CollegeBoard
Advanced Placement Program

# AP® Environmental Science

## Teacher's Guide

Dean Goodwin
Kimball Union Academy
Meriden, New Hampshire

connect to college success™
www.collegeboard.com

## The College Board: Expanding College Opportunity

The College Board is a national nonprofit membership association whose mission is to prepare, inspire, and connect students to college success and opportunity. Founded in 1900, the association is composed of more than 4,300 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 23,000 high schools, and 3,500 colleges through major programs and services in college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT®, and the Advanced Placement Program® (AP®). The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities, and concerns.

For further information, visit www.collegeboard.com.

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 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 more information about equity and access in principle and practice, contact the National Office in New York.



***For further information, visit apcentral.collegeboard.com.***

# Permission to Reprint Statement

The Advanced Placement Program® intends this publication for noncommercial use by AP® teachers for course and exam preparation; permission for any other use must be sought from the AP Program. Teachers may reproduce this publication, in whole or in part, **in limited print quantities for noncommercial, face-to-face teaching purposes.** This permission does not apply to any third-party copyrights contained within this publication.

When educators reproduce this publication for noncommercial, face-to-face teaching purposes, the following source line must be included:

> ***AP Environmental Science Teacher's Guide*. Copyright © 2003 by the College Entrance Examination Board. Reprinted with permission. All rights reserved. www.collegeboard.com. This material may not be mass distributed, electronically or otherwise. This publication and any copies made from it may not be resold.**

The AP Program defines "limited quantities for noncommercial, face-to-face teaching purposes" as follows: Distribution of up to 50 print copies from a teacher to a class of students, with each student receiving no more than one copy.

No party may share this copyrighted material electronically—by fax, Web site, CD-ROM, disk, e-mail, electronic discussion group, or any other electronic means not stated here. In some cases—such as online courses or online workshops—the AP Program *may* grant permission for electronic dissemination of its copyrighted materials. All intended uses not defined within ***noncommercial, face-to-face teaching purposes*** (including distribution exceeding 50 copies) must be reviewed and approved; in these cases, a license agreement must be received and signed by the requestor and copyright owners prior to the use of copyrighted material. Depending on the nature of the request, a licensing fee may be applied. Please use the required form accessible online. The form may be found at: http://www.collegeboard.com/inquiry/cbpermit.html. For more information, please see AP's *Licensing Policy For AP® Questions and Materials.*

# Table of Contents

# Table of Contents

# Preface

I began teaching a college-level environmental science course as a high school elective in the late 1980s. When I heard about the development of a new AP® course and exam in environmental science in the mid-1990s, I was eager to learn more about this exciting initiative. Suffice it to say that since that time, my involvement with AP Environmental Science—from teaching the course to running workshops for the College Board and working with ETS® and other AP teachers at the annual AP Reading where the AP Exams are scored—has been a highlight of my career. It has afforded me some rewarding opportunities for professional development and enabled me to meet stimulating environmental educators from colleges and high schools around the country. I am privileged to have become friends with such a talented group of individuals.

A main goal in the production of this edition of the *AP Environmental Science Teacher's Guide* was to develop a resource that would prove useful to teachers who are new to the subject and also be a valuable resource for veteran AP Environmental Science teachers who are looking for new ideas and instructional approaches. The content of this guide and its eight sample syllabi should have something for everyone who teaches this dynamic course. I hope that it helps you in creating and developing your own course and also in providing your students with material that will engage and excite them.

I am indebted to my colleagues who have shared their thoughts, syllabi, and curriculum ideas on labs and other resource materials in the pages that follow. As you will quickly ascertain from the variety of approaches that are used in their classrooms, there is no "right" way to teach an AP Environmental Science course. Each of the instructors has built up a series of activities and strategic methods that meet their own students' needs and suit the location of their educational institution. That is the beauty of the AP Environmental Science program; it can be taught successfully from a variety of pedagogical approaches, incorporating a teacher's own personal perspective. I hope that you get as much out of the experience of teaching the course as I have over the years, and I wish you the best in all of your endeavors with the AP Environmental Science program.

The number of students taking AP Environmental Science has increased notably in the short period of time since the first AP Environmental Science Exam was administered in 1998, and I think we will witness continuing growth for several years to come. There are some obvious conclusions to be drawn from these increasing numbers. More students taking the exam implies that more schools are offering the course, and therefore more teachers must be moving into the arena of environmental science education. A number of factors have contributed to the maintenance of the high quality of the AP Environmental Science course in the face of this rapid expansion.

- **AP Central™.** The College Board Web site for AP professionals (apcentral.collegeboard.com) has given teachers access to a wide variety of resources that are useful to them in their own classrooms. Reviews of textbooks, Web sites, videos, and other multimedia materials are just a few of the examples of the collection of reviews that are added on a regular basis. Each year the free-response questions and their scoring guidelines are posted soon after the AP Reading has taken place.

- **Professional Development Programs.** The College Board (along with other institutions) runs many Summer Institute and training workshops throughout the year. These have been invaluable in helping teachers set up new AP courses in their own schools and providing them with ongoing training. For more information, go to AP Central and click on Institutes & Workshops.

- **The Electronic Discussion Group.** The AP Environmental Science electronic discussion group (EDG) has become a very popular avenue for communication among AP Environmental Science teachers. The messages that are posted relate to topics ranging from free-response questions on particular content to advice on textbooks or requests for a good LD-50 lab. Postings like these provide a lively discourse on environmental science between teachers throughout the country. More information about this resource can be found in Chapter II, "How to Begin an AP Course in Environmental Science."

As we move into the future, other new initiatives are emerging that will maintain a healthy and vibrant AP Environmental Science program. For example:

- **Lab Activities on the Web.** A lab project cosponsored by the College Board and the Environmental Literacy Council is currently underway. This will result in a series of suitable AP Environmental Science labs being posted on the respective Web sites of these two organizations. Teachers have asked for more suggestions for lab activities, and this project is helping to fulfill that need.

- **More Exam Questions.** In the near future, another full AP Environmental Science Exam will be published. This will provide more examples of suitable multiple-choice and free-response questions for teachers to use when preparing their students for the AP Exam.

- **Continuing Curriculum Review.** The AP Environmental Science Development Committee continually reviews and makes revisions to the course's curriculum to ensure that its content remains current and reflects the types of environmental science courses that are being taught at the college level.

# Preface

As a consequence of the increased student demand for the AP Environmental Science course, I predict that more teachers will have to be certified to teach environmental science in order to meet the demand for trained educators to teach the program. As students move on to college after taking the AP Exam, more of them will be asking their colleges to grant them credit for their AP Exam grade. This should result in an increase in the number of colleges that grant such credit to AP Environmental Science students. Textbooks will continue to be updated on a regular basis and will be enhanced by a good selection of supplemental materials from which teachers can choose. The outlook for the future of AP Environmental Science remains bright and should cast a long shadow for many years to come!

I would like to personally thank Timothy Knox (Headmaster) and Allan Munro (Chairman of the Board of Trustees) of Kimball Union Academy for the support, vision, and encouragement they have given to me and for providing me with the opportunity to pursue and promote environmental education.

Dean Goodwin
Director of Environmental Education
Kimball Union Academy
Meriden, New Hampshire

# Chapter I

# Introduction: The Context and Role of AP Environmental Science

***Thomas B. Cobb***

*Bowling Green State University*

*Bowling Green, Ohio*

Since its introduction as "the new kid on the block" more than five years ago, AP Environmental Science has now matured sufficiently to take its place solidly among other long-established AP programs sponsored by the College Board. From an initial volume of around 5,000 exams in its pilot year of 1997-98, nearly 30,000 students at 1,568 high schools in the United States and abroad completed the AP Environmental Science Exam in May 2003. This growth rate shows no signs of slowing. AP Environmental Science is now well integrated in the secondary school curriculum. Summer Institutes and training workshops sponsored by the College Board help train teachers to deliver these courses, and AP Central provides a convenient means of sharing information among practicing teachers.

In contrast to what some had feared during the development phase of this program, AP Environmental Science has *not* replaced or detracted from enrollments in AP Biology, Chemistry, or Physics but rather seems to have truly found its own niche. Students who otherwise might not have considered taking an AP science course are attracted to AP Environmental Science. This is consistent with the original prediction of the College Board Task Force and serves to validate and confirm the importance of the course.

In spite of its widespread acceptance among high schools, environmental science still does not seem to enjoy the same general integration at the college and university level. The reasons for this have more to do with traditions in the university than with the subject matter itself. The intrinsic interdisciplinary nature of environmental science may not be compatible with the established disciplinary divisions at the typical university.

Over the years, many environmental concepts have been embraced and incorporated into the university curriculum, but more often than not these concepts are included as a subset of topics within a particular discipline. For example, we now often find specialty science courses like environmental biology, environmental science chemistry, environmental geology, and environmental physics. In the social sciences and humanities, we see classes like environmental economics, environmental history, environmental ethics, environmental literature, environmental sociology, environmental law, environmental policy, environmental psychology, and many others. Unless the college or university has a formal administrative structure for interdisciplinary studies, this is the usual way environmental science is offered—as a subset of topics in one or more of the traditional disciplines. This is good for the disciplines, but it is bad for the student who is seeking to gain an overview of the subject without first having to specialize. An overall perspective is more difficult to achieve because fragmentary and incomplete knowledge is acquired in a limited context.

AP Environmental Science overcomes these problems by focusing on environmental issues rather than the disciplines from which these issues arise. This usually presents more problems for the teachers than for the students because AP Environmental Science instructors are called upon to teach a variety of topics from many disciplines for which they may not have been specifically trained. This teacher's guide provides some suggestions on how to overcome these problems. In spite of the broad spectrum of topics, AP Environmental Science is limited in the sense that emphasis is placed on the *science* of environmental issues. Environmental examples are used to help students think analytically and critically about issues, and opportunities are given to apply quantitative methods for analysis. In so doing, AP Environmental Science provides an opportunity for students to gain firsthand experience in the practical application of science to real-life problems and to do so with topics that generally are of personal interest and societal importance. In this respect, AP Environmental Science provides an excellent introduction to the study of the environment, and it offers an entrée into the world of science that can form the basis for a lifetime of work and satisfaction.

## Course Content

Even though some policy components are included in the recommended outline of course topics, AP Environmental Science maintains a definite science orientation. The suggested outline has undergone some slight revisions since its initial publication in the *Course Description for AP Environmental Science.* The latest edition of the course description is posted on AP Central. (You must register to use this free site. Choose "The Courses" and then "Course Descriptions.") Prospective teachers should pay special attention to the list of topics given there. Percentages beside each category correspond to the degree of emphasis placed on those topics in the multiple-choice section of the AP Exam. Accordingly, students who take courses that closely follow this outline should feel better prepared for the exam.

It is important to recognize that the outline of topics for AP Environmental Science was not taken from any existing environmental science text. Rather, course content was developed after extensive surveys of environmental science curricula and professors at a number of colleges and universities had been conducted, and the list of topics was recommended by a committee of practicing high school and college instructors (the AP Environmental Science Development Committee) after reviewing many college course syllabi and extant textbooks. The resulting outline represents the consensus opinion of this Development Committee as to what should constitute an appropriate course, and the result is consistent with national recommendations for environmental literacy.

Because AP Environmental Science was developed independently of any text, the complete list of topics is not likely to be found in any single textbook. Moreover, an unspecified laboratory/field experience component is also required. Recognizing that some may find such ambiguity disconcerting, the Development Committee recommends that teachers develop a personal course syllabus in conjunction with the text(s) of their own choosing, using representative syllabi like those included in this teacher's guide as references. The course does not need to follow the same sequence in which the topics are presented in the recommended outline, but all topics should be covered to some degree. Some topics lend themselves to laboratory or field exercises more easily than others, and this fact, among others, may dictate when during the year the topic is covered and what emphasis is given to it.

## The Role of the AP Environmental Science Teacher

What background should a person who wants to be an AP Environmental Science teacher have? Certainly, teachers should be certified in secondary science teaching, preferably with certifications in both the physical and life sciences. But perhaps more important than any specific certification is an interest in and curiosity about environmental issues, a willingness to collaborate or perhaps team teach, flexibility and readiness to learn about diverse topics, and a positive orientation toward fieldwork. Environmental science students often are highly motivated, but they need careful guidance in the application of scientific methods to the solution of environmental problems. Willingness to seek out and work with other teachers and with resource persons in the community is essential to a successful AP Environmental Science experience.

*Environmental science teachers Leigh Jenkins (left) of Berkeley Springs, West Virginia, and Cindy Wandling of Charleston, West Virginia, use a CBL probe and handheld calculator to determine the level of dissolved oxygen in a mountain stream.*

*Photograph courtesy of Thomas B. Cobb.*

## Preparation for Students Taking AP Environmental Science

Prerequisites for students enrolling in AP Environmental Science classes are spelled out in the *Course Description for AP Environmental Science.* Specifically, two years of science and one year of algebra are considered minimum preparation. Although environmental science typically is less mathematical than chemistry or physics, it nonetheless has quantitative aspects, and students should be made aware that some computational work will be expected. Because AP Environmental Science is a science course, quantitative work should be included whenever possible. Those who score the AP Environmental Science Exams each year know all too well the need for increased mathematical rigor on the part of secondary school students.

Students need practice in using scientific notation, working with units, estimating, using ratios and proportion, doing percentage calculations, reading and interpreting graphs, and employing logical and deductive reasoning. AP Environmental Science provides a good opportunity for them to practice such skills in the context of personally interesting and socially important issues, and the AP Environmental Science teacher should reinforce such activities as much as possible. Because all AP courses are intended to be comparable to college courses, an increased level of independence should be demanded of the AP Environmental Science student.

## Textbook Selection

Although no single environmental science text is likely to follow the AP Environmental Science outline exactly as it is presented in the course description, most of them probably include the necessary topics in some manner. Within the past few years, many new texts have been developed and older ones revised. Some of these include content that is similar to the AP Environmental Science outline and some have laboratory components associated with them. While the College Board does not endorse any particular textbook, published reviews for several texts are included in the Teachers' Resources section of AP Central and a list of such books is included in the course description as well as in this teacher's guide. We recommend that teachers select a text that is suited to their personal style and to their students, keeping in mind the *science* emphasis of the AP Environmental Science course.

Many of the major texts on the market today can serve as an adequate reference for the course, but some texts are more quantitative than others and many have special emphases depending on the background and interests of the authors. Ancillary materials, such as study guides, test banks, booklets of topical readings, videos, CD-ROMs, laboratory manuals, and other materials, are also frequently available. Regardless of the text that is chosen, teachers need to keep the AP Environmental Science outline of topics in mind and continually reinforce those topics and the associated science concepts to their students.

## Supplemental Resources and Resource Persons

In addition to textbook selection, the AP Environmental Science teacher will want to be cognizant of the many supplemental materials and resources that are available for use both in and out of the classroom. For instance, many good videos, Web sites, data files, computer simulations, group activities, games, role-playing exercises, and more are available. Some of these are listed in this teacher's guide.

If you live near a college or university, consider inviting its faculty members to speak to your class on topics of mutual interest. Many federal agencies, such as the EPA, DOE, NIH, NIEHS, USDA, NASA, and others, have education divisions that can provide teachers with free materials for the classroom. Environmental materials and speakers can also be obtained, usually at some cost, from independent environmental organizations like the Sierra Club, Worldwatch Institute, Population Reference Bureau, World Resources Institute, and Rivers Unlimited. Do not neglect local government agencies like your state's department of natural resources and the local farm bureau or county agricultural agent. Local utilities, museums, zoos, nature centers, landfills, and water treatment plants can also provide opportunities for interesting field trips, and some of these agencies have speakers who are willing and able to come to your school free of charge.

AP Environmental Science teachers should work to develop close rapport with local contact persons who can help augment classroom teaching, provide expertise beyond that of the individual teacher's capability, and enrich learning opportunities for the students. However, one caveat should be given concerning the use of supplemental classroom materials and speakers. Some agencies or individuals may have a particular agenda in mind and they may have many resources at their disposal to promote it. The AP Environmental Science teacher must be a filter for such activity and ever mindful of the need to present environmental issues in an unbiased and scientific manner.

## Laboratory/Field Experience

*Dorothy Scharf, a chemistry and environmental science teacher at Charleston Catholic High School in Charleston, West Virginia, looks for color changes in a treated water sample to test for nitrates in a local stream.*

*Photograph courtesy of Thomas B. Cobb.*

In developing the AP Environmental Science course, the Development Committee was unanimous in their recommendation that a laboratory experience be included. Such experience was viewed as essential for a true science course and for environmental science in particular. Laboratory and field experiences provide students with opportunities to:

- learn and practice scientific methods,
- observe nature in operation,
- design experiments,
- form and test hypotheses,
- collect and analyze data,
- interpret results, and
- organize and communicate findings to others.

As part of the laboratory experience, students should learn how to prepare proper scientific graphs, to read and interpret graphs, to distinguish between good and bad experimental design, to recognize the difference between strong and weak arguments, and to draw conclusions and make inferences. All of these critical thinking skills apply regardless of the laboratory topic. So, even though no fixed set of labs is prescribed, the inclusion of a laboratory/field experience component to the AP Environmental Science course is considered essential and some aspects of this experience are tested on the exam.

In this teacher's guide, you will find examples of labs that have been performed by other practicing AP Environmental Science teachers. When deciding which labs to use, you should choose those that fit well with the possibilities your location offers. For example, if you live in the Midwest, you are not likely to do a tide pool experiment. Within the past few years, some of the science supply houses have developed labs that are tailored specifically for AP Environmental Science students. Certainly, you should consider these experiments, but do not limit yourself to them simply because someone in a marketing department classifies it as "AP Environmental Science material."

Although there is no specific set of required labs for the AP Environmental Science course, there are some common topics that teachers should be aware of and consider seriously for inclusion in any AP Environmental Science class. These are experiments in the areas of habitat evaluation, biodiversity, water quality (chemical and biological analyses), air pollution, toxicity, dose-response experiments, population and demography, energy use, and soils. Several good lab manuals exist and some are identified in this teacher's guide. Experiments from other AP Environmental Science teachers are often made available during workshops sponsored by the College Board. Teachers should also check in regularly at AP Central for any postings related to lab experiments.

### The Importance of Field Trips

Field trips to local sites of interest can be an enriching and educational component of an environmental science course. In spite of the difficulty of arranging these and building them into the course curriculum, they should be strongly considered. Plan field trips well in advance so that the time is used effectively. For instance, if a visit to the local zoo is planned, give students some preliminary worksheets on animal behavior to complete while they are there. For a trip to the local landfill, include information on the amount, composition, and origin of the waste as well as information about pre- and post-treatment and procedures for locating and preparing the landfill site itself. For a visit to a local water resource, information about habitat and wildlife should precede and follow the trip. Water quality analysis, both chemical and biological, is an important activity for an environmental science course. Procedures for habitat evaluation are available from many sources, including the local department of natural resources, the local EPA office, or other professionals like the scenic rivers coordinator in your state.

## Equipment and Supplies

While there is no absolute requirement for any specific equipment in the environmental science classroom, some basic items in common with biology and chemistry should be available for at least part-time use. These include hand lenses and microscopes, basic glassware like beakers and test tubes, Bunsen burners, thermometers, and balances. Certain experiments, such as water quality testing, may require special chemicals, access to a pH meter, a dissolved oxygen probe, aquarium tank, growth chamber, or other items. Many teachers have found some of the calculator-based laboratory (CBL) probes made by Vernier and other companies to be useful. Students can use these probes to measure and record such things as temperature, dissolved oxygen, pH, and other parameters. The data can be downloaded to a computer for later analysis and can form the basis of many good laboratory experiences for students. However, teachers

should take care to ensure that science dictates the technology rather than the reverse. Such methods should be used only to the extent that they facilitate the collection of data and expand opportunities for learning science. Such equipment is not essential for a meaningful AP Environmental Science experience.

## Preparing Students for the AP Environmental Science Exam

In this teacher's guide you will find specific information in Chapter IV about the AP Environmental Science Exam along with recommendations for preparing students to take it. As with any program of this type with a single, standardized exam, there is the danger of having "the tail wag the dog," i.e., teaching to the test. The primary focus should be on providing a comprehensive environmental science course whose content is consistent with the topic outline published in the *Course Description for AP Environmental Science.* If those topics are covered adequately in the proportions recommended, and if they are coupled with an integrated laboratory experience, the student who comprehends the associated concepts should have no trouble in performing satisfactorily on the AP Exam.

Many topics in environmental science do not lend themselves to short-term memorization of facts or figures that can be learned in a specific, targeted approach. Rather, the emphasis of AP Environmental Science is more on understanding systems and processes, and many of the exam questions, especially those in the free-response section, are designed to test students' comprehension of these larger concepts. Students should be given practice in critical analysis and taught to recognize the difference between opinions and scientific arguments. They should have experience in analyzing and presenting data. On the exam they may be required to integrate information from a number of contexts into a reasoned analysis. Thus, students who have practice in performing such analyses will not only be more successful on the exam but will also be more likely to become contributing and responsible citizens who are able to devise and implement solutions to real-world problems.

## Obtaining College Credit for the AP Environmental Science Experience

The differences between the comprehensive approach of AP Environmental Science and the traditional piecemeal approach to environmental science in the typical university make credit equivalencies more difficult to determine than those for other AP courses. Accordingly, obtaining college credit for AP Environmental Science may not be straightforward. Although the College Board considers those students who earn a grade of 3 or higher on the AP Environmental Science Exam to be qualified to receive college credit, the actual granting of credit is up to the individual college or university. With nearly 3,000 institutions of higher learning in the United States, you can imagine that this is hardly a consistent system. Every credit offering must be evaluated by the particular college or university to which the student has applied, and each school has its own requirements and department or departments where environmental science is offered. Thus, the granting of credit for AP Environmental Science is inherently more complex than it is for the traditional disciplines.

This is not to say that students should abandon the idea of obtaining college credit for AP Environmental Science. Rather, they should be aware of the possible difficulties and be ready to support their case with additional information if required. In addition to the textbook and course syllabus, we recommend that AP Environmental Science students retain copies of their lab reports as well as other special assignments they have completed during the course. Although many introductory environmental science courses in college do not include a lab, the inclusion of such information in a student portfolio will help to convince reviewers of the comprehensiveness of the AP Environmental Science course and assist evaluators in finding equivalencies in the college curriculum. It should also help determine whether credit is to be offered through a science or humanities division of the university. Because most colleges do not have the luxury of devoting a full year, including lab, to introductory environmental science, students in a yearlong AP Environmental Science course will have had a richer experience than they would from a university's one-semester survey course with a large enrollment and no lab. Keeping good records of their AP Environmental Science experience will help students demonstrate this to college officials.

## Summary

The study of environmental science has never been more important. The AP Environmental Science course is well established and serves a unique need in the educational arena. It fills a niche that cannot be served easily by colleges and universities and at the same time provides a valuable service to society by teaching students how to apply science to the solution of important social problems. It provides opportunities for students to apply scientific methods to practical and real-life problems, thereby reinforcing the value of science to society and enhancing skills learned in the classroom.

Major environmental issues remain to be addressed, such as global warming, ozone depletion, acid rain, air pollution, water pollution, habitat destruction, species extinction, energy supply and use, transportation issues, food supplies, population growth, and more. The challenge for AP Environmental Science teachers is to present facts about environmental problems without communicating a sense of hopelessness and despondency and to motivate students to devise solutions. Teachers also should communicate a sense of environmental responsibility so that as students take their place in society they become responsible voters and contributing world citizens.

The topics included within the AP Environmental Science curriculum are so diverse that an individual teacher may require help to cover them all. Designing and implementing meaningful laboratory experiences is also challenging and time consuming. In spite of these challenges, both teachers and students will be enriched through the AP Environmental Science experience. As one of the original developers of this course, I fully recognize and appreciate the difficulties, but I have also been inspired and impressed over the years by the many dedicated and talented teachers who participate in the endeavor. Several of them have contributed to this teacher's guide. If you are a continuing AP Environmental Science teacher, on behalf of the entire Development Committee, I congratulate and thank you and wish you much continued success. If you are a teacher who is new to AP Environmental Science, I welcome you and hope that your experience is personally enjoyable and professionally rewarding.

## The Course

The yearlong AP Environmental Science course is designed to be the equivalent of a one-semester, introductory, college-level course in environmental science that offers the rigors of a college class. The course is popular both with students who would not normally take an AP course in the traditional science subjects of biology, chemistry, or physics, and also with those who do take more than one AP science course. Students often "double up," with the AP Environmental Science course being their second or even third AP subject.

The latest version of the *Course Description for AP Environmental Science* can be found on AP Central. Every year or two, the AP Environmental Science Development Committee reviews the curriculum to ensure that it best serves the stated goals and objectives of the course. Teachers who are thinking about starting an AP Environmental Science course in their school need to be fully conversant with the course description and take it into account when designing their own course. The most successful courses are those in which the teacher has developed an environmental science course that closely follows the course description.

The goal of the AP Environmental Science course is to provide students with the scientific principles, concepts, and methodologies that are required for them to understand the interrelationships of the natural world. The course helps students to identify and analyze both natural and human-induced environmental problems. It enables them to learn how to assess the risks associated with these problems and evaluate alternative solutions for resolving and preventing them. From a personal perspective, in today's world it is of the utmost importance to prepare our students to become the environmentally literate citizens of tomorrow. The AP Environmental Science course goes a long way toward doing so.

Class size is dependent on the individual school and student interest in the subject. Obviously, a smaller number of students in each section leads to greater interaction from each participant during class discussions and may make planning field trips and labs easier. I have heard of section sizes ranging from below 10 to greater than 30. Although there is no designated optimum number, lab safety should be considered. Most teachers would probably agree that less is more when it comes to class size.

Whenever a new course is introduced into a school, one of the main concerns is that the costs that will be incurred may be too high. A course like AP Environmental Science can be offered with a minimal amount of extra costs, particularly if the equipment for conducting labs and carrying out fieldwork is readily available within the existing science department. Some schools ask for an increased amount to be added to the science budget, while others establish a separate line-item account specifically for the AP class.

Teachers need to research what will work in their school to provide the necessary funding and not forget about the possibility of obtaining grants in order to get the course up and running. Having money available for equipment allows greater sophistication in the types of experiments and investigations that can be conducted. At a bare minimum, teachers need to have such items as water and soil test kits readily available for their students; the spectrophotometers can come later. Do not be afraid to contact local companies to see if they would like to donate their older equipment when they upgrade.

## Teacher Selection and Training

Teachers of AP Environmental Science come from a wide variety of backgrounds and tend to have previous experience as instructors of biology, chemistry, earth science, physics, or any combination of these disciplines. Some teachers get together with colleagues and team teach, drawing on each other's skills and expertise. As the demand for the AP and other environmental science courses has become more widespread throughout schools in the nation, there is now a flow of teachers coming into the profession after having majored in environmental science in college. This was not the case a decade or so ago. An increasing number of colleges are developing professional development courses specifically for environmental education. Some veteran teachers have taken college or online courses in environmental science in preparation to teach the subject. In the early to mid-1990s, a number of colleges ran a credit telecourse based on the popular PBS series Race to Save the Planet. The bottom line for being an AP Environmental Science teacher is that you are highly motivated, interested in the subject, comfortable with the process of science, and a definite must is that you display a contagious enthusiasm for the topic.

Some schools have added a faculty teaching position specifically to cover the AP and other environmental science courses and have raised funds to initiate the program. In other schools, the AP course has been taken on and offered by an enthusiastic teacher as an additional science elective. Other teachers have replaced one of their regularly taught classes with that of AP Environmental Science. Once again, it is evident that the AP course in environmental science has a nice "one size fits all" aspect to its character, and it can be incorporated into a school's science curriculum in many ways with a little imagination and ingenuity by the individual teacher and the school administration.

The AP Environmental Science course demands a strong field and laboratory component, and a teacher needs to have a healthy and enthusiastic approach to this facet of the course. Putting together a good set of labs takes time and effort. (Discussion of and ideas for laboratory investigations are given in other sections of this teacher's guide.) Initially, other AP Environmental Science teachers are good resources for advice on the laboratory component of the course. Other opportunities to get information and training are available at many state, regional, and national conventions. These offer valuable sessions

that relate to class, lab, and field activities that can be incorporated into an AP Environmental Science course. Teachers are encouraged to take advantage of such opportunities when they arise.

Teachers should also contact their College Board Regional Office for information about workshops in their area. The office locations, e-mail addresses, and phone numbers can be found on AP Central and on the inside back cover of this teacher's guide. The College Board sponsors weeklong Summer Institutes and one- and two-day workshops throughout the year to train teachers in planning and implementing AP courses. These institutes and workshops provide AP teachers with instructional information, strategies, and ideas for laboratory explorations. They explain the exam format, describe how the exam is administered, and give examples of the best methods for preparing students. Many schools, colleges, and universities arrange their own workshops during the summer. Even though these workshops may not be officially sponsored by the College Board, if they are taught by experienced AP teachers they can provide another valuable opportunity and resource for in-service training. Workshops may offer teacher recertification credit for participation. Many school districts and state education departments provide funding for such professional development experiences, and teachers should investigate their school's policy on funding such activities.

## AP Central™ – apcentral.collegeboard.com

As part of its mission to support professional development for AP teachers, the College Board developed AP Central, the online home of AP professionals and the Pre-AP™ program. AP Central provides the most up-to-date information on the AP Program and AP Environmental Science, including course descriptions, sample free-response questions and scoring guidelines, sample syllabi, and feature articles written by AP teachers.

