	▪ More children will survive to adulthood
People marry later	▪ Childbearing delayed/fewer children
Changing cultural values	▪ Socially acceptable to have fewer children
Government policies that restrict number of children allowed per woman	▪ Countries are facing overpopulation issues
Increased cost of raising children	▪ Standard of living and education costs have increased
Increased urbanization	▪ Lessens living space for more children

Scoring Guidelines for Question 4 *(continued)*

(c) **Consider the data in table 2 above [table 2 in the exam]. Identify and discuss TWO economic or societal factors that account for the difference between the TFR of Kenya and that of the United States.**

(Four points can be earned: 1 point for each correct factor and 1 point for each correct discussion of the factor. Discussion points may be earned without an identified factor. However, if factors are given, discussion and factors MUST BE LINKED.)

Factors (Societal or Economic)	Discussion
Kenya has a much higher infant mortality rate.	▪ There is a shortage of prenatal and pediatric care due to poverty in Kenya. ▪ Kenyans have more children to ensure that some survive.
Kenya is more agricultural (second stage of demographic transition).	▪ In Kenya more children are needed to help farm.
Kenya is a less-developed country (lower per-capita income)/poorer/nonindustrialized.	▪ Children provide income to the family. ▪ Contraceptives are not affordable.
Women in Kenya lack education and job opportunities.	▪ Women in Kenya have fewer career/work choices so they have children at an earlier age than women in the United States do. ▪ Women in Kenya do not delay childbearing, in contrast with women in the United States who often delay starting a family due to the high cost of childcare.
There is no pension system to support people as they age in Kenya.	▪ More children are needed to support parents in old age.
There is less education about family planning in Kenya.	▪ There is less ability to control fertility.
Cultural values favor larger families in Kenya.	▪ More children mean greater social status.
Women in Kenya have a low social status/marry at an earlier age.	▪ Women have little or no choice/control of their fertility; they have more years of childbearing.
There is a preference for male children in Kenya.	▪ People have more children to get as many sons as possible, because sons will continue to support the family.
The cost of raising a child in the United States is much higher than in Kenya.	▪ People in the United States choose to have smaller families.
Abortion is illegal in Kenya.	▪ Results in more births.
Religious values in Kenya prohibit contraception/abortion.	▪ Results in more births.

Scoring Guidelines for Question 4 *(continued)*

(d) Describe TWO human activities related to the rapidly growing world population that are having an impact on Earth's biodiversity.

Two points can be earned: 1 point for each accurate description. The student must link a specific activity to a specific impact on biodiversity.)

- Deforestation for the following purpose destroys habitats and reduces biodiversity (may use two activities for 1 point each):
  - farming (i.e., creation of monocultures);
  - housing/development (i.e., urbanization);
  - fuel (wood);
  - fossil-fuel recovery (mining and drilling).
- Fossil-fuel burning releases carbon dioxide resulting in climate change, altering global/regional/local temperature and precipitation patterns leading to reduction of biodiversity within ecosystems where organisms have very specific climatic requirements for survival.
- Pollution (student must identify specific contaminants linked to human activity that have a negative impact on species and biodiversity).
- Intensive fish farming spreads parasites and disease to native species, reducing biodiversity.
- Diversion of freshwater for agricultural, municipal, and industrial use reduces water supply for biodiverse freshwater ecosystems.
- Damming of rivers makes it difficult for species that breed/spawn upstream (e.g., salmon) to reproduce, reducing biodiversity.
- Overfishing leads to small, unsustainable populations of fish species, reducing biodiversity.
- Building landfills for increased amounts of trash destroys habitat, reducing biodiversity.
- Poaching of wild animals (e.g., bush meat) due to increased human population and demand for food leads to dwindling populations that may not be sustainable.
- Using genetically modified crops to increase yield of food crops can negatively impact other species (e.g., monarch butterfly larvae can be killed when they ingest toxin-containing genetically modified corn pollen that has settled on milkweed leaves near genetically modified corn fields).