An important component of the Web site is the Teachers' Resources section. Here AP teachers can find useful, informative, and innovative teaching materials that can be used to develop classroom lessons and activities or to improve their understanding of their discipline. For AP Environmental Science, there are reviews of textbooks, scientific equipment, periodicals, Web sites, software, videos, and more. Specific information on the origins, location, content, and quality of the resources is included. All reviews are written by college and high school faculty with specific reference to their value in teaching AP courses.

The Teachers' Corner of AP Central contains insightful articles, teaching tips, activities, lab notes, and other course-specific information contributed by colleagues in the AP community.

Other AP Central features include:

- A searchable Institutes & Workshops database that provides information about professional development events offered through the College Board and other educational organizations and professional associations.
- My AP Central, which allows you to create a personalized page with links to the content most important to you.
- In-depth FAQs, including brief responses to frequently asked questions about AP courses and exams, the AP Program, AP Environmental Science, and other topics of interest.
- Links to AP Environmental Science books and publications that can be purchased online at the College Board Store.
- Contact AP, providing a means to quickly send e-mail inquiries about the Program, a course, or AP Central.
- Moderated electronic discussion groups (EDGs) for each AP course, including a forum for AP Environmental Science, to facilitate the exchange of ideas and practices.

## AP Electronic Discussion Groups

The AP Program has developed an electronic discussion group for AP Environmental Science teachers, who have found this free resource to be an invaluable tool for exchanging ideas with colleagues on syllabi, texts, teaching techniques, and other issues of interest and concern. When teachers have a specific problem, they can always depend on the generosity of fellow discussion group participants to share their experiences, advice, and resources. Teachers have consulted with one another on such matters as whether a particular film is appropriate to show in the classroom, how to cut down on paperwork, and acquiring much-needed teaching materials. Teachers share their favorite Web sites, add links to each other's sites to their own Web pages, and even provide technical support for one another whenever possible. To find out how to join the discussion group, go to the Environmental Science Teachers' Corner at AP Central or to the AP Community tab at the top of any AP Central page.

## Ensuring Student Success

The AP Environmental Science course offers interested students an excellent opportunity to study the subject in a challenging, rigorous, and meaningful way. Before taking the course, students should have successfully completed two years of high school science: one year of life science and one year of physical science. In addition, because of the analytical component the course demands, students should have taken at least one year of algebra. These prerequisites usually mean that students take the course in their junior or senior year. This does not preclude accelerated tenth grade students from admission to the course. However, these students tend to be the exception, not the norm.

Many schools require students to discuss their desire to take the course with the AP Environmental Science instructor. The teacher should assess a student's prior academic performance, as well as written and other work, to determine if the student will be able to successfully meet the challenges of the textbook and supplementary reading materials for the course. It is also useful to have recommendations from the student's current math and science teachers.

When first instituting an AP Environmental Science course in a school, it may take a few years to establish and set the appropriate criteria for student selection. Schools should, however, ensure that their criteria are fair and equitable. This standard is explained in the *AP Program Guide:*

> 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 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 more information about equity and access in principle and practice, contact the College Board National Office in New York.

The interdisciplinary nature of AP Environmental Science, which draws on material from the areas of biology, chemistry, earth science, and physics, is of great interest to many students. This underlying high motivation to learn about the subject is the most important factor that will lead a student to success in the class. Students who want to take the course simply to obtain college credit or just to have an AP course on their college applications will not be as successful as the well-prepared and highly motivated students who display a true desire to learn about the environment. These characteristics are responsible for drawing increasing numbers of students to choose AP Environmental Science as their viable AP science choice.

To meet the challenges of the course, students should have a solid academic record, good critical-thinking ability, and excellent reading skills. Having the capability to articulate their thoughts well in writing is also of prime importance and will be particularly useful to them on the free-response section of the AP Exam. It is essential to have parental support as well. Teachers need to ensure that they explain the goals and expectations, as well as provide information relating to the AP Environmental Science course, to both students and parents prior to enrollment.

## Other Resources

Information regarding resources for use in the AP Environmental Science classroom, including textbooks, magazines, videos, software, Web sites, and professional associations, can be found in Chapter VI, "Bibliography and Resources." Teachers should review as much material as possible in order to determine what will be most useful to them and when to introduce it to their class. Other important resources that can be used to supplement the course can be found in the community. For example, compiling a list of sites for field trips for the class to go on and a list of guest speakers from universities and colleges or businesses and industries to visit with the class are important considerations for teachers when setting up an AP Environmental Science course. The time and effort that is devoted to this research beforehand will benefit teachers in the design plans and greatly enhance the value and content of their own curriculum.

Computer access for students is another important feature that teachers should take into account when establishing an AP Environmental Science course. Having a number of computers with Internet capability within the classroom is the ideal situation for research and other purposes. The availability of computers provides options for incorporating interactive laboratory simulations into the course. Most major textbooks now have accompanying Web sites containing a wide range of ancillary materials for use by students and teachers. If computers are not available in the classroom, then the teacher should investigate other options, such as scheduling a regular time to use the school's computer or technology center.

## Overview

The AP Environmental Science course is exciting and fun to teach because of the interdisciplinary nature of the subject matter. It draws on elements from the different fields of science and also touches on such diverse topics as ethics and social science. It requires students to learn, think, and question as they delve deeply into a scientific study of the environment.

Because environmental science is a constantly evolving and changing field, it is most important for teachers and students to keep current with the latest information regarding environment issues. Students can participate in this process by researching and reviewing articles or topics on a regular basis. Grade these written reviews and keep them as part of an ongoing collection in a class file that is added to as the year progresses. Having students carry out assignments of this type where they have to read, assimilate, understand, and think critically about issues will help them when they attempt the document-based question on the AP Exam. Teachers should also stay abreast of the latest media offerings, such as new television programs that pertain to the environment and could have potential classroom use. When teaching with films and videos it is advisable to follow up with some form of assessment that relates to the content of the viewed material. This could be a quiz or a short essay in response to a given thesis statement.

It is important to provide students with an outline that has a concise course description as well as the objectives and requirements of the course. This should include the dates on which testing will occur and when any lab reports are due. It should also describe how homework assignments, quizzes, daily preparation, and participation grades will be determined. Giving students a weekly, biweekly, or monthly syllabus will help them manage their time better, plan ahead for projects and tests, and stay on task more consistently. Examples of such time lines are provided in the eight sample syllabi that appear later in this teacher's guide. The course outline a teacher develops may change from year to year. Refining the outline to allow more or less emphasis on various topics is an ongoing process.

Laboratory investigations are not a mandatory part of all introductory college or university courses in environmental science, but they do play a major role in the AP course. This is where the high school AP Environmental Science course has the edge when compared to many of its college-level equivalents. Although there are no set number or type of labs as there are in AP Biology for example, it is nevertheless important to expose students to such investigations. Students who participate in lab and fieldwork as part of the environmental science course will have a better grounding and education in the subject than students who study only the content.

Some teachers have found this aspect of the course rather daunting and have experienced difficulty in deciding which labs to perform. This is where teachers can be creative and have the most impact on the

course, really putting their own stamp on it. The lab portion can reflect a teacher's own personal preference of study and expertise. The type of labs that students do is not as important as the *process* that is involved in doing labs. Having students actively involved in the acquisition and analysis of data is the significant thing. So do not expect to carry out experiments on every chapter in the textbook. Choose those investigations you are interested in and feel comfortable doing and that will be of benefit to the class from the perspective of a hands-on learning experience.

The Internet is providing more opportunities for teachers to interact with one another, whether it is through using an electronic discussion group to seek suggestions for suitable labs and textbooks or by establishing direct links with AP Environmental Science teachers within a region. Interaction of this type will no doubt increase in the future, and it enables students to share lab data with AP Environmental Science classes in other parts of the country and even around the world. For example, as a storm front crosses the United States, a class can record parameters like barometric pressure, temperature, the amount of precipitation, and pH levels, and then post the results of such investigations on the Internet.

## Selecting a Textbook

Undoubtedly, this is the first thing a teacher needs to do. After a textbook has been selected it can be referred to as the course is mapped out for the year. It is imperative that teachers take the time to review each textbook option carefully before coming to a final decision as to which one is the best fit for their own teaching style. Other AP Environmental Science teachers can be very helpful in this process and offer advice pertaining to the pros and cons of each available textbook. This subject is often a topic that is discussed in the AP Environmental Science electronic discussion group at AP Central. Chapter VI, "Bibliography and Resources," lists some of the textbooks that are currently used in introductory, college-level environmental science courses. Remember that no one book follows the AP Environmental Science curriculum exactly, and that being on the list is not an endorsement by the College Board, ETS, or the AP Environmental Science Development Committee.

Review copies of textbooks are available from their publishers. It should be noted that teachers might have to track down the current publisher of any given textbook due to the fact that recently several publishing houses have been in either a state of acquisition or undergoing some type of merger. The Web site links given in Chapter VI represent the current publishers at the time this guide was published. AP textbooks are usually listed in the college textbook section of a publisher's inventory or in a separate section specializing in AP texts for use in high schools. When requesting inspection copies of potential textbooks, it is helpful for teachers to identify themselves as a high school AP teacher and also ask to be sent the ancillary materials that may accompany the textbook. If possible, check out any related Web sites that have

been established to supplement the textbook. Some sites have free access; others may require a temporary password from the publisher. Although ultimately only one textbook will be decided on for use by the students taking the course, most teachers have many textbooks in their personal library for reference purposes.

Teachers can also contact their local college or university and speak to one of the professors about the textbook that is used in the institution's introductory environmental science course. A visit to a college bookstore may also be beneficial and give teachers the chance to look at possible texts before having review copies sent. It might be useful to contact the state department of education for information about textbooks that may have been adopted by other schools in the region.

The field of environmental science is dynamic; the topic is under constant revision as new data emerges. This is reflected in the fact that most textbooks have new editions published every few years in order to keep the content current. This, in turn, means that the school administration needs to appreciate that AP Environmental Science textbooks have to be replaced more frequently than those for other AP science courses. It also means that teachers may have to modify their course outlines every few years to remain consistent with any changes that occur from one edition to the next.

Teachers should read several chapters to compare the content of various textbooks. Use the curriculum outline described in the current edition of the *Course Description for AP Environmental Science* as a reference guide when assessing content. There are a number of criteria that should be taken into account when selecting a textbook for the course. The text must be interesting, appealing to both students and teachers, and provide a depth of coverage that is conducive to an introductory college-level course. Choose a textbook that is clearly written and has good illustrations and photographs. Ensure that it contains useful chapter outlines and chapter summaries in addition to a selection of end-of-chapter questions. Many textbooks also include sidebar issues and case studies that can be used as topics for further classroom discussions and to engender critical thinking.

Many of the available textbooks come with a variety of ancillary materials, such as a designated Web site, instructor's guide, computerized test bank, overhead transparencies, CD-ROMs that can be used to produce PowerPoint® presentations, and video series, which can be used to supplement the course. The availability of good quality ancillary materials may be the deciding factor for some teachers as they finalize their decision as to which textbook to choose. Whichever one you select, make sure that it best fits your own personal approach and style of teaching. In addition to the textbook, it is important that you make other resources available for students, for example, a good selection of journals and magazines in the school library or access to specialized resource materials in the local college or university library.

## Laboratory and Field Investigations

In the AP Environmental Science course, students are exposed to the science behind the environmental content and issues that are studied. It is imperative that a strong laboratory and field component is associated with the course. A comprehensive hands-on investigative approach to the laboratory and field component substantially enhances the content material students learn throughout the course. It enables them to make their own observations about the environment as they test the concepts they encounter in the classroom. Explorations may go into great depth with regard to a particular topic and allow students to encounter real-world environmental situations that are often right on their own doorstep. These experiential investigations are especially appealing to students who learn best by doing and often lead to improved student enthusiasm for covering the core content material in the classroom.

Before embarking on any type of laboratory testing or fieldwork, it is essential that teachers stress the safety aspects associated with each experiment or exercise. The type of activities that students undertake should be diverse, expose them to the analysis of real data, and help them acquire skills in specific laboratory techniques and field procedures. Activities can include one-time visits to local areas of interest or be part of a long-term, ongoing study of a local ecosystem or habitat.

As noted in the course description, every laboratory and field activity should include such elements as:

- highlighting a link to a major scientific concept described in the course outline,
- allowing students to have direct contact with an organism or environmental system, and
- fostering the scientific method through observation, collection and analysis of data, and the communication of results and conclusions.

A well thought-out and planned laboratory and field component should challenge students' ability to:

- critically observe environmental systems;
- understand environmental problems and investigate solutions through critical thinking;
- develop hypotheses and conduct well-designed experiments, clearly identifying the independent and dependent variables, control groups, constants, and more;
- utilize appropriate techniques and instrumentation;
- analyze and interpret data, including mathematical, statistical, and graphical evaluations;
- draw conclusions and assess their validity;

- make suggestions for further studies; and
- communicate the results of observations to others in an accurate and constructive manner.

## Laboratory Component

Although some textbooks have accompanying lab manuals, no one lab manual fully meets the needs of the AP Environmental Science course. Some of the available lab manuals emphasize classroom lab exercises, whereas others focus more on fieldwork. It is important to collect as much information on lab activities as possible. Many teachers adapt existing materials to suit their own requirements or devise entirely new approaches to lab investigations and field studies. Several of the sample syllabi in this teacher's guide refer to a number of possible activities as well as commercially available lab kits, and there are some general suggestions for lab and field investigations in the *Course Description for AP Environmental Science.* The section on basic equipment needs contains a number of suggestions for the types of tests that can be performed as part of the laboratory component of the course. Once again, the AP Environmental Science electronic discussion group at AP Central provides a forum for discussion of many lab ideas. State, regional, and national conventions or workshops are also good resources for lab activities. I encourage teachers of AP Environmental Science to refer frequently to AP Central for information on the laboratory component of the course.

Any opportunity for students to participate in hands-on investigations is of great value. The activity could be part of an ongoing monitoring project, for example, of a local pond or stream or of the air quality at a busy intersection. It could also be one in a series of stand-alone experiments that are conducted at regular intervals during the course. Projects that link directly with the lives of the students or their community tend to have the most impact. There are a number of interactive software programs listed in Chapter VI that simulate lab and field investigations and serve to provide other options for AP Environmental Science teachers.

Students should keep a detailed lab notebook in addition to a good set of course notes. Should they seek college credit for their AP course, these can be useful to show to colleges and universities. It is also beneficial for students to be required to produce a number of formal lab reports during the course so that they are made aware of what constitutes good representation and reporting of the scientific method and its application. At the end of this chapter is a typical example of the basic format of a lab report. Not only does it contain an explanation for students of what is required in each subheading, it also allows them to display an understanding of the strategies involved in experimental design. This latter addition is not always found in formal lab report guidelines, though it is one of the most important components of the experimental design technique.

Having students design experiments of their own really enables them to think like scientists. It gets away from the cookbook approach to labs and tends to be a more meaningful and productive experience for students. I download two versions of the lab template onto a disk for each of my students so they can either transfer them to their own computers or use the disk as their working copy. One version contains the explanations and the other contains the basic template they are to use to produce their lab reports. I have shared this lab format with AP Environmental Science teachers at numerous workshops sponsored by the College Board and provide it at the end of this chapter as a resource that can be used as is or modified to suit the needs of the individual instructor. I am a firm believer in exposing students to the rigors of experimental design. It may also help them on the free-response section of the AP Exam with questions that ask them to design an experiment to prove a stated hypothesis.

## Fieldwork and Field Trip Components

This aspect of the course is very exciting for students. Before embarking on any field trip, the teacher needs to put in the time to plan a meaningful student experience that enhances the concepts covered in the classroom. Two factors to take into account are the ease with which you can obtain permission to use land in the area and the ease of access to the site. Teachers should contact the manager of any facility they would like to visit and, if at all possible, visit the location personally beforehand. Depending on the type of field trip, a limit may be placed on the number of students who are allowed to participate. Transportation issues need to be resolved, and the teacher needs to get any testing materials and other equipment packed and ready to go. Well-planned field trips are the best.

Useful locations for fieldwork and field trips include, but are not limited to:

- **The school campus or nearby ponds, streams, rivers, wetlands, fields, and woodland** for ecological studies, habitat analysis, and biodiversity inventories. These provide opportunities to test the biological, chemical, and physical properties of both terrestrial and aquatic areas.
- **A local farm** to study such topics as best management practices, soil erosion issues, crop rotation strategies, genetically modified crops, fertilizer and pesticide usage, organic farming techniques, and food production (milk, meat, or grain).
- **A sewage treatment plant** to find out what really happens each time we flush. This could be compared to a household septic system or the use of "Living Machines" as alternative treatment options.
- **A water treatment plant** visit may be combined with a trip to a sewage treatment facility. This could be compared to obtaining water from a household well and linked to groundwater usage and aquifer depletion studies.

- **An electrical production facility.** Depending on the location, this could be a nuclear power plant, a hydroelectric dam, a cogeneration power plant, a coal or wood chip burning power plant, a wind farm, or a solar powered electric generating unit. Some of these facilities may put limits on student age or group size.
- **A local cemetery for population demographic and survivorship studies.** Good data sets on longevity can be obtained if collected from an old cemetery versus a new one. Have students be respectful when entering such a site. Permission should be obtained and it is advisable not to visit if a burial is scheduled for that day. The teacher should also be aware of any students with relatives who may be recently deceased or interred at the location.
- **A local landfill, incinerator, or recycling center** to evaluate the fate of household and other wastes generated in the area.

The location of your school and the availability of suitable field trip sites in the area will ultimately determine the number and diversity of such excursions. Teachers should also keep in mind the following as additional field trip opportunities: hospitals, museums, zoos, aquariums, botanical gardens, hazmat response team headquarters, supermarkets, construction sites, town meetings, conservation and zoning board meetings, superfund sites, logging operations, coal mines, paper mills, petroleum refining plants, and dealerships that specialize in hybrid cars.

In certain instances, students may be able to do field trips on their own, outside of class time, and report their experiences to the class. There are also a number of "virtual" trips available on the Internet. Depending on your geographic location, the weather may affect the number and type of field trips that can be accomplished. It is possible to undertake winter tree identification labs and animal tracking studies in the snow. Be as creative as possible in coming up with ideas, sites, and activities for field trips. Any hands-on opportunities that teachers can provide will be beneficial to their students.

## Basic Equipment Needs

Students should be exposed to a certain amount of environmental analysis and testing procedures and equipment, such as:

- **Water quality testing.** This can be drinking water or stream or pond water. A number of good test kits are easy to use and come with clear instructions and premeasured chemicals. If the funds are available, then one setup for every two or three students is ideal; if not, then one type of test kit per group is useful. Tests can include dissolved oxygen, fecal coliform, pH, BOD, temperature, total phosphate, nitrates, nitrite, ammonia, turbidity, total solids, hardness, and the iron, copper, or lead levels for drinking water.

- **Soil analysis.** Students can bring in soil from their own homes' lawns and gardens. It can also come from the school's playing fields or a local farm. Nutrient quality tests can include determining the levels of nitrogen, phosphorus, and potassium. Other parameters, such as pH, soil texture, and microorganism content, can also be assessed.
- **Air sampling equipment.** Some basic air monitoring tests can be performed.
- **Collection of field guides.** A good set of field guides is essential when carrying out biodiversity studies in an ecosystem.
- **Computers.** In order for students to perform graphical and statistical analysis of their collected data, it is useful to have appropriate software available.

These suggestions supplement the usual standard laboratory equipment like glassware, Bunsen burners, microscopes, thermometers, and the like. More sophisticated equipment like monitoring units that can download data into a computer or electronic probes for measuring dissolved oxygen levels can be added to the laboratory resources as funds allow. Ideally, a teacher will have a budget to purchase equipment and test kits specifically for the AP Environmental Science course and not be totally dependent on borrowing materials from the biology, chemistry, earth science, or physics labs. The amount of available funding will determine the extent and sophistication of the equipment that can be purchased. Keep a wish list with current prices and ordering information in case funds become available during the year.

## What to Do After the AP Exam

Depending on the school calendar, teachers may be faced with anywhere from a week to a month of classes after their students have taken the AP Exam in May. Maintaining a focus to the end of the school year may offer a challenge to some teachers and the opportunity to be creative to others. There are a variety of activities that can be undertaken during this time. If end-of-year school exams are mandatory, then an academic focus must continue and can be accommodated by student research projects and presentations. If the teacher has some flexibility, then many options can be considered. This is a time when teachers can get into more of an environmental studies theme with their students or introduce material and activities that are interdisciplinary in nature. Teachers from other departments can be involved and participate in the class. Some examples of the types of student projects and activities that can be pursued include:

- Doing projects in the community or on campus, such as clearing and maintaining hiking trails
- Continuing to monitor projects involving local pond, woodland, and other natural resources
- Holding a film festival where movies with environmental themes are critically evaluated

- Holding an ethics debate on environmental issues
- Reading and discussing environmental literature
- Conducting an environmental writing workshop
- Assigning "art and the environment" projects
- Conducting in-depth studies of major environmental figures like Thoreau, Muir, Leopold, and Carson
- Helping students in local middle schools learn about the environment
- Creating a butterfly garden at the school
- Running a plant-a-tree campaign
- Implementing a hazardous waste collection day
- Interviewing local residents on how the environment has changed during their lifetime
- Taking additional field trips to museums and other places
- Removing invasive plants from protected areas
- Participating in an energy conservation awareness campaign at the school or in the local community
- Designing a sustainable house for a family of the future
- Constructing a model of a "Living Machine" that can be used by the next year's class
- Constructing bird houses for beneficial bird species
- Having a speaker series with an environmental focus on a particular issue

No one can carry out all of these suggestions; they represent the types of activities AP Environmental Science teachers have described to me when I have conducted workshops for the College Board or been at the annual AP Exam Reading. Whatever you do, be creative and have fun at the end of the year!

# Sample Handout: Typical Format for Writing a Lab Report

This example includes directions for students in italics.

**Science Department**
**Laboratory Report**

Name:

Class:

Teacher:

Experiment #:

Date of Experiment:

Due Date of Lab Report:

**Title**

*The effect of the IV (independent variable) on the DV (dependent variable).*

**Abstract**

*Provide a concise summary of the experiment.*

**Purpose**

*Give a rational explanation as to why you are conducting this experiment.*

**Background Research and Bibliography**

*Provide a summary of the information you have found that relates to the type of lab you are conducting and cite the source(s).*

**Materials Used**

*Provide a concise list of the materials that are required to perform the experiment (e.g., chemicals, type of plant seed, etc.).*

**Equipment Used**

*Provide a concise list of any specific equipment that is needed to carry out the experiment (e.g., pH meter, dissolved oxygen meter, etc.).*

**Procedure**

*Give a detailed, step-by-step description of how this experiment is conducted. Remember—another scientist should be able to use your method to perform your lab exactly, so do not leave anything out!*

**Data Collected**

(A) Data Table

*Produce a labeled table of your results, including units of measurement.*

**Data Analysis**

(B) Calculations

*Show any calculations you used in interpreting the results.*

(C) Graphs

*Provide any labeled, suitably scaled graphs to help interpret the data you collected.*

(D) Summary of Data Trends

*Give a brief explanation of the observable trends or links in the results (e.g., how did the IV affect the DV?).*

**Error Analysis**

*Explain how errors could have occurred during the experiment and what steps were taken to minimize their effect. Provide a statistical analysis of the accuracy of your data.*

**Conclusion**

*Give a full explanation of the outcome of your experiment, noting if the purpose was fulfilled using this procedure. Was your hypothesis validated by the collected data? Why or why not? Explain concisely what you achieved by performing this experiment.*

**Suggestions for Further Investigation**

*Now that you have conducted the lab, reflect on what you or another scientist could do for a follow-up set of experiments that would take the investigation to the next level.*

**Experimental Design Diagram**

**Title:** *The effect of the IV on the DV.*

**Hypothesis:** *Relate what you think will occur to the DV as you change the level of IV (e.g., If the IV does this, then the DV will do this. Your educated guess as to the outcome of the experiment).*

| **Independent Variable:** *Name the variable that you purposefully change during the experiment; include units. Indicate the levels of IV in the columns below.* | | | | |
|---|---|---|---|---|
| | | | | |
| **Repeated Trials:** *How many data sets were collected; how many times was the experiment done?* | | | | |
| **Control:** *Note the experimental group used for comparison purposes.* | | | | |

**Dependent Variable:** *Name the variable that responds to changes in the IV; include units.*

**Constants:** *List everything that was kept the same in the experiment. Remember—only the level of IV should change.*

# The AP Environmental Science Exam

The AP Environmental Science Exam is administered annually in May. It provides teachers with a culminating focus for the environmental science course they teach and enables students from all over the United States and abroad to measure and compare their knowledge and understanding of environmental science in an objective assessment. Each exam is based on the topic outline that is published in the *Course Description for AP Environmental Science,* the most current version of which can be found on AP Central, and each exam goes through at least a two-year developmental stage that is overseen by ETS on behalf of the College Board.

The Chief Reader and ETS content experts work closely with the AP Environmental Science Development Committee, which meets twice a year to review and approve suitable exam questions. This group also reviews the AP Environmental Science course description periodically and makes changes to ensure that the curriculum is in line with any advances in the field of study. The AP Environmental Science Development Committee is made up of three experienced high school AP teachers and three college professors with experience in teaching introductory-level environmental science courses. Committee members are appointed by the College Board on a rotating basis. They come from different geographic regions of the United States and from both private and public educational institutions.

## Format and Administration

The AP Environmental Science Exam is three hours long and consists of two 90-minute sections. The first section is composed of 100 multiple-choice questions and counts for 60 percent of a student's final score on the exam; the second is a free-response section composed of four questions and counts for the remaining 40 percent of the final score. **The use of calculators is not allowed on either section of the exam.**

The multiple-choice section is designed to test the breadth of students' knowledge and understanding of fundamental environmental science concepts and facts. The number of multiple-choice questions taken from each topic area is closely aligned with the percentages given in the course description for that topic area. The free-response section requires students to answer questions in greater depth and to display their ability to organize, reason, and analyze material from a number of sources into a coherent answer. Questions in this section are made up of:

- one data-set question, which may include the analysis and interpretation of graphical or tabular data;
- one document-based question (DBQ), which may include material from real-life documents like newspaper articles; and

- two synthesis and evaluation questions, which may draw upon any concept in environmental science for an in-depth analysis.

The multiple-choice section is scored on the basis of the number of questions answered correctly, minus one-quarter of those questions answered incorrectly. If a student can eliminate one or two of the answer choices, it may be of benefit to make a guess from the remaining options.

Each free-response question is equally weighted. It should be noted that in the free-response section opinions are not awarded points; **points are only awarded for arguments that are supported by scientific facts and principles.** Although each question is scored on a scale of 0 to 10 points, the sum of the potential points for a question may add up to more than 10 points. In order to receive the maximum score of 10 points for a free-response question, students must address and answer each part of the question (for example, a, b, c, *and* d). Many students may find the AP Exam to be more difficult than the tests they have encountered in the classroom. They should be reassured to know that the mean score on the AP Exam is designed to be about 50 percent.

In May, after schools return the AP exam materials to ETS, the multiple-choice answer sheets are scored electronically. The free-response section is scored by experienced AP Environmental Science teachers and college professors at the annual AP Reading in early June. AP Grade Reports are sent to students and schools in mid-July.

## Encouraging Students to Take the AP Exam

If the AP course has closely followed the course guidelines, there is no reason why a well-prepared student should not earn a grade of 3 or higher on the AP Exam. Of course, motivation plays a role in how well an individual student will perform. Some schools require each student who is enrolled in an AP course to take the AP Exam. This may not be a motivating factor, particularly for seniors who have already been accepted by their college of choice. Other schools rely on their teachers to encourage students to participate in the AP Exam. Some schools pay the cost of the exam for their students, while others require the students (parents) to pay the cost themselves. Whatever a teacher can do to allay the costs for students and encourage as many as possible to take the AP Exam is advantageous.

One of the major benefits of taking the AP Exam is that a well-qualified student may be able to obtain credit for an equivalent college course. More than 90 percent of the colleges and universities in the United States, as well as colleges and universities in 21 other countries, have an AP policy granting incoming students credit, placement, or both on the basis of their AP Exam grades. Many of these institutions grant

up to a full year of college credit (sophomore standing) to students who earn a sufficient number of qualifying AP grades. In such cases, the financial outlay to take the AP Exam is more than made up for in the savings on tuition and books, and it may enable a student to be placed in an advanced or accelerated college-level environmental science course. In recent studies by ETS it is apparent that even if a student does not do well enough to attain college credit for taking the AP Exam, those who have taken AP courses in high school perform at higher average academic levels in college than students who have not previously been exposed to the rigors of an AP course.[1]

Each teacher will have to determine which strategy to use to successfully encourage students to take the AP Exam. There are a number of resources that offer assistance to financially disadvantaged students to help defray the costs involved in taking the AP Exam. Possible options that teachers can help their students pursue include: the department of education within their state; scholarships through the school and local organizations; and financial assistance for eligible candidates from the College Board, arranged through the school's AP Coordinator.

## Preparing Students to Take the AP Exam

One of the most enjoyable features of teaching the AP Environmental Science course is that there is no right or wrong way to teach it. As you will see in the sample syllabi in this teacher's guide, teachers use a variety of different methods and curriculum strategies in their approaches to the subject matter. As long as the syllabus a teacher develops includes the topics that are outlined in the course description, any student should be able to approach the AP Exam in May with confidence. I personally do not feel that I am "teaching to the test," and in my mind, having the AP Exam available for my students to take after they have completed my AP Environmental Science course is an added bonus.

In order to alleviate any anxiety students may feel toward the AP Exam, I ensure that the tests I give throughout the year follow the same format they will see on the AP Exam, namely a multiple-choice section and a free-response section. A word of warning: when using a test bank that accompanies a textbook to prepare multiple-choice questions for end-of-chapter evaluations, choose questions that have a suitable level of critical thinking associated with them. Multiple-choice questions that are too simplistic or have answers like "all of the above" or "none of the above" do not meet the same level of analytical deduction that students will experience on the actual AP Exam.

[1] Rick Morgan and Behroz Maneckshana, AP Students in College: An Investigation of Their Course-Taking Patterns and College Majors (Princeton, NJ: Educational Testing Service, 2000).

I use the previously released 1998 AP Environmental Science Exam as a practice test and as a resource for multiple-choice and free-response questions. I also use examples of the free-response questions from the course description and from other old AP Exams when preparing suitable tests for my class. They are also an excellent resource for review questions. Ordering information for released exams can be found in Chapter VIII, "AP Publications and Resources."

## Sample Handout: Tips for Students Taking the AP Exam

Aside from covering the content material as fully as possible and providing several productive review sessions, giving tests in the style of the AP Exam is the best way to prepare students for the exam in May. In addition, I give my students the following handout and go over it with them to help them get ready for the exam. I include it here because my students have told me that going over the handout before the exam was very beneficial for them. They knew what to expect and felt the exam did not seem as daunting as it might have been without this preparation. It helps to remove some of their anxiety. Maybe the accompanying student handout will be useful for your students as well.

**Tips for Students Taking the AP Environmental Science Exam**

**NOTE: You *may not* use a calculator on any part of the exam.**

**The Multiple-Choice Section**

The first 90-minute section of the AP Environmental Science Exam consists of 100 multiple-choice questions that represent 60 percent of your final grade. The number of questions on each topic corresponds approximately to the percentages given in the course outline.

- *Read the entire question.* Read each answer selection (a, b, c, d, and/or e) carefully before choosing your response! You may be able to eliminate several of the answer selections right away. Do not just read (a) and (b) and chose (b) as the correct answer (even if you know it is) without going on and reading (c), (d), and (e).
- Again, read each question carefully! Some students find that underlining key words in the question and answers as they read them helps them to focus. The multiple-choice questions are designed to make you *think critically.*

- Many students wonder whether or not to guess on questions about which they are not certain. In the multiple-choice section, 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 totally sure of the correct answer but have some knowledge of the question, you may be able to eliminate some of the less likely answers. If you can narrow it down to a choice between *two* or *three* possibilities, then I suggest you make an educated guess. Your chances of getting the right answer are improved, and it may be to your advantage to answer such a question using this strategy of elimination. If you cannot narrow it down, then I suggest you do not answer the question and go on to the next.

- One way to approach the multiple-choice section is to go through the exam answering first only those questions you find the easiest. If you come across a question for which you do not have a clue as to the answer, mark that question with a minus sign "–" and move on to the next question. If you come across a question you think you can answer but it may take a little time, mark that question with a plus sign "+" and move on to the next question. After you have reached the end of the multiple-choice section and answered all of the questions you found easiest, go back and work on the "+" questions.

- Remember, you may only want to guess if you can eliminate two or three wrong answers for a question. If you have time after finishing all of the "+" questions, then go through the "–" questions. If you really have difficulty eliminating answers to a "–" question, then it is best not to guess; just leave the question unanswered. This is a fairly common approach to taking multiple-choice tests and you may already be used to this strategy from previous classes.

- Use a sharpened No. 2 pencil to fill in the bubble for your answer. Take a good supply of sharp No. 2 pencils with you! This will help to minimize the noise from sharpening one pencil over and over again and be less of a distraction to other students who are trying hard to concentrate. Give only *one* answer to each question. If you change an answer, be sure the previous mark is erased completely and the new answer fully fills the bubble.

- You may finish this section with time to spare. Do not be alarmed if you do. Do not be alarmed if you don't! But do spend any extra time you have checking over your answers, especially those of which you are unsure.

**The Free-Response Section**

The second 90-minute section of the AP Environmental Science Exam consists of four required free-response questions that represent 40 percent of the grade. One question is data-based and includes a data table or graph and is designed to measure your ability to manipulate and interpret data from various sources. One question is document-based and includes newspaper articles, product advertisements, or other real-life documents and is designed to measure your ability to apply knowledge of environmental science to contexts that are timely, relevant, and authentic. Two questions are synthesis and evaluation questions. These in-depth and often multi-part essays are designed to measure your ability to synthesize and evaluate ideas by using concepts from environmental science.

Points are awarded only for *arguments that are backed by scientific facts and principles.* Although the sum of the potential points available in separate parts of a question may total more than 10 points (say, 12, for example), the maximum score awarded for any question is 10 points. Parts of questions also have maximum part scores to ensure that all parts of the question have to be answered to earn a score of 10.

- Use a black or blue pen to answer the questions. If you make a mistake, simply cross it out and write in your correction. (Pencil should only be used as a second choice, and it has to be dark enough to read.) Do not use any funky colored ink because it may be hard to read! Remember to take the time to *write legibly.*
- Some students find it best to attempt the questions in order so as not to waste time, that is, to start with question number 1 and then go on to numbers 2, 3, and 4. Some students choose to attempt the questions in another sequence. For example, if number 3 is the one you think you know the most about and can do the best on, you may want to do that first and then go on to do, say, 4, 1, and 2. Whatever sequence you choose, make sure you decide quickly! Read each question carefully. You have only 22.5 minutes to answer each one. The time will go by very fast!
- Write the number and letter that correspond to each question and question part: 1 (a), 1 (b), 1 (c), 1 (d). Try to answer all parts of each question.
- If you come to a part you cannot answer at that time, write the number and letter that correspond to that part and leave a space in the answer booklet before going on to the next part of the question. This way you can always go back to answer it later if you are able. You may be able to score points on each question even if you answer only parts of it.
- If you do not know the answer to a question or part of a question, just do the best you can to answer. This is not the time or place to write a poem or an essay on your life story just to make sure everyone taking the exam sees you working profusely and thinks you are producing a wonderful answer!

- Do not restate the question as the beginning of your answer. It takes up time and will not get you any points. Likewise, do not bother to say what an important question it is. Just answer it.
- Do not answer in outline form or use only one or two words as your answer. The reader can only score what you write, so answer the questions using *sentences* when asked to describe, discuss, or explain a particular point.
- *Write legibly.* Take time to do this. Making your answer easier to read will make it easier for the people who score the question to see where they can give you points.
- Stick to the point. Do not attempt to show your knowledge about the effect of increased atmospheric carbon dioxide levels if the question relates to the carrying capacity of ecosystems. You will not get any points for irrelevant information.
- For data-based questions, *show all of your work* in the correct place in the *pink* answer booklet. If you simply write a correct answer to a calculation-based question without showing how you arrived at the answer, you may get no points for that correct answer! Conversely, if you set up your calculation correctly and make a simple arithmetic error, you may earn partial credit. Also, putting your work in the green booklet and then neglecting to transfer it to the *pink* booklet will not get you any points either! Only the *pink* booklets are sent to ETS to be scored; the green booklets are collected and given to your teacher several days later.
- When answering any calculation-based question, include *units* in *each part* of your answer.
- If the question asks you to discuss short-term and long-term effects or environmental versus economic costs, then make sure that you differentiate between the two parameters.
- If you use a picture or a drawing to explain your answer, then make sure that you back it up with writing in order to explain it fully, and do not forget to include labels!
- Remember that you can score points even if you answer only one or two parts of the question. So if you do not know the answer to parts (b) and (d), but you do know the answer to parts (a) and (c), then write your answers to parts (a) and (c).
- Do not think that the more you write the more points you will get! More often than not, a brief, concise answer may score the most points. So be brief enough to provide a good answer that is concise and to the point! If you wish to elaborate on a particular point in order to substantiate and display a greater depth of knowledge on a particular question, only do so if it has direct relevance to the question and enhances your answer. In other words, do not waffle on and on!

- If the question asks for two examples, then give two, not three or four. Only the first two you give will be counted for scoring anyway. So, if you give four examples and the first two are wrong and the next two are correct, you will not get any points because only the first two you describe will count when the exam is scored.
- If a question asks you to identify and describe three labeled parts of a diagram, then identify and describe only three. Again, only the first three answers you give will be counted toward your score, so do not waste time showing the people who score the exams your knowledge of all six or seven!
- At the end of the exam make sure you have followed the instructions with regard to completing the identification information, supplying your AP number, and indicating your preference for the use of your exam, as an example or sample answer, by the College Board.

You have worked hard this year and covered many environmental science topics. Do not expect to remember everything we have discussed or every little fact and detail. A good night's sleep is in order before the exam so you will feel alert and refreshed when you take it. We have covered a vast amount of material and have done so in such a way that gives you the potential of earning a grade of 5 on the exam. If you have put in some quality reviewing time over the last few weeks, then there is no reason for you not to do well. So strive for a five! It's up to you! Good luck and best wishes for the future.

# Introduction

Experienced and well-respected teachers from a wide variety of geographic locations throughout the United States have contributed the eight syllabi in this chapter. These individuals bring a vast background of knowledge about the AP Environmental Science course and all of them have been involved in the scoring of the AP Environmental Science Exam. Several have also been involved as members of the AP Environmental Science Development Committee. It is hoped that bringing together people with such backgrounds to contribute to this teacher's guide has resulted in a publication that is useful not only to teachers who are new to the AP Environmental Science course but also to the many veteran teachers in the AP Environmental Science community.

Five of the syllabi are from AP teachers who work in public or private high schools, and three are from instructors of introductory environmental science courses taught at the college level. Included in each syllabus is a:

- Personal philosophy that briefly describes each teacher's rationale, motivation, and personal goals in teaching the AP Environmental Science course or its college-level equivalent.
- School profile that provides information about the institution where each contributor teaches.
- Class profile that identifies any course prerequisites.
- Course overview that gives a concise description of each course.
- Course planner that gives a full breakdown of the sequencing and a week-by-week time line of the course and notes the primary textbook that is used.
- Specific teaching strategies that are used by each teacher.
- Explanation of how a lab component is incorporated into the course, with different lab exercises highlighted.
- Explanation of how students are evaluated.
- List of other resources the teachers use in their course.
- Description of successful student activities the teachers use.

Each syllabus is unique and reflects its author's personal solutions to managing the exciting and creative challenge of teaching today's students what they need to know in order to become tomorrow's stewards of the environment. These syllabi demonstrate that the AP Environmental Science course is versatile enough to be taught successfully, particularly in regard to lab activities, in many different locations around the country, and they show how a variety of teaching strategies can be used to deliver the core material.

## Personal Philosophy

***Nita Ganguly***

*Oak Ridge High School*

*Oak Ridge, Tennessee*

Recent scientific and technological developments have resulted in complex social issues that must be intelligently addressed. Such developments include nuclear power, genetic engineering, global warming, ozone depletion, and alternative energy, to name a few. Evaluation of the benefits and risks inherent in these developments requires a knowledge and understanding of science and its methods.

My goal for AP Environmental Science is to make sure my students master the scientific techniques and methodologies that will enable them to become independent learners, capable of gathering and evaluating information and making rational and informed judgments that they will be able to communicate to others. This will enable them to be successful not only in college, but it will also allow them to function effectively as responsible citizens in a society that is increasingly shaped by science and technology.

## School Profile

**School Location and Environment:** Oak Ridge High School is located in the city of Oak Ridge, Tennessee, about 25 miles from Knoxville, which houses the main campus of the University of Tennessee. There are also two community colleges, Roane State and Pellissippi State, within 15 miles of the school. We have lab access and faculty involvement with all three campuses. The school's location allows us to take field trips and do labs in the Smoky Mountains (50 miles away), the University of Tennessee Arboretum, and the marina in Oak Ridge.

In addition, the Oak Ridge National Lab, which is down the street, is very involved with the school system, in part because the children of its scientists and engineers attend the schools in this system. This has helped immensely with the AP Environmental Science course because we can have speakers come to our classes a couple of times every semester. AP Environmental Science students are involved in organizations that deal with environmental issues involving the community. They also participate in a Greenway project in the city.

The average SAT® and ACT™ scores are above the national average. At the time this teacher's guide was published, Oak Ridge High School had 13 National Merit Finalists and 22 Commended Scholars. There is another tier at the school that has a number of tutorial programs and specialized classes with 10 to 12 students, which allows students with special abilities to be successful at their level.

**Grades:** 9–12.

**Type:** Public high school.

**Total Enrollment:** Approximately 1,500 students.

**Ethnic Diversity:** African Americans compose 10.8 percent of the student population; Asian Americans 2.5 percent; Hispanics 1.6 percent; Native Americans 0.06 percent; and Native Hawaiians 0.06 percent.

**College Record:** Sixty percent of graduating seniors go on to attend four-year colleges; 20 percent go on to two-year colleges.

## Overview of AP Environmental Science

**AP Program**
Oak Ridge High School has been involved with the AP Program since 1958. Currently, we offer the following AP courses:

- Studio Art
- English
- Languages: French, German, Spanish
- Math: Calculus AB, Calculus BC, Computer Science, Statistics
- Science: Biology, Chemistry, Environmental Science, Physics B, Physics C
- Social Studies: European History, Macroeconomics, Microeconomics, Psychology, U.S. History

AP course enrollment at the time this teacher's guide was published was about 30 percent of the student population. Most are eleventh and twelfth graders, but there are some tenth graders as well. Because the school system does not pay for AP Exams, students enrolled in AP courses are not required to take the exam. They are, however, strongly encouraged to do so, and a majority of the students do take the exam.

**Class Profile**

There are usually three AP Environmental Science classes per year, with an average enrollment of approximately 24 students. The class is scheduled for a 53-minute period on Monday and Friday; Wednesday is an abbreviated schedule with a 38-minute period. On Tuesday and Thursday there is a double period for labs. Labs may be (a) cookbook, (b) open-ended, inquiry based, (c) long-term, running for 8 to 10 weeks, or (d) field studies. The AP review sessions run for an hour before school on Tuesdays and Thursdays for six weeks prior to the AP Exam.

**Course Prerequisites**

All students who register for AP Environmental Science must have completed a year of biology and a year of chemistry. They may be taking AP Physics, AP Biology, or AP Chemistry concurrently. They must have also completed or be enrolled in geometry. Consequently, all enrolled students are either juniors or seniors. In addition, to enroll in an AP science course students need the recommendation of their present science teacher.

## Course Overview

This course "is designed to be the equivalent of a one-semester, introductory college course in environmental science." Its goal is the same as that described in the *Course Description for AP Environmental Science:* "to provide students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them."

**Primary Text**

The text for the course is the twelfth edition of *Living in the Environment: Principles, Connections, and Solutions,* by G. Tyler Miller.

# Syllabus 1

**Course Planner**

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| **I.** | **Interdependence of Earth's Systems: Fundamental Principles and Concepts** | | |
| | Environmental Issues, Their Causes and Sustainability | 1 | |
| | Environmental History: An Overview | 2 | 6 days |
| | **Activity:** *The Lorax* (video)<br>Students observe the commonality of environmental problems across the world. | | |
| | **Lab:** Something Fishy<br>Using goldfish crackers and pretzels, students simulate the method of "tagging," a way of determining the population of a particular area. | | |
| | **Lab:** Footprint Activity<br>Using a footprint calculator on the Internet (www.esb.utexas.edu/drnrm/EcoFtPrnt/Calculate.htm), students calculate their ecological footprint and relate it to their lifestyle. | | |
| | **TEST # 1:** Chapters 1 and 2 | | |
| | Scientific Principles and Concepts: Critical Thinking and Scientific Analysis | 3 | 6 days |
| | **Lab:** Scientific Method Lab<br>Using various characteristics of the human body (height, weight, arm length, temperature of the hand), students propose hypotheses and design experiments to prove or disprove their hypotheses. | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | **Lab:** Design an Experiment<br>See "Student Activity 2" on page 54. | | |
| | Matter and Flow of Energy | 4 | 3 days |
| | **Lab:** A Vital Commodity<br>Using beans, students simulate the transfer of "a vital commodity—energy" as it moves through a food web. | | |
| | **TEST # 2:** Chapters 3 and 4 | | |
| | Ecosystems and How They Work | 8 | 15 days |
| | **Lab:** Owl Pellets<br>Students assemble a skeleton from the bones found in the pellets and calculate the biomass required to support the predator. | | |
| | **Lab:** Diagram a Food Web<br>Using about 30 organisms found in the Smoky Mountains, students diagram a food web and look at the intricate interactions of the different food chains. | | |
| | **Lab:** Environmental Legislation<br>See "Student Activity 1" on page 53. | | |
| | Climate, Weather, Biomes | 6, 7 | 9 days |
| | **Project:** Biomes<br>In groups of two, students do a PowerPoint presentation on the physical characteristics, flora, fauna, and environmental impacts on different biomes. | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | **Project:** Climatograms<br>Students design climatograms of assigned biomes, using data they have researched on the Internet (precipitation and temperature). | | |
| | **TEST #3:** Chapters 6, 7, and 8 | | |
| | Geology: The Dynamic Earth | 10 | 8 days |
| | **Lab:** Plate Tectonics<br>Using the *Theory of Plate Tectonics* CD-ROM, students observe and analyze the movement of tectonic plates. | | |
| | **Lab:** Chemical Weathering<br>Students recreate the effects of chemical weathering on rocks of different compositions. | | |
| | **Lab:** Micrometeorology<br>Students study the effects of weather in a locality. Parameters used: (a) ambient air temperature, (b) soil temperature, (c) humidity, and (d) plants. | | |
| | Nonrenewable Minerals and Soil | 14 | 10 days |
| | **Lab:** Soil<br>Students collect soil from different sites and do physical and chemical measurements on the samples. | | |
| | **TEST # 4:** Chapters 10 and 14 | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| **II.** | **Population Dynamics** | | |
| | Population Dynamics | 9 | 9 days |
| | **Lab:** Population Study—Seeds<br>Population Study—*Daphnia*<br>Using both seeds and *Daphnia,* students analyze population issues: (a) carrying capacity and (b) population dieback. | | |
| | **Lab:** Natural Selection<br>Students conduct a simulation of adaptation of organisms to different habitats and use simple statistical tools to analyze their data. | | |
| | **Project:** APES in the News<br>Students collect, make a journal, and analyze newspaper articles over a nine-week period. | | |
| | Human Population: Growth, Demography | 11 | 8 days |
| | **Lab:** The Power of the Pyramids<br>Using demographic data from different countries (from the Internet), students make age structure pyramids and analyze them using social and economic parameters. | | |
| | **TEST # 5:** Chapters 9 and 11 | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| **III.** | **Renewable and Nonrenewable Resources: Distribution, Ownership, Use, Degradation** | | |
| | Water | 13 | 9 days |
| | **Lab:** Personal Water Usage<br>Students keep a record of their water usage for a week, calculate their total water usage, and analyze their impact on the environment. | | |
| | **Lab:** Salinization Lab<br>Students observe the effect of salinity on mustard seeds. | | |
| | Biological—Forest, Rangelands | 23 | 8 days |
| | **Game:** Go for the Green<br>Students play a board game that shows the difficulty of maintaining an ecological and economic balance when the rain forest is involved. The game comes from the book *Earth Matters.* | | |
| | **TEST # 6:** Chapters 13 and 23 | | |
| | Land—Food Resources | 12 | 5 days |
| | **Lab:** Effect of Radiation<br>Students observe the effect of radiation on mustard seeds. | | |
| | Land—Pesticides and Pest Control | 20 | 6 days |
| | **Lab:** Toxicity Studies<br>Students check the effect of common household chemicals on brine shrimp and also calculate the LD-50 levels. | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | Land—Urban Land Use | 25 | 8 days |
| | **Lab:** Land Use Activity<br>Given certain parameters, students design an environmentally friendly township and present it to the class. | | |
| | **TEST # 7:** Chapters 12, 20, and 25 | | |
| | Energy—Nonrenewable | 14 | 5 days |
| | **Lab:** Cookie Mining<br>Using a chocolate chip cookie and toothpicks as tools, students do a mining simulation activity. | | |
| | **Lab:** Fossil Fuels<br>Students keep a weekly record of their driving habits and calculate how much carbon dioxide is emitted as a result. | | |
| | Energy—Renewable | 15 | 8 days |
| | **Project:** Alternative Energy Sources<br>In groups of two, students do a PowerPoint presentation on alternative sources of energy—sources, economics, advantages, and disadvantages. | | |
| | **Field Trip:** Power Plants | | |
| | **TEST # 8:** Chapters 14 and 15 | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| **IV.** | **Environmental Quality** | | |
| | Air Pollution | 17 | 7 days |
| | **Lab:** Airborne Particulates<br>Using test strips from Carolina Biological, students monitor and calculate the number and size of particulates in their bedrooms. | | |
| | **Lab:** Exhausting Problems<br>Students calculate the amount of carbon dioxide emissions that result from their driving habits. They measure the levels of carbon dioxide, carbon monoxide, and sulfur dioxide emissions from their cars using a Gastek instrument from Carolina Biological. | | |
| | **Lab:** Cars—Internet Lab<br>Students compare various models of cars and rate their pollution levels using the Tailpipe Tally Web site, www.environmentaldefense.org/tailpipetally. | | |
| | Water Pollution | 19 | 8 days |
| | **Lab:** Ecocolumn/Water Quality Lab<br>Using test kits, students measure chemical and physical parameters in an ecocolumn they have built. The measurements are done for eight weeks. Students write a lab report. | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | **Lab:** No Water Off a Duck's Back<br>Students simulate the damage done to birds as the result of an oil spill. Hard-boiled eggs are immersed in oil over a timed period and peeled to see the effects. Feathers are immersed in oil and washed with either water or detergent to see the effect on the morphology. | | |
| | **TEST # 9:** Chapters 17 and 19 | | |
| | Solid and Hazardous Waste | 21 | 6 days |
| | **Lab:** Grass Decomposition<br>Students look at a pattern of decomposition of grass over an eight-week period. | | |
| | **Lab:** A Lab of Rot<br>Students compare the decomposition rates of banana peels and newspaper under varying conditions. | | |
| | **Lab:** Recycling—Internet Lab<br>Students go to the EPA's Web site Recycle City at www.epa.gov/recyclecity/mainmap.htm to observe various recycling issues. | | |
| | **Field Trip:** Waste Water Treatment Plant | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | Toxicology and Human Health | 16 | 5 days |
| | **Lab:** LD-50 Using *Daphnia*<br>Using *Daphnia,* students check the LD-50 of different household chemicals. | | |
| | **TEST # 10:** Chapters 16 and 21 | | |
| **V.** | **Global Changes and Their Consequences** | | |
| | Deforestation and Loss of Biodiversity | 23 | 9 days |
| | **Lab:** Diversity Study<br>Students measure the diversity of trees in a forest setting. | | |
| | Sustaining Wild Species | 22 | 7 days |
| | **Project:** Endangered Species<br>In groups of two, students do a PowerPoint presentation on an endangered species of their choice—characteristics, reason for endangerment, and solutions to the problem. | | |
| | **TEST # 11:** Chapters 22 and 23 | | |
| | Climate Change and Ozone Loss | 18 | 10 days |
| | **Lab:** Greenhouse Effect<br>Students investigate the processes that might occur in global warming and compare them to those that take place in the Earth's atmosphere. | | |

| UNIT | TOPIC | CHAPTER | DAYS |
|---|---|---|---|
| | **Lab:** Measuring Ozone Levels<br>Students make ozone test strips and check ozone levels in the surrounding areas. | | |
| | **Lab:** What Can You Do to Stop Global Warming?<br>Students address this problem using teacher-generated scenarios that apply to their daily lives. | | |
| | **TEST # 12:** Chapter 18 | | |
| **VI.** | **Environment and Society** | 26, 27, 28 | 4 days |
| | **Project:** Environmental Issues in Your Environment<br>Students research, write a paper, and do a PowerPoint presentation of an environmental issue in their state. | | |
| | **Project:** Environmental Hot Spots<br>Using the Scorecard Web site at www.scorecard.org, studentswrite a major paper on one of the following pollutants in Tennessee: criteria pollutants, carbon monoxide, lead, nitrogen oxides, particulates, sulfur dioxides, land contamination, toxic release, water, hazardous air pollutants. | | |
| | **TEST # 13**: Chapters 26, 27, and 28 | | |

## Teaching Strategies

Because students enrolled in this course are taking a number of AP courses at the same time, I try to give them as much information as I can up front, especially the due dates of assignments. This helps them in their time management. On the first day of school, I give my students the following:

- **A complete course syllabus for the entire school year.** This details the topics to be covered in class, laboratory experiments to be performed, and daily reading assignments to be completed. It also includes the test dates.
- **A set of handouts** that have hints for writing essays and lab reports, basic laboratory directions, and safety procedures.

In addition to the lecture component, which is always on PowerPoint, and the laboratory component, I have some additional requirements for the course.

- **A summer reading assignment.** I give students a list of about five books from which they can choose. In the past, these have included *Ishmael* by Daniel Quinn, *Desert Solitaire* by Edward Abbey, *Tales of a Shaman's Apprentice* by Mark Plotkin, *Small Is Beautiful* by E. F. Schumaker, and *The Solace of Open Spaces* by Gretel Ehrlich.
- **One major PowerPoint presentation** every nine weeks on an assigned topic (e.g., biomes, endangered animals, non-native species, and so on).
- **One major lab write-up** of six to ten pages (with figures, charts, graphs, and statistics) every nine weeks.
- **A review of current newspaper articles.** I often use the Tuesday edition of the *New York Times.*
- **Attendance at special seminars** on a variety of environmental topics after school.
- **Review sessions** an hour before school on Tuesdays and Thursdays starting about six weeks before the AP Exam in May.

## Lab Component

The lab component can be broken down into several sections.

- **Indoor Labs.** Tuesdays and Thursdays are a double period for labs. This time is used for setting up labs and observations of classroom-centered labs. For long-term labs, routine measurements sometimes have to be taken in the morning before school so that they do not cut into class time.
- **Outdoor Labs.** The Tuesday and Thursday lab time is also needed to do labs where the outdoors is used as a classroom, such as soil collection and measurements, water quality assays, and biodiversity studies using transects.
- **Field Trips.** It is not possible for us to take many field trips because most of the students are taking multiple AP courses, but we take at least two field trips every semester. During the fall semester, we spend a day at a wastewater treatment plant and a recycling facility, both about 15 miles away from the school. During the spring semester we spend a day at a wind-powered electrical generator about 25 miles away from the school and a coal-fired power plant about 10 miles away. The major field trip we take is to the Smoky Mountains at the end of the year. We bring soil testing kits, water quality testing kits, and ozone testing kits. It takes a day to complete these measurements.

## Student Activities

**ACTIVITY 1: ENVIRONMENTAL LEGISLATION PROJECT**

In an effort to make sense of the many laws that are associated with environmental issues, we are going to do a project that will result in a summary of important legislation. You will work with your lab partner and be responsible for researching an assigned regulation or act, and you will discover the answers to the following questions. This is not designed to be a major research project, as most of the information will be found in your text or on the Internet (use www.epa.gov as a starting point).

**Questions to be answered:**

1. In what year was this law enacted?
2. What events or situations led to the enactment of this law?
3. What controversy, if any, is or was connected to this law?
4. What does the law do?
5. What impacts has this law had? In addition to discussing this from a broad sense, include at least one specific example.

**When you have found the answers to the questions above, please prepare the following:**

1. **Poster.** On a standard 22″ x 28″ posterboard (of any color) present the above information, as well as at least four pictures that provide a visual representation of some aspect of the law. These may be downloaded from the Internet, photocopied from an original source, or cut from a magazine. You must include a bibliography on the front of the poster. Your poster will be graded with respect to accuracy, completeness, clarity, analysis, organization, creativity, and readability. It will be worth 25 points.
2. **Handout.** Prepare a handout that provides the information above on one side of a standard sheet of paper. You may use single spacing but you must use a 10-point font. I will photocopy it and give each person a copy. Your handout will be graded with respect to accuracy, completeness, clarity, analysis, and organization. It will be worth 25 points.

You will be expected to know about environmental legislation on the next test.

## ACTIVITY 2: DESIGN YOUR OWN EXPERIMENT

### Background

Why do people fertilize plants? Does it really make a difference in the growth of the plant? Does it make flowers bloom more rapidly or vegetable plants grow larger and produce more vegetables? The answers to these questions are all within the realm of science because they are testable by controlled experiments, observations, and data gathering.

### Problem

Do seeds germinate faster if fertilizer is applied?
Do more seeds germinate when fertilizer is applied?
Do different strengths of fertilizer cause different rates of growth in plants?
Do stems, roots, or leaves grow faster or bigger if fertilizer has been applied to the plant?

**Hypothesis**
Make a group decision about which of these questions you will test, or make up a different question. Finally, form testable hypotheses about the questions.

**Plan the Experiment**
Use the AP Environmental Science Lab Report handout as a guide.

1. Write your experimental plan in the form of a numbered list. First, list the materials you will need and then give the details of your procedure.
2. Identify the conditions you will hold constant and name a single independent variable. The independent variable could be the amount of fertilizer or the strength of the fertilizer. Decide which dependent variable you will measure and how you will know if your data supports your hypothesis.