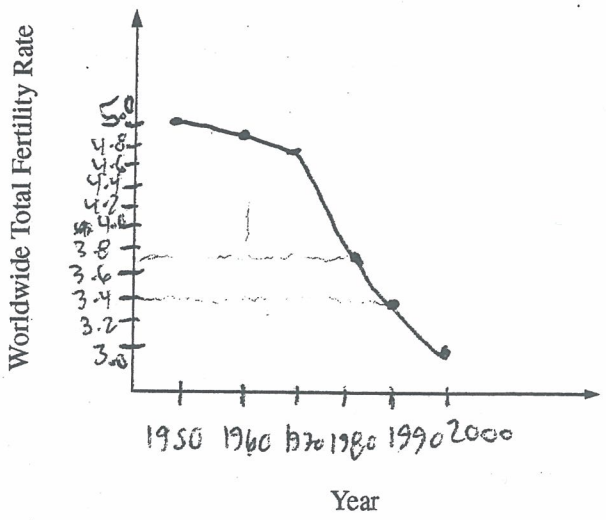
Sample Student Responses for Question 4
Student Response 1 (Score: 9)

4. Answer the following regarding world human population.

(a) Create a graph of the data from table 1 below on the axes provided.

Table 1:
Worldwide
Total Fertility
Rate (TFR)

Year	TFR
1950	5.0
1960	4.9
1970	4.7
1980	3.7
1990	3.4
2000	3.0



(b) One cause for the trend displayed in part A is that birth control use has increased which allows for women to have less children by mistake which lowers the world wide Total Fertility Rate. Secondly, more women have joined the work force (in recent history) due to the increase in education opportunities for women which decreases the amount of time for women to spend with potential children which causes women to not want to have many children which lowers the worldwide TFR.

(c) 1 economic factor that accounts for a higher TFR in Kenya than the USA is that less women in Kenya can afford birth control because ~~[illegible]~~ Kenya is a developing nation which causes many women in Kenya to have more kids & increases the TFR than women in the USA. Secondly, women in Kenya get married at a ~~[illegible]~~ much younger age than women in the USA which means that they are sexually active for a longer period of time which gives them more opportunities to get pregnant & have kids which raises their TFR.

(d) ~~[illegible]~~ 1 human activity is the increase in medicine practice which leads to advancements in medicine which leads to less deaths which increases the population which increases the Earth's biodiversity. Secondly, education opportunities have increased which allows for people to get better jobs which allows for people to make more money which allows for people to have good living conditions for children which increases the population which increases the Earth's biodiversity.

Commentary

In part (a) 2 points were earned: 1 point for correctly plotting all data points and 1 point for correctly setting up both axes.

In part (b) 1 cause point was earned for the statement that "birth control use has increased," and 1 linked discussion point was earned for the statement that birth control "allows for women to have less children." A cause point was earned for stating that "more women have joined the work force." The linked discussion point could have been earned for the explanation that increased educational opportunities cause "women to not want to have many children," but the maximum of 3 points for part (b) had already been earned.

In part (c) 4 points were earned: 1 point for stating that "less women in Kenya can afford birth control" and 1 linked discussion point for the explanation that this "causes many women in Kenya to have more kids." A point was earned for the statement that "women in Kenya get married at a much younger age," and 1 linked discussion point was earned for explaining that this "gives them more opportunities to get pregnant."

No points were earned in part (d) for the discussions of medicine and education.

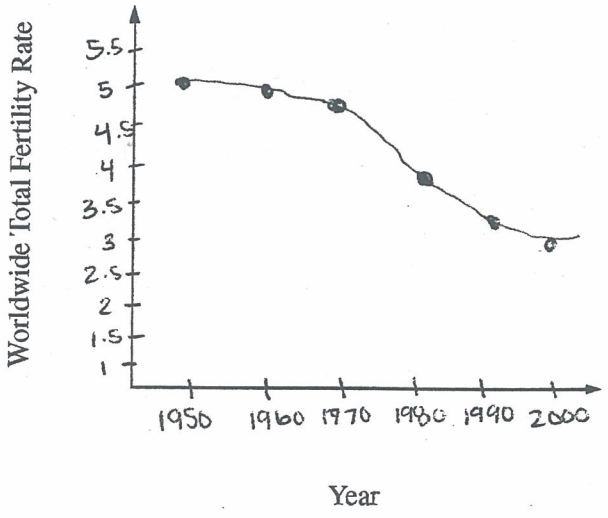
Student Response 2 (Score: 7)

4. Answer the following regarding world human population.

   (a) Create a graph of the data from table 1 below on the axes provided.