**Check the Plan**
Review the "Scientific Method" to make sure that you have included all the pertinent steps.

1. Does your plan test only one variable, such as the amount of fertilizer added?
2. Have you determined how many seeds or plants you will use in each group and which dependent variable you will measure? Also, have you decided how often you will take measurements?
3. Did you make a data table that compares the observations you made on the control and experimental groups? Did you include a graph of your data?

**Possible Materials**

| | | | |
|---|---|---|---|
| seeds | water | plastic trays | plant seedlings |
| sand | foam cups | fertilizer | potting soil |
| balance | ruler | graduated cylinder | |

**Carry Out the Experiment**

**Write a Formal Lab Report**
Use the guidelines in the AP Environmental Science Lab Report handout to do this.

**AP Environmental Science Lab Report Guidelines**

Lab reports must be typed, double-spaced, in 12-point font, and have a cover page.

1. **Title**
2. **Purpose:** *A simple statement of the purpose of the lab or activity.*
3. **Background:** *Use the introduction I have given you to get started.* ***Do not copy the information I have given you.*** *You should have a broad overview, so that someone who is unfamiliar with the subject matter will be able to understand what is going on.*
4. **Hypothesis:** *Make an "if . . . then" statement. What is the effect of the independent variable on the dependent variable?*
5. **Materials:** *This can be a list.*
6. **Procedure:** *This has to be in detail so that you know exactly the protocol that you are following.*
7. **Data:** *The best way to report this is a data table. Always use the proper units. You should also make sure that you are recording both qualitative as well as quantitative data. Try to use graphs and charts to explain your data. Any anomalies during the running of the experiment should also be recorded.*
8. **Analysis:** *This is the most important part of your lab. If there are questions on the lab, use them as guides for what to include in this section. Explain what the data means and the source of errors. If there are ways to improve the lab mention them here.*
9. **Conclusion:** *This section can be fairly short and can respond to the purpose of doing the lab.*
10. **What Did You Learn from the Experiment?:** *Write a short paragraph explaining what you learned from the experiment as it relates to AP Environmental Science.*

## Student Evaluation

Grades are determined every nine weeks by the total number of points earned from the following categories.

- **Review Questions.** These are given at the beginning of each chapter. Students are expected to hand in their answers on the day of the unit test.
- **Unit Tests.** Each test is composed of 45 to 60 multiple-choice questions (factual, conceptual, and lab-based) and one 20-minute essay. Tests are graded, returned the next day, and discussed. Misconceptions are corrected before moving on to the next unit. Both AP rubrics and AP-style rubrics are used, depending on the test being given.
- **Lab Reports.** Students write one formal report every nine weeks on experiments they have designed. These typed reports include an abstract, introduction, background, hypothesis, procedure, observations, data tables, graphic representation of data, analysis, and conclusions. Other minor lab write-ups allow students to make critical observations and sharpen their analytical skills.
- **Presentations.** Once every semester, students working in groups of two or three prepare and present a PowerPoint presentation on an assigned topic. Examples of student presentations include biomes, endangered animals, hazardous pollutants, alternative energy, and non-native species.
- **Journals.** Students keep these as a response to a particular question from each chapter. These responses may be a poem, skit, essay, drawing, or some other form. This individual form of expression allows students to display their creative side. The journals are graded once every nine weeks.
- **Midterm and Final Exam.** The midterm is given at the end of the first semester and is worth 100 points. There are 90 multiple-choice questions and one essay worth 10 points. The final exam, which is comprehensive, is given three days before the AP Exam. It is also worth 100 points, with 80 multiple-choice questions and two essays worth 10 points each. Both AP rubrics or AP-style rubrics, depending on the test being given, are used to grade all the essays.

The grading scale for all assignments is:

A = 90 – 100%
B = 80 – 89 %
C = 70 – 79 %
D = 60 – 69 %
F = below 60%

# Teacher Resources

**Text**

Miller, G. Tyler. *Living in the Environment: Principles, Connections, and Solutions.* 12th ed. Pacific Grove, CA: Brooks/Cole, 2002.

**Other Texts Used for Reference**

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet.* 3rd ed. New York: John Wiley, 2000.

Cunningham, William P., and Barbara Woodworth Saigo. *Environmental Science: A Global Concern.* 6th ed. Boston: McGraw-Hill, 2001.

*A Guide to the Global Environment.* Washington, DC: The World Resources Institute, 1994.

Mitchell, Mark K., and William B. Stapp. *Field Manual for Water Quality Monitoring.* 9th ed. Dexter, MI: Thomson-Shore Printers, 1995.

Roa, Michael L. *Environmental Science Activities Kit.* West Nyack, NY: The Center for Applied Research in Education, 1993.

Wasserman, Pamela, and Andrea Doyle. *Earth Matters: Studies for Our Global Future*. 2nd ed. Washington, DC: Zero Population Growth, 1991.

**Laboratory Manuals**

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities.* 7th ed. New York: McGraw-Hill, 1999. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

Harley, John P. Laboratory Manual. 3rd ed. Englewood Cliffs, NJ: Prentice Hall, 1990. Accompanies the textbook *Environmental Science: The Way the World Works,* by Bernard J. Nebel.

Rosenthal, Dorothy B. *Environmental Science Activities.* New York: John Wiley, 1995.

**Software**

Lopez, Gary. *Population Concepts.* Danbury, CT: EME, 1994. CD-ROM.
This can be ordered from EME Corporation at www.emescience.com or 800 848-2050.

Tarbuck, Edward J., and Frederick K. Lutgens. *The Theory of Plate Tectonics.* Version 2.0. Taos, NM: Tasa Graphic Arts, n.d. CD-ROM for Windows and Mac. This can be ordered from Tasa Graphic Arts, Inc. at www.tasagraphicarts.com or 800 293-2725, 505 758-553.

**Kits from Carolina Biological Supply Company**

Carolina™ Airborne Particulates Examination Kit

CHEMetrics water test kits for dissolved oxygen, phosphate, nitrate, and hardness

Estimating Population Size of *Daphnia pulex* Kit

Irradiated radish seeds set

LaMotte water test kits

Oil Spill Bioremediation Lab Investigation

Owl pellets

Precision Gas Analysis Apparatus TR-65-3072, with gas detector tubes for oxygen, carbon monoxide, carbon dioxide, and ozone

Soil test kits

**Kits from Ward's Scientific**

Ward's Exploring Chemical Weathering Lab Activity

Ward's Exploring Mechanical Weathering Lab Activity

Ward's Exploring Porosity and Permeability Lab Activity

**Videos**

*Alaska: Outrage at Valdez.* Produced by Jean-Michel Cousteau. Turner Home Entertainment, 1990. 57 minutes.

*Cane Toads: An Unnatural History.* Written and directed by Mark Lewis. New York: First Run Features, 1987. 48 minutes.

The Earth at Risk Environmental Video series. Presented by Kevin Seal. 10 videos. Schlessinger, 1993. 30 minutes each.

*Ebola: The Plague Fighters.* NOVA, 1996. 60 minutes.

*The Search for Clean Air.* N.p., n.d.

*The Lorax.* Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. This is currently out of print, but some libraries may have a copy.

*Modern Marvels: Garbage.* A & E Home Video, 1996. 50 minutes.

*The People Bomb.* CNN Collection series. Turner Home Entertainment, 1992. 105 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343-4727.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

*Understanding Oceans.* Narrated by Jane Curtin. Discovery Home Video, 1997. 50 minutes.

*What's Up with the Weather?* Produced by Frontline and NOVA. Boston: WGBH Boston Video, 2000. 120 minutes.

*World Population.* Washington, DC: Population Connection, 2000. 7 minutes.This can be ordered from Population Connection (formerly Zero Population Growth) at www.populationconnection.org or 800 POP-1956.

## Personal Philosophy

***Dean Goodwin***

*Kimball Union Academy*

*Meriden, New Hampshire*

I am passionate about environmental education and have been involved in a number of initiatives ranging from developing summer enrichment programs for middle school students and facilitating a week-long teacher institute on problem-based environmental curriculum design, to establishing yearlong environmental science courses at the high school level. I first designed and began teaching a college-level environmental science course as a high school elective in 1989 and feel fortunate to have been involved in the AP Environmental Science program since its inception. As Director of Environmental Education at Kimball Union Academy since 1995, I have assisted several departments in the school in integrating environmental themes into their curricula.

Environmental education should be more than just an alternative science course; it must be seen as a basic discipline that is essential for everyone to understand in order to meet the challenges of the future successfully. The interdisciplinary opportunities that environmental science courses provide are numerous. I enjoy using many aspects of biology, chemistry, and physics and applying them to real-world situations on a regular basis in my AP Environmental Science course. It is the most fun I have had as a teacher! Seldom does a day go by without some interesting environmental topic being reported on in the media. This helps me underscore for my students the importance of the AP Environmental Science course they are taking, showing them that it applies to everyone's daily lives, no matter where you live.

The AP Environmental Science course is deeply rooted in scientific analysis of the environment. Students' critical thinking and problem-solving skills are sharpened as they unravel the complexities of the natural world. The course helps me prepare them to face the challenges that lie ahead for this generation. Increasing scientific and environmental literacy is the beginning step these students are taking. Probably at no other time in our history has it been so important to fully understand our relationship to the planet that is our home. I firmly believe that a course in environmental science should be mandatory in every school in the country. It is imperative to increase everyone's understanding of how human activities are affecting the balance of the natural systems that operate on this planet. Our future depends on ensuring that we maintain sustainable systems. We all need to be aware of our own ecological footprint and take steps to minimize it! The AP Environmental Science curriculum goes a long way toward helping me achieve my goals as an environmental educator.

# School Profile

**School Location and Environment:** Kimball Union Academy is located in the small community of Meriden, a rural New Hampshire setting. The 1,500-acre campus and the 750-acre Snow Mountain wilderness tract include a variety of different habitats and ecosystems that are used as sites for field study. Ponds with beaver lodges, streams abundant with aquatic life, meadows and woodland areas that provide homes for moose, deer, coyote, birds, and plant life provide an ideal setting for studying the environment. Located 13 miles south of Hanover, the site of the excellent resource of Dartmouth College, and some six miles from the Connecticut River and the Vermont border, Kimball Union Academy students have ample opportunity for many off-campus and outdoor activities. Approximately 200 students live on campus, and the male to female ratio is about 3 to 2.

**Grades:** 9–12.

**Type:** Private, coeducational, residential, independent high school.

**Total Enrollment:** Approximately 310 students.

**Ethnic Diversity:** Hispanics compose approximately 3 percent of the student population; Asian Americans 2 percent; African Americans 1 percent; and Native Americans 1 percent. Approximately 10 percent are international students.

**College Record:** Each year about 98 to 99 percent of the senior class goes directly to four-year college programs. A few students take a year off before embarking on a college career, while others return to their country of origin to attend college.

# Overview of AP Environmental Science

**AP Program**

Kimball Union Academy has had an AP program for 20 years. The school offers between 15 and 18 AP classes a year, and approximately 80 students participate in the program each year. Many students take two AP courses at a time. Those who wish to take more in any given year must get special permission. The most popular AP courses are environmental science, English language, and English literature. All students who take an AP course are required to take the AP Exam; the school does not pay the exam fee.

**Class Profile**

Two class sections of AP Environmental Science are offered, with a maximum of 14 students in each section; the total number of students who take the course is between 24 and 26 each year. Over a two-week rotation during the fall and spring terms, the class meets for seven 50-minute periods and one 85-minute period. In the winter term (mid-November until the beginning of March), the class periods are shortened to six 40-minute periods, one 50-minute period, and one 80-minute period. The laboratory component is normally undertaken during the long periods that occur every other week, with additional time allotted from the shorter class periods when necessary.

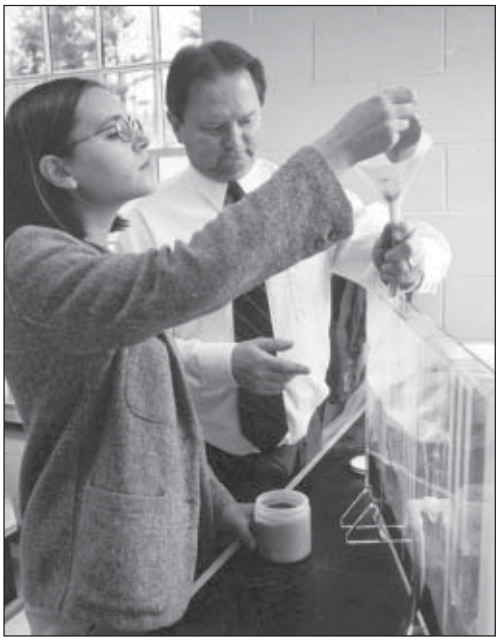
**Course Prerequisites**

The course is open to juniors and seniors, and each student ideally should have previously taken biology, chemistry, and algebra II. (On occasion a student may be co-enrolled in chemistry as a junior.) Students need the recommendation of their current science teacher and academic advisor as well as the permission of the department head to be registered in the course. Some of the prerequisite requirements may be waived depending on the needs of the individual student. This allows qualified sophomores to take the course, but the majority of the enrollment comes from the senior class. There is a summer reading requirement; each student prepares an essay to be submitted on the first day of class and takes a test on the material in the assigned book. In the past the assigned book has been Bill Bryson's *A Walk in the Woods.*

## Course Overview

The overall theme of the AP Environmental Science course curriculum can be seen as balance versus imbalance: a balanced system is sustainable and survives, while an imbalanced system collapses. Balance is the key to understanding and preserving the complex systems and cycles that make up planet Earth. The various environmental crises humans face are the result of ignoring and upsetting critical ecological balances. Likewise, the solutions lie in understanding and tailoring our endeavors in a way that will restore and sustain these balances.

The yearlong elective AP course details the environmental constraints that humankind confronts and describes the actions that may be taken to cope successfully with them. A deeper understanding of, and appreciation for, nature is developed through discussions on ecological principles, population, conservation, pollution, natural resources, and other issues. The laboratory section of the course is geared toward each student developing problem-solving skills and working as part of a research team. The class is complemented by local field trips and prepares students for college courses on a variety of environmental issues.



*Student Marien Levy helps Dr. Dean Goodwin in the environmental science laboratory at Kimball Union Academy set up a ground-water modeling system that can be used to demonstrate water flow in an aquifer.*

*Photograph courtesy of Dean Goodwin.*

**Course Objectives**

One basic goal is to show how everything in nature is interconnected and to provide this information in an accurate, unbiased, and interesting way. Environmental education at Kimball Union begins in our own back yard and endeavors to instill a sense of place in each student. Important teaching objectives also include:

- helping students discover that dealing with environmental issues is fun, interesting, and important to their lives;
- showing how environmental problems are interrelated and emphasizing that they must be responded to in an integrated way, locally, regionally, nationally, and globally;
- giving a realistic but hopeful view of what has been done and what remains to be done in sustaining the Earth for us and other species;
- helping students develop an appreciation for their environment and the Earth;
- challenging students to take actions in their own personal lives to sustain rather than degrade the environment; and
- presenting the scientific method with an emphasis on experimental design, research, and the collection and evaluation of information.

**Textbooks**

The textbook I have used most frequently in the course is *Environmental Science: Toward a Sustainable Future,* by Richard T. Wright and Bernard J. Nebel. The other main text is *Environment,* by Peter H. Raven and Linda R. Berg. Both are easy for high school students to read and contain many good photographs, diagrams, and ancillary teacher resource materials, some of which are Web based. I generally choose whichever one of these texts currently has the newest edition available.

# Course Planner

The following guide is based on my 30-week class schedule, divided over the course of two semesters. This breakdown can be used with either the seventh or eighth edition of the Wright and Nebel text. I have also indicated the relevant chapters, or sections of chapters, as they relate to the third edition of the Raven and Berg text.

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| **Section 1** | Too Many People | | |
| 1 | Human Population Dynamics | 6 | 8 |
| | **Lab/Activity:** Cemetery Lab<br>Students collect lifespan data from local cemeteries, then construct and analyze survival curves. | | |
| | **Videos:** *World Population* and *Do We Really Want to Live This Way?* (from the Race to Save the Planet series) | | |
| 2 | What Can Be Done about Overpopulation? | 7 | 9 |
| | **Lab/Activity:** Census Data Research<br>Students research and analyze government census data on the Internet for their hometown and other regions. | | |
| | **Lab/Activity:** Constructing Population Profiles<br>Students construct graphs of population data from different regions worldwide. | | |
| | **Lab/Activity:** Ecological Footprint Activity<br>Students assess their own consumptive lifestyles and compare this to that of the developing world. | | |
| | **TEST #1** | | |

# Syllabus 2

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| **Section 2** | How Nature Works | | |
| 3 | Introduction to Environmental Problems<br>The Scientific Method | 1 | 1/2 |
| | **Lab/Activity:** Experimental Design—Part 1<br>Students are guided through the process of designing a good and sound experiment of their choice. They have three lab periods to work on their labs, and then they write up their lab reports. | | |
| | **Videos:** *The Lorax* and *The Environmental Revolution* (from the Race to Save the Planet series) | | |
| 4 | Biospheric Interaction of Matter and Energy | 3 | 4/6 |
| | **Lab/Activity:** Experimental Design—Part 2 | | |
| 5 | Basic Ecosystem Structure | 2 | 5/6 |
| | **Lab/Activity:** Owl Pellets Analysis<br>Students dissect owl pellets, identify prey types, and deduce the average dietary intake. | | |
| | **Lab/Activity:** Construction of Food Webs<br>From the owl pellet lab and other given information, students construct a typical owl food web. | | |
| | **Lab/Activity:** Food Chain Computer Simulation<br>A systems management approach is used to determine the parameters required to sustain a pond ecosystem in order for sunfish to survive. | | |
| | **TEST # 2** | | |

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| 6 | Population Dynamics in Ecosystems | 4 | 5/8 |
| | **Lab/Activity:** Study of Succession on Campus<br>A tour of the campus is taken and students identify areas where succession is or is not occurring. | | |
| | **Lab/Activity:** Ecosystem Analysis—Species Identification<br>Several areas on campus are chosen, for example the pond, and students identify aquatic and other species. | | |
| 7 | How Change Occurs in Ecosystems | 5 | 5/6 |
| | **Lab/Activity:** Experimental Design—Part 3 | | |
| | **TEST #3**<br>End of 1st Quarter | | |
| 8 | Maintaining Ecosystem Diversity | 11 | 16 |
| | **Lab/Activity:** Biodiversity Inventory of Local Area<br>A second area on campus is chosen, for example a wooded area, and students identify as many species as possible and identify any links between species. | | |
| | **Videos:** *Cane Toads: An Unnatural History* and *Remnants of Eden* (from the Race to Save the Planet series) | | |

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| 9 | Management of Ecological Resources | 12 | 7/15/7 |
| | **Lab/Activity:** *Fishbanks, Ltd.*<br>For this computer simulation, the class is divided into groups of three to four students. Each team operates a fishing company, deciding where to fish and how many boats to use. The activity ties in well with overuse of resources, management of natural resources, and Garrett Hardin's "Tragedy of the Commons." | | |
| **Section 3** | Problem-Based Unit on Energy | | |
| 10 & 11 | Fossil/Fuel Use | 13 | 10 |
| | **Lab/Activity:** See "Student Activity" on page 75.<br>**Videos:** *More for Less* (from the Race to Save the Planet series) | | |
| 12 & 13 | Energy from Nuclear Power | 14 | 11 |
| | **Lab/Activity:** See "Student Activity" on page 75. | | |
| 14 & 15 | Renewable Energy Options | 15 | 12 |
| | **Lab/Activity:** See "Student Activity" on page 75. | | |
| | **TEST #5**<br>End of 2nd Quarter | | |
| | **END OF FIRST SEMESTER: 1ST SEMESTER EXAM** | | |

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| **Section 4** | Issues of the Atmosphere and Hydrosphere | 21, 22 | 19/20 |
| 16, 17 & 18 | Atmospheric Pollution and Climate Change | 21, 22 | 19/20 |
| | **Lab/Activity:** *Focus on the Environment*<br>A computer simulation in which the class assesses and manipulates a number of factors that affect ecosystems. | | |
| | **Lab/Activity:** Car Exhaust Testing<br>Testing students' vehicles for carbon monoxide, carbon dioxide, and hydrocarbons using test kits from Carolina Biological. | | |
| | **Lab/Activity:** How Much Carbon Dioxide Do You Generate?<br>Students are provided with data on the amount of carbon dioxide generated during everyday activities, assess their own output, and determine ways to minimize their contribution to global warming. | | |
| | **Videos:** *What's Up with the Weather?* and *Only One Atmosphere* (from the Race to Save the Planet series) | | |
| | **TEST #6** | | |
| 19, 20 & 21 | The Water Cycle: Its Overuse and Pollution | 9, 18 | 13/21 |
| | **Lab/Activity:** Field Trip to the Sewage Treatment Plant<br>Students tour a nearby sewage treatment plant to learn the fate of their own wastes! | | |

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| | **Lab/Activity:** Water Analysis—Pond or Stream Water, Drinking Water, Precipitation<br>Chemical tests are carried out on water samples from various sources and the results are compared and discussed. | | |
| | **TEST #7** | | |
| **Section 5** | The Lithosphere and Other Issues | | |
| 22 & 23 | Soil and Soil Dynamics | 8 | 14 |
| | **Lab/Activity:** Soil Analysis of School Playing Fields<br>Soil samples from different playing fields on campus are provided by the head groundskeeper and analyzed for their relative concentrations of sand, silt, and clay. Nutrient content of each soil is determined and a fertilization plan is provided to the head groundskeeper. | | |
| | **TEST #8**<br>End of 3rd Quarter | | |
| 24 | Feeding a Growing Population | 10 | 17/18 |
| | **Lab/Activity:** Field Trip to a Local Farm<br>Students visit a nearby dairy farm that supplies milk to a regional cheese-making company. They learn about the whole operation and witness best management practices firsthand. | | |
| | **Video:** *Save the Earth—Feed the World* (from the Race to Save the Planet series) | | |

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| 25 | Controlling Pests | 17 | 22 |
| | **Lab/Activity:** Effect of Herbicides on Plant Growth<br>Different chemicals are evaluated for their potential effectiveness as herbicides on store-bought plants. | | |
| 26 | Hazards to Human Health | 16 | 21 |
| | **Lab/Activity:** Personal Risk Assessment<br>Students participate in an activity to determine probability and risk and how this affects their own daily lifestyle. | | |
| | **TEST #9** | | |
| 27 | Hazardous Chemicals in the Environment | 20 | 23 |
| | **Lab/Activity:** *Environmental Science: Field Laboratory*<br>Another computer simulation in which the class determines a number of factors that affect ecosystems by performing simulated experiments that alter the different parameters. | | |
| | **Lab/Activity:** Brine Shrimp Toxicity Experiment<br>Different chemicals are evaluated to determine their relative toxicity to brine shrimp or other test organisms. | | |

# Syllabus 2

| Week # | Material/Topic Covered | Chapter # Wright | Chapter # Raven |
|---|---|---|---|
| 28 | Garbage: What Can We Do with Our Trash? | 19 | 23 |
| | **Lab/Activity:** Field Trip to the Local Landfill<br>Students tour a nearby landfill and its recycling center to evaluate what happens to the trash we generate at home and school. | | |
| | **Video:** *Waste Not, Want Not* (from the Race to Save the Planet series) | | |
| | **TEST #10** | | |
| **Section 6** | Today and Tomorrow | | |
| 29 | Today's Society and the Environment | 23 | 3/17 |
| | **Lab/Activity:** Review for the AP Exam | | |
| 30 | The Way Forward: Looking Toward Tomorrow | 24 | 24 |
| | **Lab/Activity:** Review for the AP Exam | | |
| | **AP ENVIRONMENTAL SCIENCE EXAM: MID-MAY** | | |

## Teaching Strategies

*Student Troy Beaver discusses the biological and chemical tests he conducted on the "Living Machine," a model wetland ecosystem, with Dr. Dean Goodwin in the greenhouse at Kimball Union Academy.*

*Photograph courtesy of Dean Goodwin.*

Since I began teaching in the arena of environmental education, it has become increasingly apparent that young people care deeply about the world in which they live. When discussing some of the environmental problems of today, I endeavor to provide an optimistic and hopeful vision of the world of tomorrow. It is all too easy to focus on the environmental problems of today and, amidst an atmosphere of "doom and gloom," not offer viable solutions. Students can quickly become disillusioned and feel helpless if the material is delivered in the wrong way. For example, I explain to them that Thomas Midgley did not invent chlorofluorocarbons to mess up the ozone layer! He did so to satisfy a desire for such chemicals because they could provide solutions. In one case they provided a solution to the problem of spoilage, keeping food cold in a refrigerator so it would last longer. I ask my class how different their lives would be without the benefits that CFCs have provided in regard to acting as a coolant in air conditioners and refrigerators, replacing other chemicals like ammonia and sulfur dioxide.

The challenge I put to them is that when they get out into the business and industry worlds, they need to ask questions about environmental regard before making decisions about new inventions and products that could have a detrimental environmental impact. Another hope is that I am creating individuals who, when they enter the business or industrial workforce, will help others realize that business and industry should not think of themselves as being on opposite sides of the environment table but at the *same* table, and that table is *round.* My course has a strong emphasis on how the subject matter relates to students' everyday experiences.

# Syllabus 2

The way I run the class is with a very student-focused approach in which I am more of a facilitator than a teacher in the traditional sense. In order to get away from memorization and to engender understanding, students are empowered to be active participants in their learning experience. They discuss, practice, and "teach" each other. I feel that, because this is a college-level course, the more students do for themselves, the more they will learn, appreciate, and understand environmental issues, in addition to becoming better prepared for the rigors of college education.

Students have responded well to this learning and teaching style and show a great deal of interest in the subject matter. They rise to the challenges of critical thinking, problem solving, and active participation, and each year some have even gone on to major in environmental science at college. Students appear to enjoy this stimulation, and they learn and have fun in the process because they feel ownership for what is done in class. It is quite rewarding to teach about the environment using this approach. It gets me away from lecturing too much and more involved in guided discussion, though I tend to summarize each chapter or so by an overview lecture at the appropriate time. The students are proud of their endeavors and parents tell me that their children are now teaching them about the environment!

AP Environmental Science is ideal for exposing students to a variety of problem-solving and hands-on activities. A questioning technique based on the Lorranne and Meyers Model, a strategy based on asking open-ended questions, stimulates critical thinking. A number of lab activities are described in the course planner and in the lab component section. The tests, which cover materials from several chapters, and the first semester examination contain both a multiple-choice and a free-response section. In this way students become familiar with the format of the AP Exam they will take in May. Because we are an independent school, our calendar is such that graduation takes place in late May; there are few classes left after students take the AP Exam. Also, the senior class does not take any end-of-year final examinations. Over the years, I have used a number of different strategies with my class after the AP Exam in order to occupy the four, five, or six remaining class periods. These range from watching and critically discussing an environmental movie to performing more water tests and ecological studies on the nearby pond.

## Lab Component

The lab section often incorporates problem solving that requires students to design and predict the outcome of experiments and give suggestions for future studies. Students learn how to work individually and as part of a lab group or "ecoteam." The lab section also provides important experiential opportunities for the students and makes use of the ponds and woodlands on the school's campus. A number of classroom-based lab experiments are also included, in addition to several computer simulations because winter weather often limits the time we can spend outdoors. Students have access to 10 computers in the lab, class, and prep room areas, giving them ample opportunity for Internet research. Students also participate in a number of field trips in the vicinity. A nearby farm, the area landfill, a wood chip burning power plant, and a sewage treatment facility offer examples of the destinations that are available to us. I often use class periods for lab activities in addition to the biweekly long period.

## Student Activity

**HOW WILL NEW ENGLAND'S ELECTRICITY BE PRODUCED IN THE TWENTY-FIRST CENTURY?**

I have used problem-based inquiry in my college-level environmental science courses for more than a decade. The following narrative describes a student-centered methodology that can be used in a research project (sample laboratory/field investigation 18 in the *Course Description for AP Environmental Science*). Several lab activities are suggested that can be incorporated into the research project, which also covers the chapters on oil and fossil fuel use, nuclear power, and renewable energy sources. Although I focus the issue on my region of the country, it can easily be used in any location.

**Goals and Objectives**

A basic approach to the problem-solving method is used to present the unit, an approach that is straightforward and follows a stepwise process. Once the "problem" has been presented to the students, they have to think about it. What is the question or problem? They examine their choices, pick a strategy, and detail a plan of action. They carry out their plan by working through the problem carefully and checking their answers. Does the solution work? Either the problem is solved or they have to go back and devise a new plan or strategy. The classroom framework must be flexible enough to allow for brainstorming, taking into account the fact that students may have to make several attempts before they can finalize a prospective solution. The teacher can further challenge the students by introducing appropriate sub-problems along the way.

Specific student objectives for such a problem-based format include:

- Develop critical thinking skills
- Become actively involved in the learning process
- Enhance their research skills
- Learn how to organize and interpret scientific data
- Make written and oral presentations of the results of their research
- Take on the role of a specific interest group and defend their position in a public forum as part of a culminating activity
- Experience the interrelationship of science to the world around them and to other disciplines
- Increase their understanding of basic scientific knowledge through deductive rather than passive reasoning techniques
- Interpret data from numerous sources, assess options, and form opinions to help predict suitable outcomes
- Develop an understanding of an important environmental issue and how it impacts our lives
- Appreciate that there are often no easy answers to certain environmental problems and issues. Many have a "give and take" situation associated with them, for example the needs of society versus environmental impact.

A problem-based educational format is in line with the current national and many state guidelines regarding standards for science education.

**Subject Matter**

This unit involves the study of energy, in particular the different methods for generating enough electricity to meet our current and future needs. The unit is focused on the New England region but involves investigating the United States as a whole, and other countries as well, to determine how electricity demands are met. Students study such topics as:

- Licensing of nuclear power plants (NRC)
- Types of nuclear power plants, how they work, the costs involved

- Nuclear safety issues: Chernobyl/Three Mile Island, inherently safe plants
- Radioactivity/half-lives/isotopes
- Radioactive materials and uses: nuclear fuel pellets/medical radiation treatments/nuclear weapons
- Nuclear fission/fusion
- Nuclear waste: types/disposal/storage
- Generation of electricity: distribution/deregulation/costs per kW-h/trends in use
- Alternative energy sources and uses: nonrenewable and renewable, coal/oil/natural gas/solar/wind/hydro/geothermal/tidal/biomass/cogeneration, and others
- Environmental pollution from each type of energy source
- Advantages/disadvantages of each energy source
- Sustainability of each energy source
- Energy conservation: individual steps/homes/business/industry
- Energy policy: current/future/local/state/national/global
- Possible solution(s) for future electricity demands in New England
- Socioeconomic impact(s) of energy production and its environmental consequences
- Energy audits: personal inventory of energy use at home or school
- Labs and field trips as required or feasible

The unit involves studying the scientific principles of electricity production and assessing the socioeconomic implications of fulfilling our energy needs now and in the future. The unit touches on a number of relevant topics in the AP Environmental Science topic outline, for example sections I.A.2.; III.E.; IV.A.1., 2., and 3.; V.A.1.; VI.B., C., D., and E.

**Description of Unit Activities**

Students are verbally given the following problem statement:

> *The licenses for nuclear power plants in the New England region are expiring over the next 25 years. The area depends on nuclear power as a source of electricity. The demand for electricity in the region is projected to increase during this time. Where will New England obtain its electricity from as we move into the twenty-first century if the nuclear power plants close down when their licenses expire? The governor of New Hampshire has selected you to be on a panel to investigate this problem and report back with a plan of action for the future.*

After being presented with the problem, students brainstorm such questions as "What do we know?", "What do we need to know?", and "How do we find out what we need to know?". These are given as both homework and in-class assignments. Students share their answers with each other and work together, generating new ideas through open discussions. They are then assigned to a research group, or "ecoteam," in order to find out the answers to the questions they have raised. Each time students bring in a new body of information we return to the three basic questions. As each area becomes clarified, issues are removed from the "need to know" column and replaced with questions that have been raised by the new information. At appropriate times the students are assisted by the facilitation of concept- or problem-mapping strategies on the board, which help to ensure the group is proceeding in the direction it wants to go.

Sub-problems can be introduced to the group or the class as a whole, so that students do not think they have found a quick-fix solution. These also serve as a way to bring related issues to their attention, particularly if they have not yet been uncovered by their research. For example, the problem of nuclear waste, the effect of deregulation, the radon problem, and other topics can be presented to students, using newspaper articles or handouts on each issue, to ensure that these points are covered in the unit.

Both class and homework times are used for the completion of this unit. Students have access to library materials, the resource center that I have set up in the classroom, and the Internet. They are also allowed to call, write, e-mail, or fax any organization they feel may be able to provide them with information. At certain times the whole class regroups to share what they have found out. Students teach each other about their findings in their particular research area. I also give them assignments that involve discussing the issue with family members and reporting their feedback to the class.

The time needed for this project depends on the teacher and the depth of coverage. I have spent anywhere from three to six weeks on the unit and find that allowing more time results in students covering the topics of fossil fuels, nuclear power, and renewable energy sources in much greater depth than is in most textbooks. During this student-centered approach the teacher acts as more of a facilitator and guides the class through the process. The students actively participate in presenting the material to the class. The class produces a final document that incorporates its collective work and suggests possible solutions. Each group presents its data to the whole class as part of a culminating activity in the preparation of the final document. In the past I have also had students present their findings as part of a debate with students from another local school who have undertaken a similar project.

**Resources and Materials Used**

When conducting units on problem-based learning it is important to have as many resources as possible at the students' disposal. For example, in this unit I made the following available:

- Library—school and town
- Books and magazines on the environment
- Computers—Web access, production of research papers, PowerPoint presentations
- Materials obtained from conferences and organizations
- *Time* magazine article: "Nuclear Power: Do We Have A Choice?" (April 1991)
- *Boston Globe* article "Power Loss" (September 1996)
- CNN video—"The Aftermath of Chernobyl"
- Race to Save the Planet video series—energy needs, supply, and production
- Laserdiscs, CD-ROMs, and software on the topics
- The school's Toyota Prius (hybrid car)—students are taken on a drive around the campus so they can experience this new vehicle technology
- Outside organizations contacted directly by the students
- Information from nuclear power plant information centers

**Suggestions for Lab Activities**

Students are encouraged to design their own experiments relating to a particular aspect of the issue. The class has already been introduced to the technique of experimental design. Some of the students' experimental ideas can be undertaken in the lab, while others remain purely theoretical. Examples of lab investigations and demonstrations that have been conducted as part of this unit include:

- Efficiency of rechargeable versus nonrechargeable batteries
- Measuring radioactivity using a Geiger counter
- Demonstrations of electricity labs—see the physics teacher for ideas
- Efficiency of building and insulating materials
- Energy audits—home and school
- Energy efficiency of various appliances and cost of use
- Energy analysis using a Watts Up! meter
- Field trips to electricity producing facility or radiotherapy unit
- Computer simulation lab—"Home Heating Audit" (part of EME Corporation's *Home Energy Conservation* CD-ROM)
- Computer simulation lab—*Environmental Science: Field Laboratory* (Falcon Software, Inc.)
- Computer simulation lab—*Focus on Environment* (EME Corporation)
- Selected investigations from the Acorn book, such as Lab 9, "Energy Consumption" and Lab 17, "The Effects of Radiation on Growth" (these labs relate to the greenhouse effect and acid deposition and can be used to link energy use to air pollution)

**Methods of Evaluation**

I use a variety of procedures and techniques to assess the students' understanding. Tasks that were given as homework are checked as part of their ongoing homework grade for the class. A student's performance on the unit is also assessed by using the following parameters.

- Discussion, in-class participation, written assignments, research data, oral presentations, and reports, tests, and quizzes on the material.

- The culminating activity (the production of the final document on the issue) is also given a grade. Each student receives an individual score for their research portfolio and presentation and a group grade for the final typed document and its presentation.
- I use a checklist for evaluating discussion and oral reports. All members of the class, including the teacher, complete this form. In this way students evaluate each other's performance and learn what constitutes effective communication.
- Quizzes expose students to a number of evaluative techniques like short-answer, true/false, matching, and fill-in-the-blank. The major test on the topic remains a multiple-choice and free-response question(s) format. Students can be quizzed on information from the student presentations, handouts of newspaper articles, student-produced handouts, data from any of the lab exercises, and facts from any of the video presentations.

When performing problem-based units with students, it is important that they be made aware beforehand of how the teacher will be evaluating their work.

**Summary**

I have found this teaching methodology to be an effective way for students to cover several important chapters in the textbook. I do not use problem-based learning units all the time in my AP course, and some years I take a break from this one; but they do represent another educational mode that gets away from the traditional lecture approach and provides an interesting experience for the class. The students learn just as well, if not better, than if I had used traditional teaching strategies! A word of advice when attempting this type of experience with your students. Do not fall into the trap of answering *all* of the questions they ask you when they are conducting their research. Instead, redirect and guide them to resources where *they* will find the answer for themselves; otherwise the problem-based experience reverts to a project-based experience that follows a more teacher-focused path.

Units of this type are very time and energy intensive to prepare from the teacher's perspective since it is easier just to present the information in the form of lectures. The teacher must collect as wide a variety of resources as possible for students to use and have various labs prepared because the class may choose any one of many types of investigations to perform as they go on this student-centered journey of discovery. However, the learning experience you will provide for your students will be well worth all of the effort that goes into getting the unit ready for them to embark on.

## Student Evaluation

There are four grading periods each year, two per semester. The quarter grades are determined numerically and then assigned a letter grade using the following conversion:

| | | | |
|---|---|---|---|
| A | 93 and above | C | 73 – 76 |
| A- | 90 – 92 | C- | 70 – 72 |
| B+ | 87 – 89 | D+ | 67 – 69 |
| B | 83 – 86 | D | 63 – 66 |
| B- | 80 – 82 | D- | 60 – 62 |
| C+ | 77 – 79 | F | below 60 |

The scale then converts to a GPA range from 4.00 for an A to a 0.667 for a D-.

Students are also assigned an effort grade based on the following scale:

| | |
|---|---|
| 4 | Outstanding |
| 3 | Strong |
| 2 | Satisfactory |
| 1 | Weak |
| 0 | Unacceptable |

A student's quarter grade in the class is comprised of the following breakdown:

| | |
|---|---|
| Homework | 20% |
| Quizzes | 20% |
| Tests | 30% |
| Labs | 20% |
| Participation | 10% |

The examination at the end of the first semester is weighted as 20 percent of the final overall grade for the first half of the year, with the first and second grading periods each counting for 40 percent of the final semester grade. The second semester grade is made up of an average of the students' scores from the third and fourth quarters.

## Teacher Resources

I use a lot of different teacher resources, so I will not mention each one individually here. The following list provides a sample of some of the major resources I use on a fairly regular basis.

**Textbooks**

Raven, Peter H., and Linda R. Berg. *Environment*. 3rd ed. Fort Worth: Harcourt College Publishers, 2001.

Wright, Richard T., and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future*. 8th ed. Upper Saddle River, NJ: Prentice Hall, 2002.

**Reference Textbook**

Miller, G. Tyler. *Living in the Environment: Principles, Connections, and Solutions.* 12th ed. Pacific Grove, CA: Brooks/Cole, 2002.

**Lab Manuals**

Bellamy, Mary Louise, and Kathy Frame. *Biology on a Shoestring.* Reston, VA: National Association of Biology Teachers, 1995.

Cothron, Julia H., Ronald N. Giese, and Richard J. Rezba. *Students and Research: Practical Strategies for Science Classrooms and Competitions.* 3rd ed. Dubuque, IA: Kendall/Hunt, 1999.

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Exercises*. 7th ed. New York: McGraw-Hill, 1999. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

Mitchell, Mark K., and William B. Stapp. *Field Manual for Water Quality Monitoring.* 9th ed. Dexter, MI: Thomson-Shore Printers, 1995.

Tomera, Audrey N. *Understanding Basic Ecological Concepts.* Portland, ME: J. Weston Walch, 1989.

In addition, I have a collection of Peterson's Guides in the classroom for species identification purposes.

**Test Banks**

I use the test banks that accompany the latest editions of the course textbook, which are provided as ancillary teaching materials.

**Resource Books and Periodicals**

McConnell, Robert L., and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating.* 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2002.

Stevenson, L. Harold, and Bruce Wyman. *The Facts on File Dictionary of Environmental Science.* New York: Facts on File, 1991.

Wackernagel, Mathis, and William E. Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island, BC, Canada: New Society Publishers, 1996.

The Worldwatch Institute. *State of the World 2002: Report on Progress Toward a Sustainable Society.* New York: W. W. Norton, 2002.

_____ . *Vital Signs 2001: The Environmental Trends that Are Shaping Our Future.* New York: W.W. Norton, 2001.

The school library has a variety of environmental books and periodicals like *E/The Environmental Magazine, Environment, Natural New England, Mother Earth News,* and more.

**Interactive Software**

Bishop, Dwight, John Hirschbuhl, and Jim Jackson. *Environmental Science: Field Laboratory*. Wellesley, MA: Falcon Software. CD-ROM for Windows. This can be ordered from Falcon Software at www.falconsoftware.com or 781 235-1767.

*Focus on Environment*. EME Corporation. CD-ROM for Windows and Macintosh. This can be ordered from EME Corporation at www.emescience.com or 800 848-2050, 772 219-2206.

*Food Chain*. High Performance Systems. CD-ROM. This can be ordered from High Performance Systems at www.hps-inc.com or 800 332-1202, 603 643-9636.

*Home Energy Conservation*. EME Corporation. CD-ROM for Windows and Macintosh. Contains "Home Heating Audit" and "Electricity and Hot Water." This can be ordered from EME Corporation at www.emescience.com or 800 848-2050, 772 219-2206.

Meadows, Dennis. *Fish Banks Ltd*. CD-ROM for PC and Mac. For more information, contact the University of New Hampshire Laboratory for Interactive Learning at 603 862-2244 or visit their Web site at www.unh.edu/ipssr/index.html. Also available from Education for a Sustainable Future at www.sustainabilityed.org/technology.htm.

**Videos**

*ABC News*. Prentice Hall Video Library series. Upper Saddle River, NJ: Prentice Hall, 2002. Accompanies the textbook *Environmental Science: Toward a Sustainable Future,* by Richard T. Wright and Bernard J. Nebel. Contains nine segments, three to ten minutes long, from selected news programs.

*Cane Toads: An Unnatural History.* Written and directed by Mark Lewis. New York: First Run Features, 1987. 48 minutes.

*The Lorax.* Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. This is currently out of print, but some libraries may have a copy.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

*What's Up With the Weather?* Produced by Frontline and NOVA. Boston: WGBH Boston Video, 2000. 120 minutes.

*World Population*. Washington, DC: Population Connection, 2000. 7 minutes.

**Internet Sites**
The site I check on a daily basis is Environmental News Network's news page at www.enn.com/news. Other sites I find useful are:

AP Central: apcentral.collegeboard.com

Environmental Literacy Council: www.enviroliteracy.org

Population Connection: www.populationconnection.org

U.S. Census Bureau: www.census.gov

U.S. Environmental Protection Agency: www.epa.gov

**Lab Equipment and Supplies**
Carolina Biological has a good selection of lab kits that can be used in the AP Environmental Science course. I particularly like the Carolina® Estimating Air Pollution Generated by Everyday Activities Kit for testing the emissions from motor vehicles. I also use this kit to test the pollutants coming from cigarettes. The majority of the soil and water analysis test kits I use come from the LaMotte Company.

## Personal Philosophy

***David Hong***

*Diamond Bar High School*

*Diamond Bar, California*

My hope is that if students are encouraged to see the relevance of science in their lives they will come to value the role science plays in society and perhaps even be inspired to further their science education at the next level. I try to remember that my students will not be hired as research scientists upon completion of an AP Environmental Science course, and as a result I try to be flexible with the time I spend supporting them as they take their first steps toward understanding the underpinnings of science.

As a chemistry major in college, I aimed to take as many courses with an environmental component as possible. Among others, I took courses in air pollution chemistry, radiation biology, and natural product synthesis. Prior to studying to teach it, I put my knowledge of chemistry to use in the Water Quality Laboratory of the Metropolitan Water District of Southern California. After teaching chemistry and physics for five years, I read of the College Board's proposed AP Environmental Science course. From the first time I read about the College Board's intention to include the study of environmental science on their long list of AP courses, I felt that the course was meant for me to teach. I saw AP Environmental Science as an opportunity to teach numerous aspects of science that are important but are not deemed fit for the curricula of traditional science courses. Moreover, AP Environmental Science would allow students in our science program to meet educational objectives that were never previously met in our science curriculum.

With that final consideration as the primary argument, I secured the encouragement and support of the administration, wrote a curriculum, received school board approval, and began teaching AP Environmental Science in 1997. I continue to believe that AP Environmental Science is the most relevant course of study amongst the AP science courses. It allows teachers the flexibility to design a curriculum that is current, and it establishes relevance through the use of local examples alongside the national and global examples in the textbooks to illustrate concepts and theories. AP Environmental Science at Diamond Bar High School will be a work in progress for the foreseeable future as we continually tinker with the course in an attempt to refine, fine-tune, and perfect it. I make every attempt to learn new things and to keep my batteries charged by taking advantage of opportunities for professional growth. In this way I can continue to provide my students with new, exciting, and outstanding examples, stories, activities, laboratories, and demonstrations.

# School Profile

**School Location and Environment:** Diamond Bar High School is in the city of Diamond Bar, California, a suburban community of about 56,000 people located about 40 miles east of Los Angeles. Approximately seven percent of the student population is composed of English Language Learners, a large majority of whom speak an Asian language as their first language.

**Grades:** 9–12.

**Type:** Public high school.

**Total Enrollment:** Approximately 3,000 students.

**Ethnic Diversity:** Asian Americans make up approximately 50 percent of the student population; Hispanics 15 percent; African Americans 5 percent; and Filipinos 5 percent.

**College Record:** Over 70 percent of the graduates typically complete the required courses for admission into the University of California and the California State University systems. Approximately 25 percent of each graduating class enrolls in a two-year junior college. Overall, approximately 95 percent of each graduating class enrolls in a two- or four-year college.

# Overview of AP Environmental Science

**AP Program**

Diamond Bar High School offers courses in 23 AP subjects. Approximately 800 students occupy 1,800 seats in all of the AP sections currently being offered. Students who are enrolled in an AP course are not required to take the AP Exam; they must pay for the exams they choose to take.

**Class Profile**

The five sections of AP Environmental Science have a maximum class enrollment of 33 students and average about 30 students. The class meets five times a week and the duration of each class period is 55 minutes. Additional time is allocated for laboratories in AP Biology, AP Chemistry, and AP Physics B; no additional time is available for AP Environmental Science or AP Physics C: Mechanics.

**Course Prerequisites**

The prerequisites for AP Environmental Science are a grade of B or better in biology and chemistry. Any student who meets the prerequisites may enroll in the course.

# Course Overview

My strategy in presenting the course to students is to begin with an introduction in which we learn some of the language that is required for rich discussions about the environment. Two ecology units follow the introduction; the content of these is intended to convey to students the concepts that govern how things "are supposed to work in the natural world." The study of human population is incorporated into the ecology units. The remainder of the course is a detailed study of the impact of humans on different components of the biosphere. We have used four different textbooks in six years. Currently our textbook of choice is the third edition of *Environmental Science: Earth as a Living Planet,* by Daniel B. Botkin and Edward A. Keller.

# Course Planner

## First Semester

**Unit 1. Introduction to Environmental Science – 2 weeks**
The first unit of AP Environmental Science (APES) acquaints students with environmental science. It introduces the theory, philosophy, rhetoric, and terminology that will be used throughout the course.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapter 1–3
Gonick and Outwater, *The Cartoon Guide to the Environment,* Chapter 1
Race to Save the Planet video series, *The Environmental Revolution*

**Labs and Activities**
Salinization Lab
Tragedy of the Commons Simulation

**Unit 2. Life on Earth, Part I – 3 weeks**
The second unit of APES is an introduction to two of the fundamental underpinnings of environmental science: basic ecology and the study of human populations.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapter 4–6
Gonick and Outwater, *The Cartoon Guide to the Environment,* Chapters 2 and 8

**Labs and Activities**
Doomsday Lab
Ecocolumn Lab
Food Webbing Activity
Oh Deer! *Project WILD* Activity
Introduction to Water Quality Testing

**Unit 3. Life on Earth, Part II – 2 to 3 weeks**
This unit completes the study of basic ecology.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapters 7–9 and Earth's Biomes
Gonick and Outwater, *The Cartoon Guide to the Environment,* Chapters 3–5

**Labs and Activities**
Tagging Lab
Species Diversity Lab
Ecocolumn Water Quality Testing

**Unit 4. Food and Agriculture – 2 to 3 weeks**
In this unit, students study the basic nutritional needs of human beings, what happens when these needs are not met, and what is being done in an attempt to make certain these needs are met for all people. Students also study agriculture, including the various methods of growing crops, the history of agriculture, and the "green revolution."

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapters 10–11
Race to Save the Planet video series, *Save the Earth—Feed the World*

**Labs and Activities**
Ecocolumn Water Quality Testing

**Unit 5. Land Use and Biodiversity – 3 weeks**
This is a transition from the study of ideal ecosystems and ecology to the study of human impact on the environment. Students study the roles of wildlife management, land use, species protection, conservation, and preservation in determining how "natural" the Earth will remain.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapters 12–13
Race to Save the Planet video series, *Remnants of Eden*
*Cane Toads: An Unnatural History*

**Labs and Activities**
Habitat Loss Lab
Quandary in Ponder (role-play activity)
APES Debates I
Ecocolumn Water Quality Testing

**Unit 6. Health, Risk, and Toxicology – 2 to 3 weeks**
This unit includes the effects that environmental hazards have on human health, as well as on the health of the environment, and an examination of the risks we face in our environment.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapter 14

**Labs and Activities**
Risk Assessment Lab
Ecocolumn Water Quality Testing

**END OF FIRST SEMESTER: FINAL EXAMINATION**

## Second Semester

**Unit 7. Energy Resources and Energy Use – 2 to 3 weeks**
Fossil fuel reserves are finite and the use of other energy sources will need to be increased in the future. Students study the advantages and disadvantages of alternative sources of energy, which can be used in place of fossil fuels.

**Textbook Reference and Other Resources**
Botkin and Keller, *Environmental Science,* Chapters 15–18
Race to Save the Planet video series, *More for Less*

**Labs and Activities**
Personal Energy Consumption Audit

**Unit 8. Water – 2 to 3 weeks**

Perhaps the most relevant unit of study for environmental science students in southern California! The world's best examples of water development are in our backyards, and we focus on these local examples throughout the unit.

**Textbook Reference and Other Resources**

Botkin and Keller, *Environmental Science,* Chapters 19–20

Cadillac Desert video series, excerpts from episodes 1–4: *Mulholland's Dream, An American Nile, The Mercy of Nature,* and *The Last Oasis*

**Labs and Activities**

Home Water Use Audit

**Unit 9. Atmospheric Dynamics, Air Pollution, Ozone Depletion, and Global Warming – 2 to 3 weeks**

Following a brief introduction to the structure and characteristics of the Earth's atmosphere is a survey of several air pollution problems. This unit includes the study of some of the most serious global environmental problems we face.

**Textbook Reference and Other Resources**

Botkin and Keller, *Environmental Science,* Chapters 21–24

Race to Save the Planet video series, *Do We Really Want to Live This Way?* and *Only One Atmosphere*

*The Lorax*

**Labs and Activities**

Airborne Particulate Lab

APES Debates II

**Unit 10. Solid Waste, Minerals, and Mining – 2 weeks**

An introduction to earth science, which includes hands-on activities designed to introduce rock, mineral, and soil identification.

**Textbook Reference and Other Resources**

Botkin and Keller, *Environmental Science,* Chapters 27–28

Race to Save the Planet video series, *Waste Not, Want Not*

**Labs and Activities**
Cookie Mining Activity
Packaging Lab

**APES Review – 2 to 4 weeks**
Students review and practice taking the AP Environmental Science Exam. They use all of the outlines and lists of vocabulary terms they completed throughout the school year. During the review unit, students complete and grade all of the released free-response and multiple-choice questions, and multiple-choice questions that are designed to simulate the multiple-choice section of the AP Environmental Science Exam.

**Unit 11. Your World Environmental Project – 2 to 3 weeks**
All of the students work together as a class to complete this project. The objective is to work as a team to produce and complete a comprehensive campaign that promotes an uncommon and not yet exploited environmental cause.

**Textbook Reference and Other Resources**
None

**END OF SECOND SEMESTER**

# Teaching Strategies

One of the most satisfying things about teaching AP Environmental Science is the opportunity to use a number of instructional strategies and observe students in a variety of settings. By the time students have completed the course, they have performed laboratory experiments as they would in any AP science course, but they have also been engaged as researchers, actors, debaters, and activists.

After the AP Exam, we complete a project in which each class selects an environmental cause to advocate and works collaboratively as though they were a nongovernmental organization to further that cause. At the conclusion of the project, each class prepares a multimedia presentation, which is evaluated by community members who determine the most outstanding project.

## Lab Component

Students work on their laboratory activities in cooperative groups. Many of the labs were designed or tweaked to work distinctively well with the AP Environmental Science curriculum, while several are

biology, earth science, or chemistry labs that fit well in an AP Environmental Science course. Students use Vernier's LabPro® along with various sensors to measure water quality. The AP Environmental Science classes do not go on any organized field trips, but students are encouraged, through enticement with extra credit, to submit posters, along with a report on an issue of environmental significance, of locations they visit on their travels during school holidays and weekends.

## Student Activities

### ACTIVITY 1: RISK PERCEPTION AND RISK REALITY

This first activity is a survey students use to gather data on how people perceive the relative risk of numerous activities and lifestyle choices. Students analyze the data graphically and incorporate what they learned about risk from their readings to draw conclusions about risk perception. They first plot the actual risk versus the perceived risk for those surveyed, then they determine if the risk is accurately perceived or inaccurately perceived, and if inaccurately perceived, whether the activity is more or less of a risk than it is perceived to be.

To assist visually with this graphical analysis, students create a "channel" on their graph by drawing two lines, one from (0,2) to (8,10) and the other from (2,0) to (10,8). Risks that fall within the channel are those that were perceived comparatively accurately, while those outside the channel are the least accurately perceived. Students should determine that those inaccurately perceived risks above the channel share the characteristic that they are higher risk than those surveyed believed them to be, and those below the channel are less of a risk than those surveyed believed them to be. After graphing their data individually and as a member of a group, students look for common characteristics amongst the risks they have grouped together and draw conclusions about them.

**Student Handout**

We all face risks in our everyday lives. Often, we do not accurately perceive the level of risk we introduce into our lives when we engage in an activity, or we believe the possibility of a particularly terrifying event, such as an earthquake, introduces more risk into our lives than is actually warranted. In this activity you will survey friends and family to find out how they perceive various risks. You will also collaborate on the compilation and analysis of data collected by a team.

**Materials**

Bring two pieces of graph paper to class on the second day of this activity.

**Conducting the Survey**

- Do not allow the person being surveyed to see the responses of others.
- Do not survey anyone younger than 16 years of age.
- Do not survey anyone who has already been surveyed by an APES student (ask them first).
- Record the respondent's name at the top of the column.
- Thank respondents for their participation.
- Conduct the survey 12 times.
- Use the last three columns of the survey to average the results of:
    1. individuals 25 years of age and under,
    2. individuals 26 years of age and older, and
    3. the average age of all respondents.

**Data Analysis**

*After Completing the Survey, Prior to Class*—Record the average of each row of data as instructed in the survey.

*In Class*—Combine your data with the rest of your team members' data and determine your team average for each age group and all respondents for each row of data.

*Plot the Data*—For the survey you conducted, plot all three averages on the same side of the same piece of graph paper. Plot the actual risk on the y-axis and the perceived risk on the x-axis. Label each graph and each point on each graph with the identity of the risk it represents.

As a team, plot all three averages on the same side of the same piece of graph paper. Plot the actual risk on the y-axis and the perceived risk on the x-axis. Label each graph and each point on each graph with the identity of the risk it represents.

*Write*—As a team, collaborate on a thoughtful, insightful, and logical discussion of the results of your team's surveys. Include explanations for large differences between actual and perceived risk as well as for relatively accurate perceptions of risk.

*Submit*—As a team, staple together and turn in each team member's data, the data analysis, and the conclusion. Write the name of each team member on the first page of the report.

**The Survey**

Please rate the following risks on a one-to-ten scale: a ten being an activity or event that you perceive as a great risk to residents of the United States and a one being an activity or event that you perceive as a minor risk to residents of the United States.

| Name | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| natural disasters (1) * | | | | | | | | | | | | | | | |
| structure fires (3) | | | | | | | | | | | | | | | |
| drowning (3) | | | | | | | | | | | | | | | |
| driving an automobile (7) | | | | | | | | | | | | | | | |
| drinking tap water (1) | | | | | | | | | | | | | | | |
| tobacco use (10) | | | | | | | | | | | | | | | |
| bicycling (3) | | | | | | | | | | | | | | | |
| indoor air pollution (6) | | | | | | | | | | | | | | | |
| outdoor air pollution (6) | | | | | | | | | | | | | | | |
| alcohol use (6) | | | | | | | | | | | | | | | |
| medical x-rays (2) | | | | | | | | | | | | | | | |
| flying commercial airlines (1) | | | | | | | | | | | | | | | |
| being slightly overweight (9) | | | | | | | | | | | | | | | |
| being severely overweight (10) | | | | | | | | | | | | | | | |
| pesticide residues on food (4) | | | | | | | | | | | | | | | |
| AIDS (5) | | | | | | | | | | | | | | | |
| living with a smoker (8) | | | | | | | | | | | | | | | |
| toxic waste (2) | | | | | | | | | | | | | | | |
| drug abuse (6) | | | | | | | | | | | | | | | |
| living in poverty (10) | | | | | | | | | | | | | | | |

* The numbers in parentheses are the actual risks, which are not revealed to the students until after the survey has been completed. The actual risks were determined by comparing and combining the risks from tables contained in several textbooks. The comparison was difficult because some risks are measured in terms of odds while others estimate the number of years that the average life span is shortened by each risk. In order to include numerous items in the survey it was necessary to combine information from several tables.

**ACTIVITY 2: HABITAT LOSS**

This is a field activity that has been modified in such a way that it will work in the boundaries of most schools. In this lab, students survey a section of the school's field and determine the number of different plant species that are present in areas of various sizes. Following the data collection, each student plots the number of species versus the area surveyed. The graph provides an outstanding visual representation of how the number of species present in a habitat clearly decreases as the area decreases. This lab illustrates that if habitat is lost, no matter how small the loss is, species may be lost as well.