Table 1:
Worldwide
Total Fertility
Rate (TFR)

Year	TFR
1950	5.0
1960	4.9
1970	4.7
1980	3.7
1990	3.4
2000	3.0



b) Worldwide fertility rate decreased over time because of a rise in awareness of family planning and growth of educational and occupational opportunities for women.

c) As the average income in the United States far surpasses that of the people in Kenya the United states infant mortality rate is much lower because better health care can be afforded. The crude birth rate in the United States is also much lower than Kenya's. This is because of more advanced family planning in the United States due to education and effective methods of birth control.

a) As the world's total population grows, so does the space that humans need to occupy. This reduces biodiversity as other habitats are being destroyed to make room for people. In addition the amount of food needed increases as the population increases. This also decreases biodiversity as humans rapidly consume without allowing much time for regeneration.

Commentary

In part (a) 2 points were earned: 1 point for correctly plotting all data points and 1 point for correctly setting up both axes.

In part (b) 1 cause point was earned for identifying the "rise in awareness of family planning," and 1 cause point was earned for "growth of educational and occupational opportunities for women." No discussion was linked to these causes and thus that point was not earned.

In part (c) 3 points were earned: 1 factor point for stating that "the United States infant mortality rate is much lower" and 1 linked discussion point for the explanation that "better health care can be afforded." A factor point was earned for the statement that there is "more advanced family planning in the United States due to education and effective methods of birth control." No discussion links the availability of family planning to the TFR so the discussion point was not earned.

No points were earned in part (d) because no specific human activity is identified.

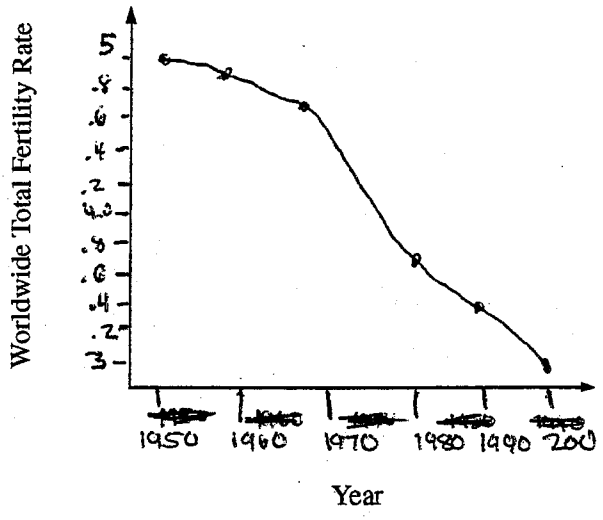
Student Response 3 (Score: 2)

4. Answer the following regarding world human population.

   (a) Create a graph of the data from table 1 below on the axes provided.

Table 1:
Worldwide
Total Fertility
Rate (TFR)

Year	TFR
1950	5.0
1960	4.9
1970	4.7
1980	3.7
1990	3.4
2000	3.0



B) The trend of in the TFR occured because many countries reached ~~maximum population~~ sustainable yield whether it be the amount of land they had available to house the people, or the amount of food and water the country had to provide the people in the country.
• Disease and war is also responsible for the decrease, because many countries that are home to the mass populations, are also the places where disaster struck like the AIDS epidemic in Africa.

C) • In Kenya, people need to have children to help provide for the family. More children means more hands to help around the home or on the farm. In America, only one person is really needed to provide for the whole family.

D) • People are having many children to either please their religious beliefs, or society standards.

Commentary

In part (a) 1 point was earned for correct setup of both axes. Two data points are misaligned.

No points were earned in part (b) for two invalid causes of decreased TFR: "many countries reached sustainable yield" and "[d]isease and war is [*sic*] also responsible for the decrease."

In part (c) 1 point was earned for the statement that children provide "more hands to help around the home or on the farm."

No points were earned in part (d) as no specific human activities are provided.

Chapter IV: Statistical Information

- Table 4.1—Section II Scores
- Table 4.2—Scoring Worksheet
- Table 4.3—Score Distributions
- Table 4.4—Section I Scores and AP Scores
- How AP Scores Are Determined
- College Comparability Studies
- Reminders for All Score Report Recipients
- Reporting AP Scores
- Purpose of AP Scores

This chapter presents statistical information about overall student performance on the 2008 AP Environmental Science Exam.

Table 4.1 shows and summarizes score distributions for each of the free-response questions. The scoring worksheet presented in Table 4.2 provides step-by-step instruction for calculating AP section and composite scores and converting composite scores to AP Exam scores. Table 4.3 includes distributions for the overall exam scores. The score distributions conditioned on multiple-choice performance presented in Table 4.4 are useful in estimating a student's AP Exam score given only the student's multiple-choice score.

College comparability studies, which are conducted to collect information for setting AP score cut-points, are briefly discussed in this chapter. In addition, the purpose and intended use of AP Exams are reiterated to promote appropriate interpretation and use of the AP Exam and exam results.

Table 4.1—Section II Scores

The following table shows the score distributions for AP students on each free-response question from the 2008 AP Environmental Science Exam.

Score	Question 1		Question 2		Question 3		Question 4	
	No. of Students	% at Score	No. of Students	% at Score	No. of Students	% at Score	No. of Students	% at Score
10	393	0.7	2,042	3.5	1,688	2.9	3,775	6.4
9	1,173	2.0	1,442	2.4	3,360	5.7	5,659	9.6
8	2,512	4.2	2,308	3.9	4,609	7.8	7,589	12.8
7	4,483	7.6	1,441	2.4	6,489	11.0	8,527	14.4
6	6,849	11.6	2,746	4.6	7,364	12.4	8,198	13.8
5	9,755	16.5	1,922	3.3	7,367	12.4	7,429	12.5
4	10,788	18.2	3,881	6.6	8,205	13.9	6,374	10.8
3	9,235	15.6	3,771	6.4	5,291	8.9	4,778	8.1
2	6,126	10.3	7,334	12.4	5,479	9.3	3,696	6.2
1	4,103	6.9	4,726	8.0	2,782	4.7	1,710	2.9
0	3,113	5.3	20,120	34.0	3,278	5.5	470	0.8
No Response	693	1.2	7,490	12.7	3,311	5.6	1,018	1.7
Total Students	59,223		59,223		59,223		59,223	
Mean	4.10		2.27		4.61		5.81	
Standard Deviation	2.22		2.94		2.76		2.53	
Mean as % of Maximum Score	41		23		46		58	

Table 4.2—Scoring Worksheet

Section I: Multiple Choice

[_____ − (1/4 × _____)] × .9090 = _____

Number Correct (out of 99)

Number Wrong

Weighted Section I Score (If less than zero, enter zero; do not round)

Section II: Free Response

Question 1 _____ (out of 10) × 1.5000 = _____ (Do not round)

Question 2 _____ (out of 10) × 1.5000 = _____ (Do not round)

Question 3 _____ (out of 10) × 1.5000 = _____ (Do not round)

Question 4 _____ (out of 10) × 1.5000 = _____ (Do not round)

Sum = _____

Weighted Section II Score (Do not round)

AP Score Conversion Chart Environmental Science

Composite Score Range	AP Score
102–150	5
80–101	4
67–79	3
53–66	2
0–52	1

Composite Score

_____ + _____ = _____

Weighted Section I Score

Weighted Section II Score

Composite Score (Round to nearest whole number)

Table 4.3—Score Distributions

More than 53 percent of the AP students who took this exam earned a qualifying score of 3 or above.

	Exam Score	Number of Students	Percent at Score
Extremely well qualified	5	6,807	11.49
Well qualified	4	14,343	24.22
Qualified	3	10,493	17.72
Possibly qualified	2	10,294	17.38
No recommendation	1	17,286	29.19
Total Number of Students		59,223	
Mean Score		2.71	
Standard Deviation		1.40	

Table 4.4—Section I Scores and AP Scores

For a given range of multiple-choice scores, this table shows the percentage of students receiving each AP score. If you have calculated the multiple-choice score (**Weighted Section I Score**) by using the formula shown in Table 4.2, you can use this table to figure out the most likely score that the student would receive based only on that multiple-choice score.

	AP Score					
Multiple-Choice Score	**1**	**2**	**3**	**4**	**5**	**Total**
76 to 90	0.0%	0.0%	0.0%	0.7%	99.3%	1.6%
61 to 75	0.0%	0.0%	0.5%	39.0%	60.5%	14.5%
46 to 60	0.1%	4.6%	32.7%	59.1%	3.6%	29.8%
31 to 45	20.2%	49.7%	26.8%	3.3%	0.0%	29.5%
16 to 30	92.1%	7.7%	0.1%	0.0%	0.0%	17.6%
0 to 15	100.0%	0.0%	0.0%	0.0%	0.0%	7.0%
Total	29.2%	17.4%	17.7%	24.2%	11.5%	100.0%

How AP Scores Are Determined

As described in Chapter II, the AP Environmental Science Exam has two sections. Section I originally had 100 multiple-choice questions, but question #68 was not scored. As a result, this section has a score range from a minimum possible score of 0 to a maximum possible score of 99 points. Section II has 4 free-response questions that each range from a minimum possible score of 0 to a maximum possible score of 10 points.