In order to successfully complete the lab within one 55-minute period, the students charged with identifying species do not attempt to precisely classify each plant species. Instead, they simply make up names for each plant; they have much fun with this. It takes about 15 minutes for six students to survey and mark the area. Golf tees work well for marking each corner; students wrap string around the tees and mark off the area. While the surveyors are working, three students are selected to be the identifiers, and they begin looking around and naming common species in the area outside the survey site. The remaining students are called collectors, and they are assigned to one of the numbered areas during the survey. Once the survey is complete, the surveyors are reassigned as collectors wherever they are needed; this is usually in the largest areas (11, 12, and 13). As the lab progresses, each time the collection in an area has been completed that area's collectors are reassigned to incomplete areas.

**Student Handout**

When habitat is destroyed, species can become extinct. By observing how the number of species changes with area, conclusions can be proposed regarding the number of species that will be exterminated when an area of habitat is destroyed.

The entire class will work together to collect data on the number of species in a given area of habitat. Your individual job will have one of the following descriptions.

- **Surveyor:** Works as a member of the team that measures and marks the area of survey and divides the entire survey area into 13 numbered quadrants as shown in the diagram. Surveyors will be reassigned as collectors after their survey is complete.
- **Collector:** Works as a member of the team that collects one sample of each species occurring in their assigned area. Once their area has been surveyed, collectors in smaller areas will be reassigned to help collectors in larger areas or to help the identifiers.
- **Identifier:** Works as a member of the team that identifies, names, and records data. The data includes the identity and location of species found by collectors.

**Procedure**

- It will take about six people working together to survey and mark the area of study.
- Following the survey, the collectors will collect an example of each species in their survey area and take them to the identifiers. **Note:** Walk carefully so that unique species are not trampled underfoot.
- The identifiers will examine and identify each species, then record which quadrant it was found in by checking the appropriate box in the data table. **Note:** The first specimen of each species is denoted with an "X" in the data table and will be named by the identifiers.
- Once all of the species present in a quadrant have been collected, collectors must help the collectors in the remaining quadrants.

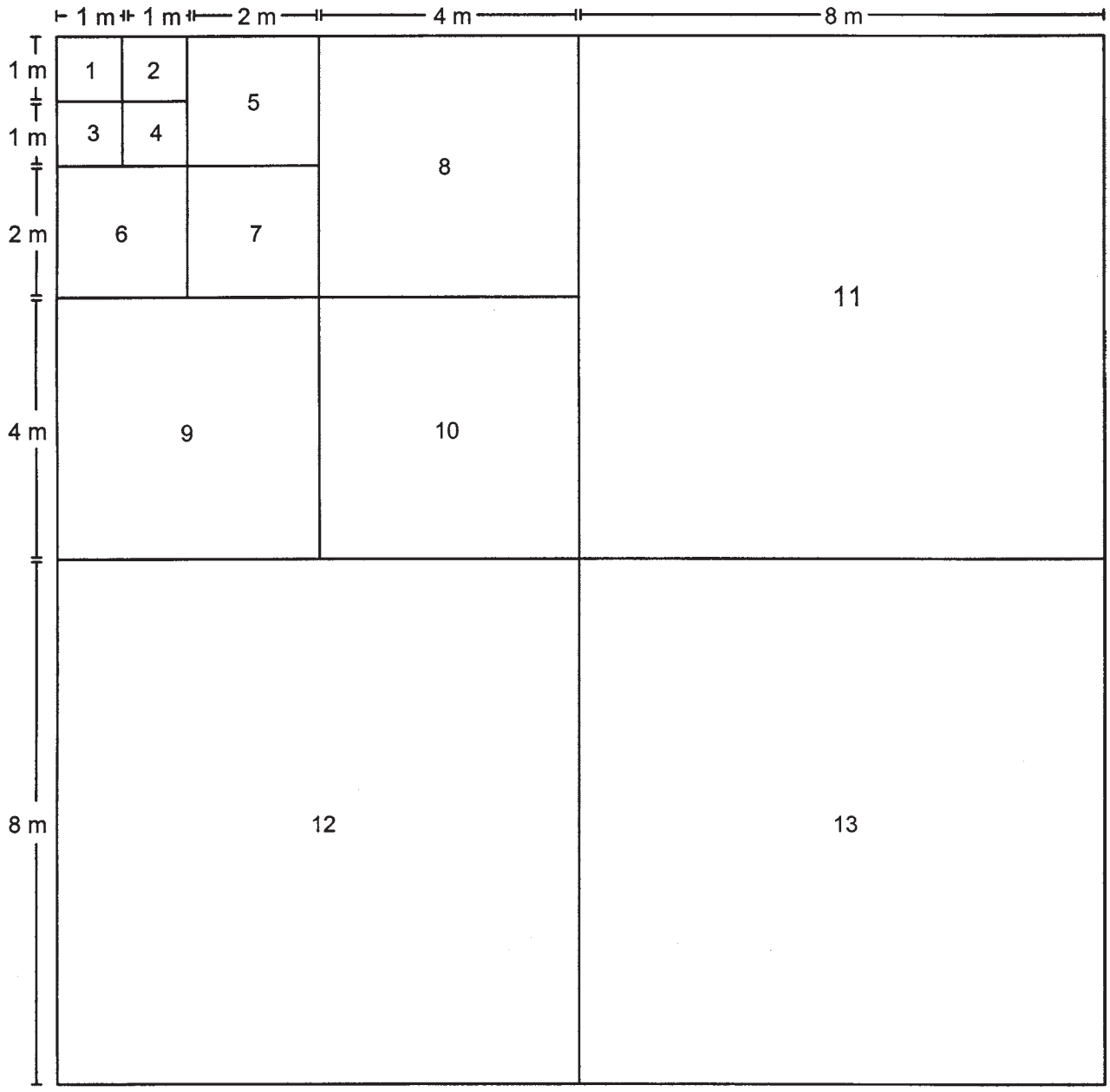
**Postlab**

- Record all of the data that was collected for your class.
- Use an entire piece of graph paper to plot the average number of species present versus the area surveyed. Include a data point for the entire area surveyed. There should be a total of five points on your graph.
- Draw a best-fit line through the data points.
- Answer the following questions.
  1. Use your graph to determine how many species are lost when 10 percent, 20 percent, and 50 percent of the surveyed habitat is destroyed.
  2. Use the equation $S = cA^z$ to determine how many species are lost when 10 percent, 20 percent, and 50 percent of the surveyed habitat is destroyed.

     where: S = number of species
     A = area surveyed
     z = 0.30

Write a thoughtful, reflective discussion of the results and their application to the study of biodiversity.

**Diagram of the Survey Area**



**Sample Data Table**

| Name of Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | | | X | X | X | | | | X | | X | X |
| 2 | | X | | X | | | X | X | X | X | X | | X |
| 3 | X | | X | X | | | | X | | X | | X | X |
| Add more rows as required | | | | | | | | | | | | | |
| Totals | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 1 | 2 | 3 |
| Averages | 1 $m^2$ quads | | | | | | | | | | | | |
| Averages | 4 $m^2$ quads | | | | | | | | | | | | |
| Averages | 16 $m^2$ quads | | | | | | | | | | | | |
| Averages | 64 $m^2$ quads | | | | | | | | | | | | |

## Student Evaluation

Students' final grades depend largely on the scores they earn on the examinations they take at the conclusion of each unit. The format of the exams is 50 percent multiple-choice questions and 50 percent free-response questions (usually two essay questions per exam). Students are required to submit an outline of the reading that accompanies each unit along with a list of 40 to 70 defined vocabulary terms and responses to 8 to 12 essay questions prior to each examination. Quizzes on the previous night's assignment are given approximately twice each week throughout the year and also contribute to the students' final grades. In addition, laboratory and activity grades contribute to each student's overall class score.

## Teacher Resources

**Texts**

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet.* 3rd ed. New York: John Wiley, 2000.

Botkin, Daniel B., and Edward A. Keller. *Student Review Guide and Internet Companion to Accompany "Environmental Science: Earth as a Living Planet".* New York: John Wiley, 1999.

deBettencourt, Kathleen B., et al. *Environmental Connections: A Guide to Environmental Studies.* Dubuque, IA: Kendall/Hunt, 2000.

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities.* 7th ed. New York: McGraw-Hill, 1999. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

Findlay, Chris, ed. *Global Environmental Change: Biodiversity, Can We Balance Resource Conservation with Economic Growth?* Arlington, VA: National Science Teachers Association, 1997.

Gonick, Larry, and Alice Outwater. *The Cartoon Guide to the Environment.* New York: HarperCollins, 1996.

Johnson, Robyn L., Scott Holman, and Dan Holmquist. *Water Quality with Calculators.* Beaverton, OR: Vernier Software and Technology, 2000.

Miller G. Tyler, Jr. *Living in the Environment: Principles, Connections, and Solutions.* 11th ed. Pacific Grove, CA: Brooks/Cole, 2000.

*Project WILD.* Houston: Western Regional Environmental Education Council, 1986. Project WILD activity guides cannot be purchased. They are given free of charge to Project WILD workshop participants. For more information, visit www.projectwild.org.

**Videos**

Cadillac Desert: Water and the Transformation of Nature series. 4 videos. Directed and written by Jon Else. Trans Pacific Television and KTEH/San Jose Public Television. Columbia TriStar Television, 1997. For more information, visit www.pbs.org/khet/cadillacdesert/home.html.

*Cane Toads: An Unnatural History.* Written and directed by Mark Lewis. New York: First Run Features, 1987. 48 minutes.

*The Lorax.* Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. This is currently out of print, but some libraries may have a copy.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

## Personal Philosophy

***Michele Morek***

*Brescia University*

*Owensboro, Kentucky*

I believe, as Thomas Berry does, that the "Great Work" of our age is to learn to revere, restore, and save the earth from ourselves. I consider my environmental science course the most important thing I teach—it is where "my great joy intersects with earth's great need." My specific goals for the course can be found in this sample syllabus.

## School Profile

**School Location and Environment:** Brescia University is located in downtown Owensboro, a city of 56,000 in rural western Kentucky. It is a Catholic school sponsored by the Ursuline Sisters of Mount St. Joseph in Mount St. Joseph, Kentucky. The school offers three Master's degree programs but is primarily an undergraduate degree-granting institution. One-third of the student population is nontraditional, many of whom attend Weekend College, a time-shortened program designed for adult learners. Many are first-generation college students and more than half are commuters.

**Type:** Catholic, coeducational, liberal arts university.

**Total Enrollment:** Approximately 800 students.

**Ethnic Diversity:** International students compose 7 percent of the student population; African Americans 5 percent; Hispanics 0.9 percent; Asian Americans 0.5 percent; and Native Americans 0.4 percent.

## Overview of Introduction to Environmental Science

I teach one section of the Introduction to Environmental Science course each semester. We meet for 50 minutes three times a week. Depending upon whether a Weekend section is being offered, there are usually 20 to 30 students taking it in a given semester.

**Course Prerequisites**

Introduction to Environmental Science is designed to help satisfy the general education requirements in natural science; it may not be counted toward the biology major. There are no prerequisites for taking this course.

# Course Overview

Introduction to Environmental Science is designed to satisfy a general education requirement for non-science majors. It is a one-semester, three-credit-hour course offered through the biology department. Although this freshman-level course is run primarily in a lecture format, it does have many small group discussions, case studies, simulations, videotapes and other visual aids, and some laboratory and field experiences incorporated. There is no formal, separate lab, but many lab "experiences" are included in the course.

The course is offered both in the traditional program and in the Weekend College's time-shortened format, which requires students to do much of their work outside of the class.

**Textbook**

The required textbook for the course is William P. Cunningham and Mary Ann Cunningham's *Principles of Environmental Science: Inquiry and Applications* (Boston: McGraw-Hill, 2002).

**Course Objectives**

The course objectives are for students to:

1. Learn the general concepts and terminology that are characteristic of ecology, the physical and biological principles that underlie environmental issues, and how the scientific method can be used to deal with environmental questions.
2. Appreciate the role that economics, history, religion, and other cultural factors have played in the human impact on the environment.
3. Enlarge their world view to the level of "spaceship earth" and the "global village" and see how issues of population, energy, resource distribution, and consumption relate to these concepts.
4. Become familiar with environmental issues that affect our local community and learn how to take personal and political action on behalf of the environment.
5. Increase their awareness of themselves as part of nature, their sense of responsibility for nature, and their enjoyment of it.
6. Increase their ability to apply knowledge to the solution of complex problems, to see the interrelatedness of all areas of study, and to "make connections."
7. Enhance their skills in writing and oral communication and in the interpretation of various kinds of data summaries.

## Course Planner

| DATE | TOPIC | CHAPTER |
|---|---|---|
| January 14 | Introduction | 1 |
| 16 | The Scientific Method | 1 |
| 18 | *The Environmental Revolution* | |
| 21 | Matter and Energy | 2 |
| 23 | M&E (continued)/Landfill Set-Up | 2 |
| 25 | Organizing Living Things | 2 |
| 28 | Cycles of Matter | 2 |
| 30 | Speciation and Evolution | 3 |
| February 1 | **EXAM 1** | |
| 4 | Species Interactions | 3 |
| 6 | Population Dynamics | 3 |
| 8 | Community Biology | 3 |
| 11 | Human Populations | 4 |
| 13 | *Six Billion and Beyond* | |
| 15 | Biomes | 5 |
| 18 | *Remnants of Eden* | |
| 20 | Field Trip or Library Day | |
| 22 | **EXAM 2** | |
| 25 | Biodiversity | 5 |
| 27 | Conservation Group Reports | 6 |
| March 1 | *Save the Earth—Feed the World* | |

## Syllabus 4

| DATE | TOPIC | CHAPTER |
|---|---|---|
| March 4–8 | Spring Break! | |
| 11 | Soil Lab | 7 |
| 13 | Sustainable Agriculture | 7 |
| 15 | Disease and Risk Factors | 8 |
| 18 | Biology of Smoking/Air Lab | |
| 20 | **EXAM 3** | |
| 22 | *Only One Atmosphere* | |
| 25 | Global Air Problems | 9 |
| 27 | Acid Rain, Indoor/Outdoor AP | 9 |
| March 29 and April 1 | Easter Break! | |
| April 3 | Groundwater Lab | |
| 5 | Water Resources/Pollution | 10 |
| 8 | Our Watershed/Water Lab | |
| 10 | Geological Processes/Video | 11 |
| 12 | **Field Trip Reports** | |
| 15 | **EXAM 4** | |
| 17 | *More for Less* | |
| 19 | Energy Sources and Uses | 12 |
| 22 | Debate: What Kind of Car? | |
| 24 | Energy Alternatives/Landfills | 12 |
| 26 | *Waste Not, Want Not* | |
| 29 | Solid and Hazardous Waste | 13 |
| May1 | **Community Study Reports** | |
| 3 | Redesigning Owensboro | 14 |
| 6–9 | **EXAM WEEK** | |
| June, July, and August | Have a great summer vacation! | |

## Teaching Strategies

I design many course activities that are to be done at home (see, for example, the "do-it-yourself field trip" on page 109 and "community study" activities on page 108) partly because of the nature of our student body and partly because my major goal for the course is for students to *connect* in a special way with their own environment and experiences.

In the very first class, students are told that they are real experts who will be used as consultants throughout the course, for each one has unique life experiences that can be brought to bear on the study and solution of environmental problems. That is why most of the assignments involve student choice—subjects they want to research on the Internet, current events from their hometown newspapers, field trips they arrange for themselves, soil and water samples they take from their own farms or backyards. Since we share everything we learn with the entire class, we have many rich (if vicarious) experiences in a semester.

Besides the assignments given on the sample syllabus, I often ask students to get in touch with their "affective side" by producing a work of art, a poem, or a letter that reflects what it feels like to be the last surviving member of an endangered species. We also have debates on coal versus nuclear fuel, hybrid versus methane conversion engines, and similar topics. We design an ideal hometown, do role-playing exercises in "lifeboat ethics" for the population unit, and other activities designed to get students out of the book and into the real world.

## Lab Component

**Sample Lab Experiences**

1. For an introduction to the scientific method, students receive a take-home lab with resealable plastic bags, vinegar, paper towels, grass seed, and instructions to design and execute an experiment to test the effects of different amounts of "acid rain" on seed sprouting.
2. Early in the semester we set up five "bucket landfills" with postage-stamp size samples of all the different sorts of materials students bring in. Each landfill receives a different amount of weekly "rain," from an overabundance of water for the "Louisiana Delta" to none for "Death Valley." After generating hypotheses about what they expect to find, the landfills are dug up at the end of the semester and used as the basis for a discussion on reduce/reuse/recycle.
3. Our urban campus is limited in natural areas, but we have plenty of weed diversity in the lawns. Using measuring rings, groups survey a square meter of lawn in different areas of the campus, identifying and counting the weeds. We come back for a discussion of biodiversity

and limiting factors and generate hypotheses about why certain weeds grow in certain areas. Students then design and execute an experiment to test their hypotheses.

4. I distribute sealed plastic petri dishes with a measured piece of double-stick transparent tape on the bottom. Each student takes one home for a 24-hour exposure to different environments, resealing the dish at the end of the exposure time. In lab we do a comparative visible particle count under the scanning lens of a microscope and use the data as an introduction to air pollution and particle size.
5. Students bring in soil samples from their own backyards or farms to test for a variety of soil nutrients, composition, particle size, and other factors. Similarly, water samples are brought in and tested for biological oxygen demand and other parameters.

## Student Activities

**Community Study**

You will submit an essay describing the top three environmental problems of your hometown and explain *why* you chose those three. The essay should be in your own words and consist of at least two typed pages. Your research should involve, at a minimum, the following resources.

- Newspaper articles on the subject (many newspapers are on the Internet)
- An interview with a local official or expert with good information
- Library or Internet material for general background on the topics

Besides the essay, you must provide a bibliography of *all* of the sources you used, including the names and positions of all of the people you interviewed; authors and titles of books; newspaper editions, bylines, and dates; and complete Web site addresses. (Check out the Web sites recommended in your text!) Due May 1.

**Community Service Project**

Give me some evidence of an action you took on behalf of the environment, such as a letter to a congressperson or local official, a practice you began in your home or at work, a talk on littering to a Brownie troop, or something similar. This might be something you did as a result of your Community Study! Due Anytime.

**"Do-It-Yourself" Field Trip**
Choose somewhere to go where you can learn about a subject related to the environment. This could be a woods walk or a museum visit, or it could be related to your Community Study. (For example, a visit to an industrial facility or a water treatment plant.) You will give an oral report on this on April 12. Be sure to check with me before you make a final decision on your site.

**Participation**
This grade will be based on your involvement in small group activities (Were you prepared? Did you contribute?) and class discussions (Did you speak up, share opinions? Were you involved in the topics?). I enforce the 20 percent absentee policy, and more than three absences will reduce your participation grade. Labs are especially hard to make up; please leave a message on my answering machine in advance if you must miss a class or lab.

## Student Evaluation

| | |
|---|---|
| Four Exams | 55% |
| Community Study | 15% |
| Community Service Project | 5% |
| Do-It-Yourself Field Trip (Oral Report) | 5% |
| Participation | 10% |
| Other (labs, study questions, etc.) | 10% |

Grading Scale: A = 100 – 93
B = 92 – 83
C = 82 – 73
D = 72 – 60
F = 59 – 0

## Teacher Resources

In addition to the main text, the 10-video series Race to Save the Planet (Boston: WGBH Boston, 1990) and the video *Six Billion and Beyond* (PBS, 1999) are valuable resources. I have also found many useful ideas (which I modify for college level) in the following publications.

Project Learning Tree activity guides. Washington, DC: American Forest Foundation. For more information, visit www.plt.org.

*Project WILD K–12 Curriculum and Activity Guide.* 2nd ed. Houston: Western Regional Environmental Education Council, 1983.

*Project WILD Aquatic K–12 Curriculum and Activity Guide.* 2nd ed. Houston: Western Regional Environmental Education Council, 1992. The Project WILD activity guides cannot be purchased. They are given free of charge to Project WILD workshop participants. For more information, visit www.projectwild.org.

Roa, Michael L. *Environmental Science Activities Kit.* West Nyack, NY: The Center for Applied Research in Education, 1993.

*Teacher's Guide to Kentucky's Environment.* Frankfort, KY: Kentucky Environmental Quality Commission, 1993.

## Personal Philosophy

***Thomas Mowbray***

*Salem College*

*Salem, North Carolina*

I first offered environmental science as a college-level course in 1978. I developed the course as a science-based elective for non-majors. My primary objective was to develop and offer a course firmly based on scientific principles that focused on important environmental issues relevant to the lives of students regardless of their eventual profession. During the first few years that I offered the course, most of the students who selected it did so to fulfill one of their science requirements for graduation. Gradually more and more students began to select environmental science because of its relevant course content.

As the student composition of the course changed, I began to see a recurring comment on student course evaluations: "This course should be required of all students graduating from Salem College." This particular comment, made by students over and over again throughout the years, has helped me maintain my interest and enthusiasm for teaching environmental science to non-majors. Along with the students' "vote of confidence" about the course's relevance, the fact that there has been a continuous succession of important environmental issues to cover has removed any element of boredom that might otherwise have come from teaching the same course year after year. In summary, my interest in teaching this course stems from the relevance of the issues the subject encompasses and the way in which science continues to refine and clarify our understanding of these issues.

## School Profile

**School Location and Environment:** Salem College is located within Historic Old Salem in the metropolitan area of Winston-Salem, North Carolina, midway between the Blue Ridge Mountains and the Atlantic coast. The Moravian Church founded the college in 1772 as a school for young women. Today the campus is a blend of the past and present, with five buildings from the original eighteenth-century town serving as residence halls, classrooms, and administrative offices. Salem is the oldest women's college in the United States and is primarily residential.

**Type:** Four-year, private, liberal arts college for women.

**Total Enrollment:** Approximately 1,000 full-time students representing 28 of the United States and 17 other countries.

**Ethnic Diversity:** African Americans compose 20.5 percent of the student population; Asian Americans 3 percent; Hispanics 2.5 percent; and Native Americans 1 percent.

# Overview of Environmental Science

The environmental science course described here is called Human Ecology (Biology 50). Although it is taught as a one-semester course for non-majors, it may be taken as a biology elective by majors. It is a four-credit course, without a separate laboratory, taught during the fall semester every year. The class meets four hours per week, with three hours (two one-and-a-half hour sessions) for lecture and discussion and a fourth hour for classroom activities, discussion, and assessment. The average class size at Salem College is 15 students; the class size for Human Ecology is generally 28 to 32 students per offering.

Students who earn a grade of 3 on an AP Exam for which the college has an equivalent offering can waive that course and take the second course in the sequence or another course in the department; students who receive a 4 or 5 on the AP Exam, receive credit for the equivalent college course as well as four credits toward graduation. Students with grades of 4 or 5 on the AP Environmental Science Exam receive credit for the Human Ecology course and four credits toward graduation. The biology department also offers the Principles of Ecology (Biology 210) course as a part of its core curriculum; Human Ecology cannot be substituted for that course.

**Course Prerequisites**

Students who elect to take Human Ecology must first complete an introductory laboratory course in the biological sciences, Principles of Biology (Biology 10).

# Course Overview

Emphasis is placed on the concepts and principles that govern the functioning of natural systems and on the importance of these principles to the understanding and potential solution of environmental and resource problems. The course is broadly interdisciplinary, covering topics in biology, geology, earth science, chemistry, physics, sociology, political science, ethics, and economics. The format of the course is lecture and discussion, with students being encouraged to participate in a meaningful way in all classroom discussions. Students often work in small, collaborative groups on the analysis of significant issues or the solution to real environmental problems. Because the course does not have a laboratory, students are assigned out-of-class activities that are integrated into classroom discussions.

The major objectives of this liberal arts science course are to:

- Cover some of the many topics that are a part of environmental science in an accurate, balanced, and interesting way.
- Develop in students a fundamental understanding of, and the ability to use, the methods of scientific investigation.
- Illustrate how environmental and resource problems are interrelated and must be understood and dealt with in an integrated manner at the local, regional, national, and global levels.
- Develop student confidence, self-esteem, and independence of thought and action by improving their higher-order cognitive skills and their ability to read and think critically.
- Clearly indicate, through the use of case studies, what individuals can do in their personal lives to help sustain, rather than degrade, the Earth's life-support systems.

**Textbook**
The textbook used in the course is the third edition of *Environment,* by Peter H. Raven and Linda R. Berg.

## Course Planner

**Week 1** **Introduction: Organization and Course Requirements**
Science, Scientific Method, and Scientific Notation

**Activity:** *A Model of Man's Impact on Earth's Systems*
This is done during the first week of class to expose students to the technique of expressing ideas as conceptual models. Using the article "A Model of Man's Impact on Earth's Systems" from *Science,* and other models from current scientific articles, I establish how conceptual models are developed and used in environmental science.

| | | |
|---|---|---|
| **Week 2** | **Humans' Impact on the Environment** | Chapter 1 |
| | Addressing Environmental Problems | Chapter 2 |

**Activity:** *Analysis of an Environmental Problem*
An activity used to familiarize students with the various stages involved in successfully solving environmental problems. Using the framework of "The Successful Cleanup of Lake Washington" from the textbook, along with several of the original scientific articles, I describe a general model by which complex environmental problems are analyzed.

| | | |
|---|---|---|
| **Week 3** | **Economics, Government, and the Environment** | Chapter 3 |
| | Concepts of Matter and Energy | Chapters 4 and 5 |

**Activity:** *Improving Critical Thinking Skills*
A self-designed activity to get students to begin reading and thinking critically. With handouts I have developed on "the rules for critical thinking," I have students use the rules to analyze a variety of environmentally oriented advertisements from magazines, looking for unsupported assumptions, incorrect interpretations, improper use of data, invalid conclusions, or conclusions unsupported by the data.

| | | |
|---|---|---|
| **Week 4** | **Ecosystem Structure and Function** | |
| | Ecosystems and the Physical Environment | Chapter 6 |
| | Physical Characteristics of Earth's Major Ecosystems | Chapter 7 |
| **Week 5** | **A Visual Survey of Earth's Major Ecosystems** | Chapter 7 |

**Video:** *The Environmental Revolution*

**TEST I**

| | | |
|---|---|---|
| **Week 6** | **Understanding Population Growth** | Chapter 8 |
| | The Problem with Overpopulation | Chapter 9 |

**Activity:** *How Long Will It Take to Fill the Earth?*
This activity, from *Environmental Issues: Measuring, Analyzing, and Evaluating,* introduces students to several important population parameters. It is excellent for helping them understand the dynamics of population growth, doing simple calculations, constructing data tables, and expressing quantitative data graphically.

| | | |
|---|---|---|
| **Week 7** | **Energy Concepts and Energy Technology** | Chapter 10 |
| | Nonrenewable Energy Sources | Chapter 11 |

**Activity:** *Calculation of the Earth's Oil Reserves*
This activity, from *Environmental Issues: Measuring, Analyzing, and Evaluating,* helps students understand the finite nature of nonrenewable resources. The calculations in the activity help them refine their quantitative skills and improve their use of scientific notation.

| | | |
|---|---|---|
| **Week 8** | **Renewable Energy and Conservation** | Chapter 12 |

**Activity:** *Bringing the World to the U.S. Standard of Living*
This activity, from *Environmental Issues: Measuring, Analyzing, and Evaluating,* demonstrates the relationship between U.S. oil consumption and the U.S. standard of living, and what the environmental impact would be of bringing world oil consumption to U.S. levels. It is another activity that helps students use large numbers (e.g., scientific notation).

**FALL BREAK**

| | | |
|---|---|---|
| **Week 9** | **Geologic Processes and Mineral Resources** | Chapter 15 |

**Activity:** *Reclamation of Surface-Mined Lands*
A self-designed activity that exposes students to the various techniques used in the reclamation of surface-mined lands. Excellent for demonstrating how our understanding of basic ecological concepts can help us solve complex environmental problems.

**TEST II**

| | | |
|---|---|---|
| **Week 10** | **Preserving Earth's Biodiversity**<br>Endangered Species: The Challenge | Chapter 16 |

**Activity:** *Coral Reef Fishes and Marine Biodiversity*
This activity, from *Environmental Issues: Measuring, Analyzing, and Evaluating,* is an excellent introduction to the importance of the world's major coral reefs and the global threats to their basic health. In addition to furthering their mathematical skills through calculations of biodiversity, students learn about the significance of coral reefs to the carbon cycle.

| | | |
|---|---|---|
| **Week 11** | **Land Resources: Conservation and Development**<br>Land Use: The Human Impact | Chapter 17<br>Chapter 18 |

**Activity:** *Soil Degradation and Erosion*
I take students to several unregulated sites to demonstrate how such uncontrolled development causes serious soil erosion and degradation. If time permits, one can include regulated sites or examples where "the best available" techniques have been used to preserve the integrity of the soil. When the weather prevents us from going outside or when the class is too large, I show students a series of slides illustrating various unregulated construction sites.

| | | |
|---|---|---|
| **Week 12** | **The Atmosphere: Local and Regional Air Pollution** | Chapter 19 |
| | Global Atmospheric Changes | Chapter 20 |
| | **Video:** *What's Up with the Weather?* | |
| **Week 13** | **The Pesticide Dilemma** | Chapter 22 |
| | **Video:** *The American Experience: Rachel Carson's "Silent Spring"* | |
| | Waste: Solid and Hazardous | Chapter 23 |
| **Week 14** | **Reducing Waste** | Chapter 23 |
| | **Activity:** *Interjurisdictional Waste Disposal*<br>This activity, from *Environmental Issues: Measuring, Analyzing, and Evaluating,* demonstrates the magnitude of municipal solid waste that is transported across political boundaries for disposal and the environmental impact of this practice. It is excellent for integrating several diverse concepts related to energy use, pollution, and safety. | |
| | A Review of Environmental Legislation | |
| **Week 15** | **Final Review and Course Evaluation** | |
| | **TEST III** | |

## Teaching Strategies

For each unit, students are given a set of learning objectives and a list of the major concepts and terms they will need to be familiar with and prepared to discuss in class. In addition, they are also assigned outside activities for each major topic. The activities, which are discussed in class, may involve a series of calculations done by the students individually, preparation of a group response to a position paper, analysis of a scientific paper, a critical analysis of an environmentally oriented magazine advertisement, preparation of opposing arguments for a controversial issue, or the collective (group) solution to a complex environmental problem. During the semester all students, either as individuals or as part of a group, serve as the discussion leader(s) during one or more of the class activity periods. A sample for the unit "Properties of Natural Ecosystems" (Week 4) is shown here.