The scores on the different parts of the exam are combined to produce a composite score that ranges from a minimum possible score of 0 to a maximum possible score of 150 points. In calculating the composite scores, scores on different parts are multiplied by weights.

Composite scores are not released to students, schools, or colleges. Instead, the composite scores are converted to scores on an AP 5-point scale, and it is these scores that are reported. The process of calculating the composite score and converting it to an AP Exam score involves a number of steps that are shown in the Scoring Worksheet (Table 4.2) and described in detail here.

1. **The score on Section I is calculated.** In calculating the score for Section I, a fraction of the number of wrong answers is subtracted from the number of right answers. With this adjustment to the number of right answers, students are not likely to benefit from random guessing. The value of the fraction is 1/4 for the five-choice questions in the AP Environmental Science Exam. The maximum possible weighted score on Section I is 90 points, and it accounts for 60 percent of the maximum possible composite score.
2. **The score on Section II is calculated.** The 4 questions in Section II are weighted equally. The weighted scores on the questions of Section II are summed to give the total weighted score for Section II. The maximum possible weighted score on Section II is 60 points, and it accounts for 40 percent of the maximum possible composite score.
3. **AP Exam scores are calculated.** Composite scores are calculated by adding the weighted Section I and weighted Section II scores together. The AP Exam scores are calculated by comparing the composite scores to the four composite cut-scores selected during the score-setting process. A variety of information is available during the score-setting process to help determine the cut-scores corresponding to each AP score:
   - Statistical information based on test score equating
   - College/AP score comparability studies, if available
   - The Chief Reader's observations of students' free-response performance
   - The distribution of scores on different parts of the exam
   - AP score distributions from the past three years

See Table 4.3 for the score distributions for the 2008 AP Environmental Science Exam.

If you are interested in more detailed information about this process, please visit AP Central (apcentral.collegeboard.com). There you will also find information about how the AP Exams are developed, how validity and reliability studies are conducted, and other data on all AP subjects.

College Comparability Studies

The Advanced Placement Program has conducted college grade comparability studies in all AP subjects. These studies have compared the performance of AP students with that of college students in related courses who have taken the AP Exam at the end of their course. In general, AP cut-points are selected so that the lowest AP 5 is equivalent to the average A in college, the lowest AP 4 is equivalent to the average B, and the lowest AP 3 is equivalent to the average C (see below).

AP Score	Average College Grade
5	
	A
4	
	B
3	
	C
2	
	D
1	

Research studies conducted by colleges and universities and by the AP Program indicate that AP students generally receive higher grades in advanced courses than do students who have taken the regular first-year courses at the institution. Colleges and universities are encouraged to periodically undertake such studies to establish appropriate policy for accepting AP scores and ensure that admissions and placement standards remain valid. It is critical to verify that admissions and placement measures established for a previous class continue for future classes. Summaries of several studies are available at AP Central. Also on the College Board Web site is the free Admitted Class Evaluation Service™ (http://professionals.collegeboard.com/higher-ed/validity) that can predict how admitted college students will perform at a particular institution generally and how successful they can be in specific classes.

Reminders for All Score Report Recipients

AP Exams are designed to provide accurate assessments of achievement. However, any exam has limitations, especially when used for purposes other than those intended. Presented here are some suggestions for teachers to aid in the use and interpretation of AP scores:

- AP Exams in different subjects are developed and evaluated independently of each other. They are linked only by common purpose, format, and method of reporting results. Therefore, comparisons should not be made between scores on different AP Exams. An AP score in one subject may not have the same meaning as the same AP score in another subject, just as national and college standards vary from one discipline to another.
- Score reports are confidential. Everyone who has access to AP scores should be aware of the confidential nature of the scores and agree to maintain their security. In addition, school districts and states should not release data about high school performance without the school's permission.
- AP Exams are not designed as instruments for teacher or school evaluation. Many factors influence AP Exam performance in a particular course or school in any given year. Thus, differences in AP Exam performance should be carefully studied before being attributed to the teacher or school.
- Where evaluation of AP students, teachers, or courses is desired, local evaluation models should be developed. An important aspect of any evaluation model is the use of an appropriate method of comparison or frame of reference to account for yearly changes in student composition and ability, as well as local differences in resources, educational methods, and socioeconomic factors.
- The AP Instructional Planning Report is sent to schools automatically and can be a useful diagnostic tool in reviewing course results. This report identifies areas of strength and weakness for the students in each AP course. The information may also provide teachers with guidance for course emphasis and student evaluation.
- Many factors can influence exam results. AP Exam performance can be affected by the degree of agreement between a course and the course defined in the relevant AP Course Description, use of different instructional methods, differences in emphasis or preparation on particular parts of the exam, differences in curriculum, or differences in student background and preparation in comparison with the national group.

Reporting AP Scores

The results of AP Exams are disseminated in several ways to students, their secondary schools, and the colleges they select:

- College and student score reports contain a cumulative record of all scores earned by the student on AP Exams during the current or previous years. These reports are sent in July. (School score reports are sent shortly thereafter.)
- Group results for AP Exams are available to AP teachers in the AP Instructional Planning Report mentioned previously. This report provides useful information comparing local student performance with that of the total group of students taking an exam, as well as details on different subsections of the exam.

Several other reports produced by the AP Program provide summary information on AP Exams:

- State, National, and Canadian Reports show the distribution of scores obtained on each AP Exam for all students and for subsets of students broken down by gender and by ethnic group.
- The Program also produces a one-page summary of AP score distributions for all exams in a given year.

For information on any of the above, please call AP Services at 609 771-7300 or e-mail apexams@info.collegeboard.org.

Purpose of AP Scores

AP scores are intended to allow participating colleges and universities to award college credit, advanced placement, or both to qualified students. In general, an AP score of 3 or higher indicates sufficient mastery of course content to allow placement in the succeeding college course, or credit for and exemption from a college course comparable to the AP course. Students seeking credit through their AP scores should note that each college, not the AP Program or the College Board, determines the nature and extent of its policies for awarding advanced placement, credit, or both. Because policies regarding AP scores vary, students should consult the AP policy of individual colleges and universities. Students can find information in a college's catalog or Web site, or by using the AP Credit Policy search at www.collegeboard.com/ap/creditpolicy.

Contact Us

National Office
Advanced Placement Program
45 Columbus Avenue
New York, NY 10023-6992
212-713-8066
E-mail: ap@collegeboard.org

AP Services
P.O. Box 6671
Princeton, NJ 08541-6671
609-771-7300
888-225-5427 (toll free in the U.S. and Canada)
E-mail: apexams@info.collegeboard.org

AP Canada Office
2950 Douglas Street, Suite 550
Victoria, BC, Canada V8T 4N4
250-472-8561
800-667-4548 (toll free in Canada only)
E-mail: gewonus@ap.ca

International Services
Serving all countries outside the U.S. and Canada

45 Columbus Avenue
New York, NY 10023-6992
212-373-8738
E-mail: international@collegeboard.org

Middle States Regional Office
Serving Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Puerto Rico and the U.S. Virgin Islands

Three Bala Plaza East, Suite 501
Bala Cynwyd, PA 19004-1501
866-392-3019
E-mail: msro@collegeboard.org

Midwestern Regional Office
Serving Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, West Virginia and Wisconsin

6111 North River Road, Suite 550
Rosemont, IL 60018-5158
866-392-4086
E-mail: mro@collegeboard.org

New England Regional Office
Serving Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont

1601 Trapelo Road, Suite 12
Waltham, MA 02451-7333
866-392-4089
E-mail: nero@collegeboard.org

Southern Regional Office
Serving Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Virginia

3700 Crestwood Parkway NW, Suite 700
Duluth, GA 30096-7155
866-392-4088
E-mail: sro@collegeboard.org

Southwestern Regional Office
Serving Arkansas, New Mexico, Oklahoma and Texas

4330 Gaines Ranch Loop, Suite 200
Austin, TX 78735-6735
866-392-3017
E-mail: swro@collegeboard.org

Western Regional Office
Serving Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming

2099 Gateway Place, Suite 550
San Jose, CA 95110-1051
866-392-4078
E-mail: wro@collegeboard.org