## Properties of Natural Ecosystems

**Learning Objectives**

- Define and describe the different levels of ecological organization and ecological study.
- Understand the complexities of the organization of an ecosystem; the Chesapeake Bay.
- Understand the fundamental laws of energy conservation and energy flow as they relate to living biological systems.
- Explain how the trophic structure of natural ecosystems demonstrates the second law of thermodynamics.
- Distinguish the different ecological roles played by producers, consumers, and decomposers in natural ecosystems.
- Discuss at least two major human impacts on biogeochemical cycles.
- Define the niche concept and the roles of competitive exclusion and limiting factors in determining niche breadth within communities.
- Describe how communities change over time through succession.
- Understand the basis of global climatic patterns and indicate several factors responsible for maintaining the earth's climate.
- Compare and contrast the characteristics of the earth's major terrestrial ecosystems.
- Describe some environmental problems associated with early industrialization.
- Discuss the causes that brought about citizen environmental activism in the United States in the 1960s.
- Explain the significance of the United Nations Conference on the Human Environment held in Stockholm, Sweden in 1972.

**Important Terms**
Biosphere
Ecosystem
Biological Community
Biogeochemical Cycles
Producers
Consumers
Decomposers
Food Chain
Food Web
Trophic Level
Bioamplification (Biomagnification)
Niche
Ecological Succession
Competition/Competitive Exclusion

**Important Concepts and Principles**
First Law of Thermodynamics
Second Law of Thermodynamics
Law of Conservation of Matter
Agricultural Revolution
Demographic Transition
Industrial Revolution
Advanced Industrial Society
Environmental Movement

**Laboratory Component**
This class does not have a separate laboratory component.

## Student Activity

**Applying the Reasoning Process**
"Applying the Reasoning Process: Evaluating the Evidence and Claims in a Scientific Article or Magazine Advertisement" is an activity I have students do on a regular basis throughout the semester. It is basically an application of the rules of critical thinking that I introduce into my course during the first weeks of class. I generally start by selecting a short article from an easy-to-read science journal like *Science News* or

an issue-oriented advertisement from any magazine that takes a specific position on an environmentally related issue. Students are given a copy of the article or advertisement with the assignment of analyzing it for the evidence and claims it makes in support of its positions and conclusions.

For each article or advertisement, students are required to apply the following rules of critical thinking (the applicability of the rules will vary somewhat depending on the nature of the article and most certainly in the case of an advertisement).

1. Gather as much information as you can.
2. Be sure that all terms and concepts are defined and that you understand these definitions.
3. Question how the data were obtained.
   - Were the studies involved well designed and carried out?
   - Were there an experimental group and a control group?
   - Were the control and experimental groups treated identically except for the variable changed in the experimental group?
   - Did the investigators repeat the experiments and get essentially the same results? If so, what was the estimated error or degree of uncertainty in the results?
   - Were the results verified by one or more other investigators?
4. Question the conclusions derived from the data.
   - Do the data support the claims, conclusions, and predictions?
   - Are other interpretations possible or more reasonable?
   - Do the conclusions involve a correlation or apparent connection between two or more variables, or do they imply a strong cause and effect relationship between such variables?
   - Are the conclusions based on the results of original research by experts in the field involved, or are they conclusions drawn by reporters or scientists in other fields?
5. Question the assumptions and biases of the investigators.
   - Do the investigators have a monetary or political interest in the outcome of the investigation or issue involved?
   - What are the basic underlying assumptions of the investigators? Would investigators with different basic assumptions take the same data and come to different conclusions?

6. Expect and tolerate uncertainty. Recognize that science is a dynamic process that provides only a certain degree of probability or certainty and that the more complex the system or process being investigated, the greater the degree of uncertainty.
7. Look at the big picture.
   - How do the results and conclusions fit into the whole system involved?
   - What additional data and experiments are needed to relate the results to the whole system?
8. Take a position by either rejecting or conditionally accepting the claims. You will rarely have enough information to answer all your questions.
   - Reject claims not based on any evidence, based on insufficient evidence, or based on evidence from questionable sources.
   - If evidence does not support a claim, reject it and state the conclusion you would draw from the evidence.
   - If the evidence supports the claims, conditionally accept the claims with the understanding that your support may change if new evidence arises.

## Student Evaluation

Student grades are based on three major tests (50 percent) and a final exam (15 percent), as well as graded activities (15 percent), participation in discussion (10 percent), and a weekly newspaper journal that is graded as a final project (10 percent).

## Teaching Resources

**Textbook**

Raven, Peter H., and Linda R. Berg. *Environment.* 3rd ed. Fort Worth: Harcourt College Publishers, 2001.

**Resource Books**

Allen, John, ed. *Annual Editions: Environment 2001/2002.* 20th ed. Guilford, CT: Dushkin, 2001.

Ambrose, et al. *Regional Environmental Issues*. Manual for the Southeastern United States. N.p.: Saunders College Publishing, 1993.

Goldfarb, Theodore D., ed. *Taking Sides: Clashing Views on Controversial Environmental Issues.* Current ed. New York: McGraw-Hill/Dushkin.

McConnell, Robert L., and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating.* Upper Saddle River, NJ: Prentice Hall. Both the first edition (1999) and the second edition (2002) are used.

The Worldwatch Institute. *State of the World 2002: Report on Progress Toward a Sustainable Society.* New York: W. W. Norton, 2002.

_____. *Vital Signs 2002: The Environmental Trends that Are Shaping Our Future.* New York: W. W. Norton, 2002.

**Periodicals**

Reprints and publications of relevant articles from periodicals, technical reports, miscellaneous printings, and newspapers are made available to students on a reserve shelf in the library. Articles used during a given semester might be taken from:

- journals like Science, Nature, Science News, Scientific American, Environment, Catalyst, and Worldwatch;
- magazines like Audubon, Smithsonian, Natural History, Sierra, and The Nature Conservancy;
- newsletters like those from of the Union of Concerned Scientists and Environmental Defense; and
- relevant articles from current newspapers.

**Internet Sites**

For census information: U.S. Census Bureau—www.census.gov

For current U.S. and world population data: Population Connection—www.populationconnection.org

For earth sciences information: U.S. Geological Survey—www.usgs.gov

For economic and environmental issues: The Fraser Institute—www.fraserinstitute.ca

For environment and economics: Foundation for Teaching Economics—www.fte.org

For the Environmental Protection Agency: www.epa.gov

For environmental research and policy information: World Resources Institute—www.wri.org

For general environmental information: www.earthsystems.org

For population data: www.ibiblio.org/lunarbin/worldpop

For the Population Reference Bureau: www.prb.org

**Videos**

*The American Experience: Rachel Carson's "Silent Spring."* Produced by Neil Goodwin. PBS, 1993. 60 minutes. This can be ordered from PBS at www.pbs.org (click on the "Shop PBS for Teachers" box) or 800 328-7271.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each. *The Environmental Revolution, Only One Atmosphere,* and *More for Less* from this series are used.

*What's Up with the Weather?* Produced by Frontline and NOVA. Boston: WGBH Boston Video, 2000. 120 minutes.

**Overhead Transparencies/Slides**

Transparencies to accompany the third edition of *Environment,* by Peter H. Raven and Linda R. Berg.

Personal slides of major ecosystems, ecological succession, endangered species, and various examples of environmental pollution.

## Personal Philosophy

***Arthur N. Samel***

*Bowling Green State University*

*Bowling Green, Ohio*

The philosophy of the Center of Environmental Programs is that our students will become more responsible stewards of the environment if they acquire a general understanding of the natural environment and are able to assess how human activity alters this extremely complex system.

## School Profile

**School Location and Environment:** Bowling Green State University is located in a rural, agricultural setting. The city of Bowling Green, Ohio, has a population of approximately 300,000 and is 25 miles south of Toledo, a city of approximately 325,000. A substantial minority of the students at Bowling Green State University represent the first generation from their families to go to college. A large majority of the students (90 percent) are residents of Ohio, and a significant cohort is from the Cleveland area. Bowling Green students represent every state in the country and over 75 foreign countries, giving the university quite a bit of diversity. Many of our undergraduates come from urban or suburban backgrounds and have a limited understanding of the surrounding environment. The university's psychology, sociology, biology, and photochemical sciences programs are highly ranked within their disciplines.

**Type:** Ph.D.-granting university.

**Total Enrollment:** 20,480 undergraduate and graduate students.

**Ethnic Diversity:** Approximately 13 percent of the student population.

## Overview of Introduction to Environmental Studies

The Center for Environmental Programs offers 9 to 12 sections of Introduction to Environmental Studies (ENVS 101) each semester. This is an introductory course that satisfies a social science undergraduate requirement. Classes are offered on a Monday/Wednesday/Friday rotation (50 minutes per session) or a Tuesday/Thursday schedule (75 minutes per session). The majority of students who take the course are freshmen, though students at all levels are enrolled. Enrollment is limited to 35 per section, where total annual registration is 700 to 750 students. Because this course satisfies a social (versus natural) science requirement it has no separate lab component. However, students do pay a lab fee for the course, which is used to defray field trip expenses. There are no prerequisites for taking this course.

## Course Overview

The environment, by definition, makes up everything that surrounds us. It is *not* an unchanging "quantity," and we, as humans, have caused substantial impacts. The goal of this course is to acquire a general understanding of the natural environment and to assess how human activity alters this extremely complex system. The premise is that an increasing population magnifies these impacts, and this is a theme that is woven throughout the lecture material. Given the wide scope of the course, we focus on four broad content areas: ecosystems, population, energy, and pollution. Each content area is discussed in detail while population issues are integrated throughout the course conversation. Anticipated learning outcomes are to:

- Identify environmental issues and problems and to formulate and frame these in ways that contribute to their solution.
- Examine the nature of decision making and the environment from a social sciences perspective and to discuss how values impact the decision-making process.
- Construct and present an argument and use evidence that supports your conclusion.
- Explore the significance of diverse cultures and how their modes of thought impact the environmental choices they make.

These outcomes are attained as each of the topics listed in the Course Planner are addressed.

**Textbooks**

The two texts used in the course are the eighth edition of *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith (Boston: McGraw-Hill, 2002) and the tenth edition of *Taking Sides: Clashing Views on Controversial Environmental Issues,* edited by Theodore D. Goldfarb (New York: McGraw-Hill/Dushkin, 2003).

## Course Planner

I do not, as a rule, include a date-specific planner in my course syllabus because I like to build in sufficient flexibility to accommodate active student participation when there is strong interest in one or more of the topics covered in the course. So the planner presented below for the fall semester of 2002 is a best-guess estimate.

| | Enger & Smith | Goldfarb |
|---|---|---|
| **Week 1: Environmental Interrelationships** | | |
| *August 27:* Introduction to the environment | 1 | |
| *August 29:* The environment as a scientific discipline | 1 | |
| **Week 2: Environmental Ethics** | | |
| *September 3:* Environmental attitudes and philosophy | 2 | |
| *September 5:* Individual and corporate ethics | 2 | |
| **Week 3: Ethics (continued); Environment and Organisms** | | |
| *September 10:* Environmental justice | 2 | |
| *September 12:* Energy and mass movement in the environment | 4 | |
| **Week 4: Environment and Organisms (continued)** | | |
| *September 17:* Habitats, niches, natural selection | | 5 |
| *September 19:* Natural selection (continuted), evolution, and kinds of organism interactions | 5 | |
| **Week 5: Ecosystems and Communities** | | |
| *September 24:* Succession and climax communities | 6 | |
| *September 26:* Climate and biomes | 6, 17 | |
| **Week 6: Ecosystems (continued)** | | |
| *October 1:* Biomes (continued) | 6 | |
| *October 3:* U.S. Endangered Species Act | | 3 |
| **Week 7 (Exam Week)** | | |
| *October 8:* Exam 1, covers all material through Week 6 | | |
| *October 10:* Fall Break, no class | | |

# Syllabus 6

| | Enger & Smith | Goldfarb |
|---|---|---|
| **Week 8: Population Principles** | | |
| *October 15:* Population characteristics (distribution, density, carrying capacity, etc.) | 7 | |
| *October 17:* Exotic and invasive species | 7, 12 | |
| **Week 9: Human Population** | | |
| *October 22:* Trends and factors that control human population; demographic transition | 8 | |
| *October 24:* U.S. and global population: past, present, and future | 8 | 7 |
| *October 26:* Field trip to St. Johns Woods (exotics removal) | | |
| **Week 10: Human Impacts on Ecosystems** | | |
| *October 29:* Sustainability and resource management | 12 | |
| *October 31:* Cost-benefit analysis; managing ecosystems | 12 | |
| *November 2:* Field trip to campus woodlot (prairie seeding) | | |
| **Week 11: Energy Resources** | | |
| *November 5:* Nonrenewable energy; fossil fuels | 10 | 18 |
| *November 7:* Renewable and potentially renewable resources (e.g., solar and fuel wood) | 10 | |
| **Week 12: Nuclear Energy** | | |
| *November 12:* History, reactors, and fuel cycle | 11 | |
| *November 14:* Nuclear waste | | 15 |
| **Week 13: Hazardous Materials** | | |
| *November 19:* Defining hazardous waste | 19 | |
| *November 21:* Environmental problems caused by hazardous waste | 19 | 13 |
| **Week 14 (Exam Week)** | | |
| *November 26:* Exam 2 (covers all material through Week 12) | | |
| *November 28:* Thanksgiving, no class | | |

| | Enger & Smith | Goldfarb |
|---|---|---|
| **Week 15: Solid Waste** | | |
| *December 3:* Methods of waste disposal | | |
| *December 5:* Municipal waste and waste reduction: reduce, reuse, recycle | 18 | 14 |
| **Week 16: Agriculture and Pest Management** | | |
| *December 10:* Different agricultural approaches; fertilizers | 15 | |
| *December 12:* Fertilizers (continued), pesticides | 15 | 9 |
| **Week 17: (Exam Week)** | | |
| *December 16 – 20:* Comprehensive final exam scheduled by the university for Wednesday (12/18), 8:30 a.m.–10:30 a.m. | | |

## Teaching Strategies

Given that ENVS 101 is a survey course, we have a lot of ground to cover in a relatively short period of time. So, for better or worse, much of the material in the course planner is conveyed in a lecture setting. Clearly, there are other meaningful ways to convey the material, and I do my best, given the time constraints, to add as much context to the course as possible. I choose to use the *Taking Sides* book because it allows me to divide the class into several groups that collaborate on each issue and develop and lead in-class debates. I have found this group-based (cooperative) learning approach to be very successful with underclassmen who need a little extra encouragement to become involved in classroom discussions. In addition to the cooperative learning that takes place within the classroom, I involve my students in a major service or work-based learning project each semester I teach the course. The project has two primary purposes: 1) to give students an opportunity to work in the field (literally) so they can actually spend some time in the environment, and 2) to teach them the value of serving the community.

## Student Activity

**Prairie Restoration Field Project**

The specific learning outcomes for this activity are to:

1. Make students sensitive to the fact that virtually all ecosystems surrounding us have been disturbed by human activities,
2. Show students the difference between native species and "exotic" species that have either been introduced by humans or have entered an ecosystem as a consequence of some human-related disruption to the ecosystem, and
3. Provide a hands-on experience for students so that they can appreciate the work that is required to help restore an ecosystem to its undisturbed state.

I have two planned field trips that enable students to achieve these learning outcomes. The first field trip is to the campus woodlot and takes place on October 26. The woodlot was a former dumping ground for the university. It is an example of an "unhealthy" forest ecosystem and is currently being restored by the Center for Environmental Programs to an oak prairie ecosystem. The second field trip is to St. Johns Woods and takes place on November 2. St. Johns Woods is an 85-acre parcel of old-growth forest on the west side of the town of Bowling Green. The parcel is surrounded by prairie and the entire property is maintained by the Wood County (Ohio) Parks and Recreation Department.

All content contained in this exercise fits into the broader theme of human disruption to ecosystems. Prior to the field trips, students are asked to keep a journal of the animal and plant species they see during a one-week period. They are expected to identify whether the species are native to northwest Ohio or exotic. This helps them realize, before the field trips take place, that most of what surrounds us is exotic. The field trips are deliberately scheduled to take place on consecutive Saturdays to 1) provide plenty of time for the students to investigate these "natural" areas, and 2) give us a chance between the activities to discuss our preconceived notions, observations, and expectations. Students are expected to write these details in their journals and, one week after the second field trip, are expected to turn their journals in for grading. Aside from the content listed in this paragraph, students are expected to gain real-world experience in prairie restoration by helping to remove exotic species (primarily garlic mustard) from the campus woodlot and by spreading native grass seed in the prairie that surrounds St. Johns Woods.

Although many of the procedural steps have been outlined, I also want to mention that I too am a participant in the activities. The field trips are actually led by someone from the Wood County Parks and Recreation Department (St. Johns Woods) and the manager of the campus woodlot. Before we engage in the work and service-based learning parts of the activity, a tour of each site is given. The tours emphasize the current state of the two parcels and show us how to identify the native and exotic species. The tour also focuses on restoration and shows us what has been done to restore each parcel to its natural state.

## Student Evaluation

There are two 75-minute midterm examinations and a comprehensive two-hour final examination. Both midterms are worth 100 points while the final exam is worth 150 points. In addition, occasional pop quizzes are given at the beginning of class to ensure that students keep current with the lectures. These quizzes are worth a total of 50 points. All quiz and exam questions are free-response. Most questions require short answers on the order of two or three well-written sentences. The exams also contain several questions that require students to show critical thinking skills. Substantially more writing is required to fully answer these questions. The field trip project is worth a total of 100 points. Finally, students are expected to be actively engaged in classroom discussions throughout the semester to earn a participation grade (100 points).
In summary:

| **Event** | **Point Value** |
|---|---|
| Midterm 1 | 100 |
| Midterm 2 | 100 |
| Quizzes | 50 |
| Participation | 100 |
| Field Trip Project | 100 |
| Final | 150 |
| **TOTAL** | **600** |

Final course grades are assigned solely on the basis of performance, are rarely curved up, and are never curved down. The point range that corresponds to a specific letter grade is not determined until after the final course distribution has been calculated at the end of the semester.

## Teacher Resources

The Center for Environmental Programs houses a resource room that contains a substantial collection of books, scholarly journals, and magazines published by the popular press, as well as videos and DVDs. Students are given a tour of the Resource Room at the beginning of the semester and are expected to use its resources to prepare for classroom debates on the issues presented in *Taking Sides.* I rarely use the video and DVD collections during class because of the limited number of meeting times I have with my students. Students are encouraged to sign out relevant videos and DVDs (24-hour checkout is allowed) so that they may watch them at home.

## Personal Philosophy

***Ben Smith***

*Palos Verdes Peninsula High School*

*Rolling Hills, California*

*Students conduct water quality tests on their ecosystems columns.*

*Photograph courtesy of Ben Smith.*

Teaching AP Environmental Science provides a wide variety of opportunities to explore topics that are quite relevant, meaningful, and of interest to students. Students often lack chances to study many of the topics that are fundamental to this course, such as the rate of human population growth and the impacts of such growth, energy use and ways to increase energy efficiency, alternative practices in solid waste management, and so on. Students find that AP Environmental Science topics apply to their everyday lives and to the choices they make today and will make throughout their lives.

Some of my goals and hopes for my students are that by the end of the course they will have increased their "environmental science literacy," that they are better able to make decisions on environmental issues, and that they are better able to see, understand, and appreciate the interrelationships and connections between the many environmental science topics. The William Butler Yeats quote, "Education is not the filling of a pail, but the lighting of a fire," fits well with how I view the AP Environmental Science course and what it provides for students. Without a doubt, environmental science is an academic discipline composed of a very wide variety of topic areas and a vast quantity of information. The application of the knowledge and understanding gained through the study of these topics is fundamental in achieving sustainability.

# School Profile

**School Location and Environment:** Palos Verdes Peninsula High School is located in Rolling Hills, California, one of several communities that sit on the Palos Verdes Peninsula in the Los Angeles area. The school campus is located in a primarily residential area approximately two miles from the ocean, 20 minutes from the Santa Monica Mountains, and 160 miles from Joshua Tree National Park. The Palos Verdes Peninsula coastline stretches from Long Beach and San Pedro to the south of Redondo Beach and up to Hermosa Beach and Manhattan Beach to the north. Approximately 10 percent of the students come from homes in which English is a second language.

**Grades:** 9–12.

**Type:** Public high school.

**Total Enrollment:** Approximately 3,050 students.

**Ethnic Diversity:** Asian Americans compose 38 percent of the student population; African Americans 12 percent; Hispanics 4 percent; and other minority groups 4 percent.

**College Record:** Ninety-eight percent of the graduating seniors continue their education at a college or university.

# Overview of AP Environmental Science

**AP Program**

AP courses have been a part of the academic program at Palos Verdes Peninsula High School since the school's inception in 1991, following the consolidation of Rolling Hills High School, Miraleste High School, and Palos Verdes High School. AP courses were offered at these schools from their opening years in the 1960s. Palos Verdes Peninsula High School offers 25 AP courses and has over 1,000 students participating in its program.

Students are encouraged to take the AP Exam, but they are not required to do so. The vast majority of the AP students do choose to take the exam, and typically 99 percent of my own AP Environmental Science students do. Students who choose to take the exam pay the fee themselves.

**Class Profile**

I typically teach five sections of AP Environmental Science each year, with approximately 32 students in each class. Each class meets Monday through Friday for a 54-minute period. Laboratory and fieldwork is conducted within these standard periods, with additional fieldwork carried out after school and on weekends.

**Prerequisites**

Students who wish to enroll in the AP Environmental Science course must have completed two semesters of biology and two semesters of chemistry.

## Course Overview

AP Environmental Science at Palos Verdes High School is a two-semester course that examines a variety of natural science fields (e.g., environmental science, ecology, environmental studies, geology, chemistry, geography) and several social science disciplines (e.g., economics, politics, ethics). The course is designed to fully acquaint students with an understanding of the many topics and subject areas within the environmental science field and to provide them with many opportunities to apply their environmental science knowledge and understanding to their daily lives today and throughout their lives. The course is designed to promote environmental science literacy so that students will be better prepared to make decisions about issues that impact the environment, be it on a small or large scale. Additional course objectives include establishing and building in every student a sense of stewardship for the environment and illustrating, throughout the course, that one person *can* make a difference.

*Examining aquatic invertebrates on the banks of the Animas River in Durango, Colorado.*

*Photograph courtesy of Ben Smith.*

**Text**

The primary textbook used in the course is the twelfth edition of *Living in the Environment: Principles, Connections, and Solutions*, by G. Tyler Miller.

## Course Planner

The following is a list of the chapter topics and the exam dates that have been set for each chapter or topic exam. This schedule may be altered slightly as we move through the school year. The quarter and semester exams are comprehensive. Several sample labs or projects are listed for most topics.

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 1 | *Environmental Issues, Their Causes and Sustainability*<br>A. Estimating Your Ecological Footprint<br>B. Salinization Lab<br>Examines the influence of varying salt concentrations on agricultural yields.<br>C. Tragedy of the Commons Simulation<br>D. Begin "scrAPESbook" (environmental science in the news) | 20 | 6 | Thursday, September 12 |
| 2 | *Environmental History*<br>A. Selected Works by Environmental Authors: R. Carson, A. Leopold, J. McPhee, E. Abbey, G. Ehrlich, M. Hertsgaard<br>B. Hetch Hetchy Debate | 8 | 5 | Thursday, September 19 |
| 3 | *Science, Systems, Matter, and Energy*<br>A. Solar Energy Lab | 25 | 8 | Thursday, September 26 |

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 4 | *Ecosystems: Components, Energy Flow, and Matter Cycling*<br>A. Ecosystem Column Lab<br>Aquatic and terrestrial ecosystem dynamics are monitored in a series of ecosystems using two-liter, three-liter, and/or larger containers. | 31 | 8 | Monday, October 7 |
| 5 | *Evolution and Biodiversity*<br>A. Biodiversity Lab: Bait Cards | 17 | 4 | Friday, October 11 |
| 6 | *Biogeography: Climate, Biomes, and Terrestrial Biodiversity*<br>A. Habitat Islands Lab<br>B. Biome Presentation/Reports | 31 | 7 | Friday, October 18 |
| 7 | *Aquatic Ecology; Aquatic Biodiversity*<br>A. Tide Pool Outing | 20 | 4 | Friday, October 25 |
| 1–7 | **First Quarter Final Exam/Midterm** | 162 | 42 | October 28 – November 1 |
| 8 | *Community Ecology: Structure, Species Interactions, Succession, and Sustainability*<br>A. Food Web Activity | 24 | 6 | Tuesday, November 12 |
| 9 | *Population Dynamics, Carrying Capacity, and Conservation Biology*<br>A. Mark and Recapture Lab<br>B. Earth's Carrying Capacity Lab | 25 | 9 | Wednesday, November 20 |
| 22 | *Sustaining Wild Species*<br>A. Endangered/Threatened Species Reports | 34 | 6 | Tuesday, December 3 |

# Syllabus 7

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 23 | *Sustaining Terrestrial Biodiversity*<br>A. National Park/Refuge/Preserve Project<br>Research the ecology, biology, geology, hydrology, botany, natural history, and challenges faced by these public lands in the United States and other nations. | 43 | 7 | Thursday, December 12 |
| 24 | *Sustaining Aquatic Biodiversity*<br>A. Raising and Releasing Rainbow Trout | 28 | 6 | Wednesday, December 18 |
| 10 | *Geology: Processes, Hazards, and Soils*<br>A. Soil Lab: Porosity, Permeability, Texture | 24 | 6 | Thursday, January 9 |
| 11 | The Human Population<br>A. Cemetery Lab<br>Human population study. Students generate lifespan graphs after gathering data in a local cemetery.<br>B. Land Needed to Feed You Project<br>Students calculate the land area (in hectares or acres) needed to grow their food for one year, based on their food intake for a one- or two-week period. | 22 | 5 | Thursday, January 16 |
| 1–11 and 22–24 | **Semester I Final Exam** | 362 | 87 | January 22, 23, 24 |

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 25 | *Sustainable Cities: Urban Land Use and Management*<br>A. Land Use Planning Project<br>Sustainable development is the focus of this project in which students design a city of 150,000 people and the services and structures needed to support its inhabitants. "Environmentally sound" methods and approaches should be used with the entire design of the project and include the following areas: energy production, water resource management, agriculture, industrial and commercial ventures, waste management, housing, schools, parks, riparian areas, public lands. | 28 | 5 | Monday, February 3 |
| 16 | *Risk, Toxicology, and Human Health*<br>A. Toxicity Lab<br>B. Ultraviolet Light Intensity Lab | 20 | 5 | Handout Only |
| 12 | *Food Resources*<br>A. Genetically Modified Food Reports | 32 | 8 | Tuesday February 11 |
| 13 | *Water Resources*<br>A. Wastewater Treatment Plant Trip<br>B. Designing a Wastewater Filter<br>C. Water Audit | 25 | 9 | Wednesday, February 19 |
| 19 | *Water Pollution*<br>A. Water Quality Testing<br>B. Cultural Eutrophication Lab | 25 | 6 | Tuesday, February 25 |

# Syllabus 7

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 21 | *Solid and Hazardous Waste*<br>A. Personal Solid Waste Inventory<br>(See "Student Activity" on page 143.)<br>B. Shoreline and Roadside Solid Waste Inventory<br>C. Plastics Degradation Lab<br>D. Grass Decomposition Lab | 30 | 10 | Wednesday, March 5 |
| 17 | *Air Pollution*<br>A. Field Testing for Ozone<br>B. Particulate Lab<br>C. Auto Exhaust Testing | 28 | 7 | Wednesday, March 12 |
| 18 | *Climate Change and Ozone Loss*<br>A. Estimating Your Carbon Dioxide Emissions | 29 | 7 | Thursday, March 20 |
| 20 | *Pesticides and Pest Control* | 15 | 5 | Wednesday, March 26 |
| 12–13<br>16–21,<br>25 | **Third Quarter Final Exam/Midterm** | 232 | 62 | March 31–April 4 |
| 14 | *Geologic Resources: Nonrenewable Mineral and Energy Resources*<br>A. Mining Simulation | 37 | 9 | Friday, April 18 |
| 15 | *Energy Efficiency and Renewable Energy*<br>A. Energy Audit | 36 | 10 | Thursday, April 24 |
| 26 | *Economics and the Environment* | 26 | 7 | Additional Information |

| Chapter | Topic | Number of Pages | Number of Sections | Date |
|---|---|---|---|---|
| 27 | *Politics and the Environment* | 26 | 6 | Review Big Ideas |
| 28 | *Ethics and the Environment* | 17 | 3 | |
| All Chapters | **Final Exam** | 758 | 180 | April 29–30 |

## AP Exam Preparation

**Review for the May AP Exam**
May 1, 2, 5, 6, 7, 8, 9, 12, and 13

**Additional Review Sessions**
Additional sessions will be held after school and on weekends.

**Exam Date**
AP Environmental Science Exam: Wednesday, May 14, 1:00 p.m.–5:00 p.m.

## Post-AP Exam Assignments

Post-AP Exam Assignments: May 15, 16, 19–23, 27–30, June 2–6, 9–12

Examples of these include:

1. Environmental book of choice. Read a book that has a clear environmental theme running through it and produce a report or journal on the work.
2. Several labs and field investigations we did not have time for prior to the AP Exam.
3. Several videos (e.g., *Never Cry Wolf, A Civil Action, Baraka*).
4. Readings from periodicals (e.g., *Worldwatch, Audubon, Wild Earth, Nature, National Geographic, High Country News, Earthwatch, E/The Environmental Magazine*).

# Teaching Strategies

The teaching and learning methods used in this class include a combination of lecture-discussion; student presentations, seminars, and debates; and laboratory and fieldwork. Students in the course have historically preferred examinations over one or two chapters at a time, as opposed to having one exam every three or four weeks. This approach seems to work very well in continually building on the foundation, which I begin to establish from day one of the course, and it seems to be very effective in helping to prepare students for the two midterm exams, the two final exams, and the AP Exam. Homework assignments are composed predominately of text readings, with periodic quizzes (announced and unannounced) and typically a question set for each chapter. In addition, oral presentations and written reports on specific topics are assigned throughout the course, with laboratory reports required for all labs and fieldwork performed.

## Lab Component

Labs are conducted within the 54-minute class periods, with no double period or block schedule. Although the majority of lab work is done in the classroom, many investigations are done in the field. Examples of these outdoor investigations include species diversity labs, air and water quality monitoring, UV intensity labs, soil profiles, rainbow trout release, and succession, to name a few.

Examples of field trips and outings taken during the course include beach cleanups and habitat restoration work for the endangered Palos Verdes Blue Butterfly and visits to an oil refinery, desalination plant, local marsh, wastewater treatment plant, Joshua Tree National Park, Sequoia and Kings Canyon National Parks, and state parks.

The computer simulation labs used in this course come from the *Environmental Science: Field Laboratory* CD-ROM by Falcon Software.

*AP Environmental Science teacher Ben Smith seines with students on the San Gabriel River in the Angeles National Forest, California.*

*Photograph courtesy of Ben Smith.*

Students work in lab groups the majority of the time, with several investigations done individually.

## Student Activity

*Weighing personal solid wastes accumulated during the seven-day assignment period.*

*Photograph courtesy of Ben Smith.*

**Personal Solid Waste Inventory**

Students record all of the materials (throughputs) they use in a seven-day period. Materials recorded should include all solid waste as well as any items that may be recycled or reused in some way. Examples of items to be recorded include mailed letters, junk mail, food wrappers, beverage containers, other product packaging (e.g., shampoo bottles, deodorant containers, toothpaste tubes), newspapers, aluminum foil, plastic and paper grocery bags, cardboard pizza boxes, paperboard roll from toilet paper, and so on. All students are to keep a running inventory of their solid wastes throughout the week, with a final tally of the number of items in each major material category (e.g., paper, paperboard/cardboard, plastic, aluminum, Styrofoam, mixed metals, glass) being tabulated at the end of this time period.

For bonus points, students may choose to *carry* all of their solid waste materials. Students who choose to do this extension of the assignment must carry any and all of the solid waste materials they generate or use during the assigned seven-day inventory period, except those materials that might present a health concern, such as used hygiene items and food waste. Students who choose to do the bonus portion of this assignment must carry their solid waste bag(s) with them at *all times* during the school day. They may not simply store their solid waste bag in their locker or car. (Students who participate in a sport or other extracurricular activity do not have to carry their solid waste bag during this activity.)

In addition to tallying all of their waste materials by category, students who have carried all of their materials (typically 95 to 99 percent of the students) mass their waste materials by category, using spring scales, and then calculate a total mass of all of their materials for the week. From this point, students calculate the mass of their *annual* solid waste production based on this seven-day period. A total solid waste mass for the entire class, as well a total for all AP Environmental Science classes may then be determined.

**Solid Waste Inventory Tally Sheet**

**Name** _____ **Period** _____ **Date** _____

*Directions:* Complete the tally sheet for your solid waste inventory, then complete the questions that follow. Use additional paper if you need more space. After tallying, use spring scales to mass each category of solid waste materials and record their values in the appropriate spaces. Use the "Other" category for any materials that do not easily fit in those provided.

1. Total **Plastic** = _____ (mass in grams or kilograms) = _____ in a year.

   Item category tally: **Plastics**

| Item | Number of Pieces | Item | Number of Pieces |
|---|---|---|---|
| Beverage containers/lids | = _____ | Straws | = _____ |
| Food wrappers | = _____ | Forks/spoons | = _____ |
| Non-food wrappers/packaging | = _____ | Other plastic | = _____ |
| | | (_____ ) | |

2. Total **Paper** = _____ (mass in grams or kilograms) = _____ in a year.

   Item category tally: **Paper**

| Item | Number of Pieces | Item | Number of Pieces |
|---|---|---|---|
| School-related papers | = _____ | Store receipts | = _____ |
| Pages of newspaper | = _____ | Mail pieces | = _____ |
| Pages of magazines | = _____ | Pages of catalogs | = _____ |
| Paper bags | = _____ | Paper towels/napkins | = _____ |
| Toilet paper (squares of or estimate of) | = _____ | Other paper | = _____ |
| | | (_____ ) | |

3. Total **Paperboard/Cardboard** = _____ (mass in grams or kilograms) = _____ in a year.

   Paperboard/cardboard pieces = _____

4. Total **Aluminum** = _____ (mass in grams or kilograms) = _____ in a year.

   Item category tally: **Aluminum**

| Item | Number of Pieces | | Item | Number of Pieces |
|---|---|---|---|---|
| Cans | = _____ | | Foil | = _____ |
| Other Al containers | = _____ | | | |

5. Total **Glass** = _____ (mass in grams or kilograms) = _____ in a year.

   Item category tally: **Glass**

| Item | Number of Pieces | | Item | Number of Pieces |
|---|---|---|---|---|
| Bottles | = _____ | | Jars | = _____ |
| Other glass | = _____ | | | |

6. Total **Mixed Metals** = _____ (mass in grams or kg) = _____ in a year.

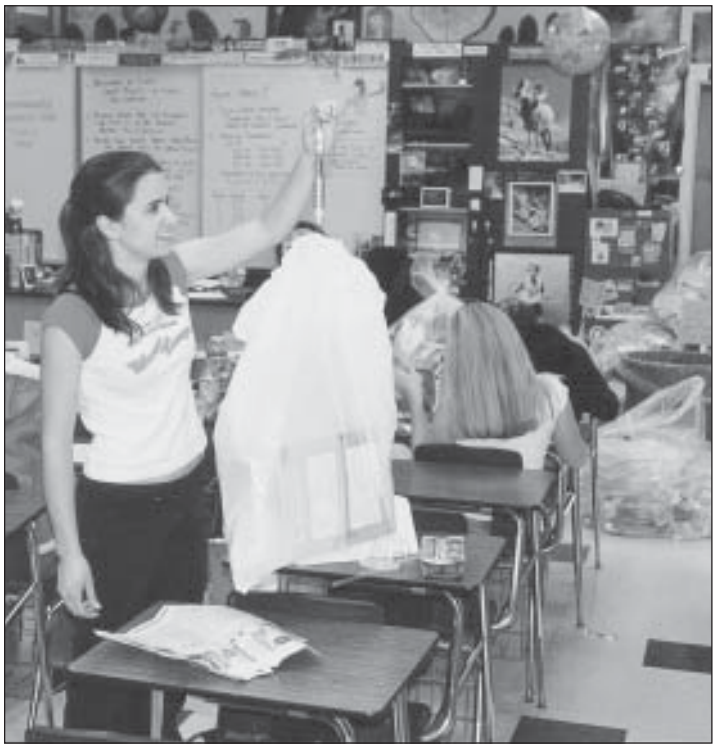
| Item | Number of Pieces |
|---|---|
| Assorted tin and other metals | = _____ |

7. Total **Styrofoam** = _____ (mass in grams) = _____ in a year.

| Item | Number of Pieces |
|---|---|
| Assorted Styrofoam pieces | = _____ |

**Totals**

1. Total Solid Waste Items for the **1 week** inventory period =_____ Items.
2. Total Solid Waste Items for **1 year** = _____ Items.
3. Total Mass of Solid Waste materials for the **1 week period** = _____ kg = ____ lbs.
4. Total Mass of Solid Waste materials for **1 year** = _____ kg =_____lbs.



*"We <u>are</u> the sum of our throughputs."*

*Photograph courtesy of Ben Smith.*

**Questions**

Students are to begin responding to these questions during the class period following the completion of the full seven-day inventory. Questions are to be finished at home and brought to the next class meeting.

- Based on your observations of the solid waste materials displayed on all of the desks in the room, what type or category of municipal solid waste seems to be the most abundant?

- Describe *three* significant and specific environmental impacts that are associated with the "life cycle" of the material type you identified in Question 1.

- If your parents completed this same solid waste project, how do you think their inventories would differ in terms of types and amounts of materials used in a week or in a year? In addition to your thoughts on this matter, please discuss this question with your parents (or grandparents, aunts, uncles) and record their specific feedback regarding this point.

- Did you alter your choices about the foods you ate or the items you purchased or used during the last seven days due to the type or amount of packaging? Describe how your choices were modified during this assignment. If you did the bonus portion of the inventory (the "carry"), was there ever a decision not to, for example, have a little orange juice because it would mean having to carry the large juice container around in your solid waste bag(s)?

- Discuss any aspects of this assignment that you found significant, meaningful, or worthwhile. Describe any experiences you may have had relating to this inventory and carrying of your solid waste material around campus for seven days that you think are memorable.

- Would you change anything about this assignment? If yes, please describe.

## Student Evaluation

Exams and quizzes compose 65 to 70 percent of the overall grade, with the remainder of the points coming from lab reports, homework, projects, and participation. The grading scale that is used is fairly traditional:

A = 90 – 100 percent
B = 80 – 89 percent
C = 70 – 79 percent
D = 60 – 69 percent
F = below 60 percent

The two midterms (end of the first and third quarters) are comprehensive, as are the Semester I final exam and the pre-AP Exam final exam. A typical chapter or topic exam is made up of approximately 45 multiple-choice questions (worth two points each) and one free-response question (worth 30 points). The two midterms and the two final exams are composed solely of multiple-choice questions.

## Teacher Resources

**Environmental Science Textbooks**

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet*. 4th ed. New York: John Wiley, 2003.

Chiras, Daniel D. *Environmental Science: A Systems Approach to Sustainable Development*. 5th ed. Belmont, CA: Wadsworth, 1998.

Cunningham, William P., and Barbara Woodworth Saigo. *Environmental Science: A Global Concern*. 6th ed. Boston: McGraw-Hill, 2001.

Enger, Eldon D., and Bradley F. Smith. *Environmental Science: A Study of Interrelationships*. 7th ed. Boston: McGraw-Hill, 2000.

Raven, Peter H., and Linda R. Berg. *Environment*. 3rd ed. New York: John Wiley, 2001.

Wright, Richard T., and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future*. 8th ed. Upper Saddle River, NJ: Prentice Hall, 2002.

**Lab Manuals, Resource Books, and Software**

Auburn University at Montgomery and Troy State University. *The Water Sourcebook: A Series of Classroom Activities for Grades 9–12*. Atlanta: Georgia Water Wise Council, 1997. This can be found on the North American Association for Environmental Education's Web site as a PDF file at www.naaee.org/npeee/WaterSourcebookv3.pdf (Adobe Acrobat Reader is required to open this document). Or call 800 666-0206.

Bender, David, and Bruno Leone, eds. Opposing Viewpoints series. San Diego: Greenhaven Press.

Bishop, Dwight, John Hirschbuhl, and Jim Jackson. *Environmental Science: Field Laboratory*. Wellesley, MA: Falcon Software. CD-ROM for Windows. This can be ordered from Falcon Software at www.falconsoftware.com or 781 235-1767.

Blair, Robert B., and Heidi L. Ballard. *Conservation Biology: A Hands-On Introduction to Biodiversity*. Dubuque, IA: Kendall/Hunt, 1996.

Brower, James E., Jerrold H. Zar, and Carl N. von Ende. *Field and Laboratory Methods for General Ecology*. 4th ed. New York: McGraw-Hill, 1997.

Campbell, Gayla, and Steve Wildberger. *The Monitor's Handbook*. [Chestertown, MD]: LaMotte Company, 2002.

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities*. 7th ed. New York: McGraw-Hill, 1999. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

Gilligan, Matthew R., Thomas Kozel, and Joseph P. Richardson. *Environmental Science Laboratory: A Manual of Lab and Field Exercises*. Savannah, GA: Halfmoon Publishing, 1991.

Gonick, Larry, and Alice Outwater. *The Cartoon Guide to the Environment*. New York: HarperCollins, 1996.

McConnell, Robert L., and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating*. Upper Saddle River, NJ: Prentice Hall, 2002.

Mitchell, Mark K., and William B. Stapp. *Field Manual for Water Quality Monitoring*. 11th ed. Dubuque, IA: Kendall/Hunt, 1997.

Newton, David E. *Environmental Chemistry*. Portland, ME: J. Weston Walch, 1991.

Newton, Lisa H., and Catherine K. Dillingham. *Watersheds 3: Ten Case Studies in Environmental Ethics*. 3rd ed. Belmont, CA: Wadsworth, 2002.

Ryan, John C., and Alan Thein Durning. *Stuff: The Secret Lives of Everyday Things*. Seattle: Northwest Environment Watch, 1997.

Wasserman, Pamela, and Andrea Doyle. *Earth Matters: Studies for Our Global Future*. Washington, DC: Zero Population Growth, 1991.

Wolff, Robert J., Calvin B. Dewitt, Karen Jankowski, and Gerrit Van Dyke. *Environmental Science in Action*. Fort Worth: Harcourt Brace College Publishers, 1993.

The Worldwatch Institute. *Signposts 2002: Envisioning the Future*. Washington, DC: Worldwatch Institute, 2002. CD-ROM for PC, Mac, and Linux. For more information, contact The Worldwatch Institute at 800 555-2028.

_____. *State of the World: Report on Progress Toward a Sustainable Society*. New York: W. W. Norton, published annually.

_____. *Vital Signs: The Environmental Trends that Are Shaping Our Future*. New York: W. W. Norton, published annually.

**Lab Equipment and Supplies**

Carolina Biological Lab Kits: Monitoring Air Pollution using Drager Tubes (HCs, CO, and $CO_2$), Carolina™ Chemical Characteristics of Soil Kit, field collection nets

LaMotte Air Sampling Pump and reagents for sampling CO, $SO_2$, $NO_2$

LaMotte Water Quality Testing Kits: Dissolved oxygen, carbon dioxide, nitrate, phosphate, turbidity, hardness, pH, salinity

Ward's Scientific Lab Kits: Bioremediation Lab/Oil Degrading Microbes, Ecosystems in Distress Lab Kit, Soil Testing Kit, LD-50 Lab, Effects of UV Radiation Kit, field collection nets

**Videos**

*Affluenza*. Hosted by Scott Simon. Produced by John de Graaf and Vivia Boe. KCTS/Seattle and Oregon Public Broadcasting, 1997. 60 minutes. This can be ordered from Bullfrog Films at www.bullfrogfilms.com or 800 543-3764.

*Africa: The Wilds of Madagascar*. National Geographic Society, 1988. 59 minutes.

After the Warming series. 2 videos. Narrated by James Burke. Maryland Public TV, 1991. 55 minutes each. This can be ordered from Ambrose Video at www.ambrosevideo.com or 800 526-4663.

*Against the Grain: Biotechnology and the Corporate Takeover of Your Food*. Written by Marc Lappé. Produced by Britt Bailey. N.p., 1999. 13 minutes. This can be ordered from The Video Project at www.videoproject.net or 800 475-2638.

*The American Experience: Meltdown at Three Mile Island*. Produced by WGBH. PBS Home Video, 1999. 60 minutes.

*The American Experience: Rachel Carson's "Silent Spring."* Produced by Neil Goodwin. PBS, 1993. 60 minutes. This can be ordered from PBS at www.pbs.org (click on the "Shop PBS for Teachers" box) or 800 328-7271.

*America's Endangered Species: Don't Say Goodbye*. Directed by Robert Kenner. National Geographic Society, 1998. 57 minutes. This can be ordered from the National Geographic Society at www.nationalgeographic.org or 800 368-2728.

*Baraka.* MPI Home Video, 1993. 92 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343-4727.

*Boise Cascade and the Environment*. Boise Cascade Corporation, 1997. 10 minutes. For more information, contact the Boise Cascade Corporation at www.bc.com or 208 384-7990.

Cadillac Desert: Water and the Transformation of Nature series. 4 videos. Directed, produced, and written by Jon Else. Trans Pacific Television and KTEH/San Jose Public Television. Columbia TriStar Television, 1997. For more information, visit www.pbs.org/kteh/cadillacdesert/home.html.

*Cane Toads: An Unnatural History*. Written and directed by Mark Lewis. New York: First Run Features, 1987. 48 minutes. This can be ordered from First Run Features at www.firstrunfeatures.com or 800 229-8575.

*A Civil Action*. Starring John Travolta and Robert Duvall. Directed by Steve Zaillian. Buena Vista Home Entertainment, 1999. 115 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343 4727.

*CNN Today Video: Environmental Science*. 4 videos. Pacific Grove, CA: Brooks/Cole, updated annually. 45 minutes each. Ancillary to the textbook *Living in the Environment: Principles, Connections, and Solutions,* by G. Tyler Miller.

*Common Ground: Modern Mining and You*. Produced by Caterpillar, 1997. 27 minutes. For more information, contact the Mineral Information Institute at www.mii.org or 303 277-9190.

*The Cost of Cool: Youth, Consumption, and the Environment*. Hosted by Alexandra Paul. Populations Communications International, 2001. 27 minutes. This can be ordered from Populations Communications International at www.population.org or 212 687-3366. Also available from The Video Project at www.videoproject.net or 800 475-2638.

*Diet for a New America*. Hosted by John Robbins. Produced by Ed Schuman and Judy Pruzinsky for KCET-TV. Wellspring Media, 1992. 60 minutes. This can be ordered from The Video Project at www.videoproject.net or 800 475-2638.

*Escape from Affluenza*. Hosted by Wanda Urbanska. Produced by Vivia Boe and John de Graaf. A coproduction of KCTS and John de Graaf, 1998. 56 minutes. This can be ordered from Bullfrog Films at www.bullfrogfilms.com or 800 543-3764. Also available from PBS at www.pbs.org or 800 328-7271.

*Fiber Farms: Growing Our Future*. Boise Cascade Corporation, 1997. For more information, contact Boise Cascade Corporation at www.bc.com or 208 384-7990.

*Forest Wars*. Narrated by Lee Horsley. Produced for The Earth Vision Institute by Summit Films, 1996. 72 minutes. For more information, contact the Hardwood Forest Foundation at www.natlhardwood.org or 901 377-1818.

*Great Wall Across the Yangtze*. Narrated by Martin Sheen. Produced and directed by Ellen Perry. PBS Home Video, 2000. 60 minutes. This can be ordered from PBS at www.pbs.org or 800 328-7271.

The Living Planet series. 12 videos. Directed by David Attenborough. Produced by BBC and Time-Life Video, 1984. 60 minutes each. These can be ordered from Ambrose Video at www.ambrosevideo.com or 800 526-4663.

*The Lorax*. Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. This title is out of print but some libraries may have a copy.

*Mind Walk*. Starring Liv Ullman. Paramount Home Entertainment, 1991. 110 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343 4727.

*Mining Seven-Up Pete*. Directed by Drury Carr. Ecology Center Productions, 1997. 29 minutes. This can be ordered from The Video Project at www.videoproject.net or 800 475-2638.

*Natural History of the Chicken*. Directed by Mark Lewis. PBS Home Video, 2001. 60 minutes. This can be ordered from PBS at www.pbs.org or 800 328-7271.

*Never Cry Wolf*. Starring Charles Martin Smith. Anchor Bay Entertainment, 1983. 105 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343 4727.

*Ozone: The Hole Story*. Presented by S.C. Johnson and Sons. Produced by Kurtis Productions, 1992. 58 minutes.

*The People Bomb*. CNN Collection series. Turner Home Entertainment, 1992. 105 minutes. This can be ordered from Videofinders at www.videofinders.com or 800 343 4727.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

*Scientists and the Alaska Oil Spill: The Wildlife, the Cleanup, the Outlook*. Exxon Company, U.S.A., 1992. 22 minutes.

*We All Live Downstream*. Oregon State University Extension Service, 1990. 30 minutes. This can be ordered from The Video Project at www.videoproject.net or 800 475-2638.

*What's Up with the Weather?* Produced by Frontline and NOVA. Boston: WGBH Boston Video, 2000. 120 minutes. This can be ordered from WGBH Boston at 800 949-8670.

*When the Salmon Runs Dry.* Produced by Ben Saboonchian for KIRO-TV. Oregon Public Broadcasting, 1991. 51 minutes. This can be ordered from The Video Project at www.videoproject.net or 800 475-2638.

*World Population*. Washington, DC: Population Connection, 2000. 7 minutes. This can be ordered from Population Connection (formerly Zero Population Growth) at www.populationconnection.org or 800 POP-1956.

## Personal Philosophy

***Judith A. Treharne***

*Ocean Township High School*

*Oakhurst, New Jersey*

In the words of a former AP Environmental Science student, "This course should be required for every high school student!" This is a course that ties together all of the science courses a student has previously taken and places them in a practical, real-world perspective. Through this course, students' critical thinking skills are nurtured, developed, and applied to real problems. I do not expect all of my AP Environmental Science students to become scientists, but I do expect them to become more environmentally literate. This is the most important science course they will ever take!

## School Profile

**School Location and Environment:** Ocean Township High School is located in Oakhurst, New Jersey, a community of approximately 4,130. Oakhurst is about 30 miles south of Newark and 39 miles east of the state capital of Trenton. The high school is located within a short distance of the recreational beaches of the Atlantic Ocean and an extensive park system. Additionally, Monmouth University is located in the Borough of West Long Branch, several miles north of Ocean Township.

**Grades:** 9–12.

**Type:** Public high school.

**Total Enrollment:** Approximately 1,328 students.

**Ethnic Diversity:** African Americans compose 8 percent of the student population; Asian Americans 7.5 percent; Hispanics 3.3 percent; Native Hawaiians/Pacific Islanders 0.7 percent; and Native Americans 0.07 percent. Over the past five years there has been a steady increase in the cultural and ethnic diversity of the students.

**College Record:** Approximately 87 percent of the graduating seniors continue their education in colleges and universities.

# Overview of AP Environmental Science

**AP Program**

Ocean Township High School offers 12 AP courses. In June 2002, a total of 263 AP Exams were administered with 70 percent of the students scoring grades of 3 or higher. All students who enroll in an AP course are required to take the AP Exam and the Board of Education pays the exam fees.

**Class Profile**

One section of AP Environmental Science has been offered each year since its inception in 1998, with the exception of the first year when there were two sections. Section size has ranged from 6 to 13 students. The course meets for the entire academic year, six periods per week—four single class periods and one double lab. Each single class period is 44 minutes and the double lab period is 92 minutes (2 x 44 minutes plus the normal passing time of four minutes between classes since the students are in the same room for the two periods) for a total of 268 minutes per week.

Students enrolled in this course are either juniors or seniors. Since AP Environmental Science is offered during the same period as AP Biology, students generally take AP Environmental Science in their junior year and AP Biology in their senior year. Some students prefer to enroll in AP Environmental Science rather than AP Biology in their senior year.

**Course Prerequisites**

Earth science is offered in the intermediate school and all of our high school freshmen take a physical science course. The prerequisites for AP Environmental Science include biology (as a sophomore) and chemistry or physics concurrently. Therefore, a junior who is enrolled in AP Environmental Science must be concurrently enrolled in chemistry; likewise, a senior must be concurrently enrolled in physics. With this approach, students may not substitute an AP course for the basic sciences.

Scheduling is completed through the student's guidance counselor who reviews previous science and math grades and difficulty levels of each course with the student. Students who are considering enrollment in AP Environmental Science are invited to meet with the course instructor to review the course requirements. A summer reading assignment is given in June and there is a summer reading quiz on the first day of school in September. Average ability students with high interest and motivation as well as Honors students have successfully completed this course.

## Course Overview

The course adheres to the objectives set forth in the *Course Description for AP Environmental Science,* which says this "course is designed to be the equivalent of a one-semester, introductory college course in environmental science" that includes a laboratory and field investigation component. Emphasis is placed on "the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them."

All students who are enrolled in AP Environmental Science are required to complete the summer reading assignment and take the summer reading quiz. They must maintain an organized laboratory data notebook, conduct laboratory work according to safety rules, and submit required formal laboratory reports as assigned. They are expected to complete the assigned readings (approximately a chapter a week plus supplemental readings and case studies) with periodic chapter quizzes and major tests covering two to three chapters. Each quarter there is a group project or presentation. There is a required midterm exam and an "alternate assessment presentation" as a final exam in June, since each student is required to take the AP Exam.

By the very nature of the topics and their relevance to current events, this course appeals to a wide diversity of students with interests in the environment and nature, science, engineering, social sciences, law, economics, computers, literature, and drama. This diversity lends itself to lively discussions and interesting presentations of scientific topics, concepts, and data. The implication of empowering a diversity of students with scientific knowledge about the environment at the college level is an exciting prospect and provides hope for a sustainable future.

**Text**

Miller, G. Tyler. *Living in the Environment: Principles, Connections, and Solutions.* 12th ed. Pacific Grove, CA: Brooks/Cole, 2002.

**Laboratory Manual**

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities.* 6th ed. Dubuque, IA: William C. Brown, 1997. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

## Course Planner

It should be remembered that this is a public high school in the northeastern United States. Therefore, not all of the weeks represented in this course planner are full weeks due to school holidays and weather-related closings. One must be flexible in planning but also remain focused on the goal of completing the topics by the AP Exam date.

**Weeks 1 – 3**

- Summer Reading Quiz
- Definition of Environmental Science
- Scientific Method and Critical Thinking
- Experimental Design and Analysis (chi-square test and p-values)
- Introduction to Environmental Issues
- Causes and Sustainability, and Environmental History
- Chapters 1–3 (to page 53)

**Weeks 4 – 7**

- Review of Basic Chemistry
- Matter and Energy Relationships (Laws of Thermodynamics)
- Ecosystems: Energy Flow and Matter Cycles
- Evolution and Diversity (Shannon-Weiner Index)
- Biogeography: Climate and Biomes
- Chapter 3 (from page 53) to Chapter 6

**Weeks 8 – 9**

- Aquatic and Community Ecology
- Species Interactions
- Succession and Sustainability

- Wetlands
- Chapters 7–8 and Chapter 24 (pages 650 – 652)

During the week around Election Day, Chapter 27, "Politics, Environment, and Sustainability," is assigned as an independent study project, which includes multiple-choice questions from the test bank and a short report on one environmental law. (Each student reports on a different law using Internet resources; a summary of major environmental legislation is provided after the reports are collected so students may review them throughout the year.) Students in New Jersey have two days off (a Thursday and Friday) for the State Teachers' Convention about this time, which enhances the timing for this independent project.

**Weeks 10 – 11**

- Population Dynamics
- Carrying Capacity
- Conservation Biology
- Chapter 9

**Weeks 12 – 13**

- Geology
- Plate Tectonics
- Earthquakes and Volcanoes
- Rock Cycle
- Soil: Formation, Characteristics and Properties
- Organisms, Erosion, Degradation, and Conservation
- Chapter 10

**Weeks 14 – 15**

- Human Population: Growth, Demography (Survivorship Curves and Age Structure Diagrams), Carrying Capacity

- Sustainable Cities: Urban Land Use and Management, Zoning and City Planning, Urban Problems
- Chapters 11 and 25

**Weeks 16 – 17**

- World Food Resources: Crops, Meat and Fish
- Chapter 12 and Chapter 24 (pages 647–649)

**Weeks 18 – 20**

- Water Resources
- Surface Water and Groundwater
- Water Pollution
- Water and Wastewater Treatment
- Water Quality and Drinking Water Standards
- Clean Water Act
- Chapters 13 and 19

**Week 21**

Midterm Exams

**Weeks 22 – 23**

- Nonrenewable Mineral and Energy Resources
- Energy Efficiency and Renewable Energy
- Chapters 14–15

**Weeks 24 – 25**

- Hazards, Risk and Risk Assessment
- Toxicology

- Human Health
- Chapter 16

**Weeks 26 – 28**

- Air and Air Pollution
- Air Quality Standards
- Clean Air Act
- Greenhouse Effect
- Climate Change and Implications
- Ozone Depletion
- Chapters 17–18

**Week 29**

- Pesticides and Pest Control
- Effects on Air and Water Quality and Human Health
- Pesticide Regulations
- Alternatives and Integrated Pest Management
- Chapter 20

**Weeks 30 – 31**

- Solid and Hazardous Wastes
- Chapter 21

During the week around April 15 (Income Taxes!) Chapter 26, "Economics, Environment and Sustainability," is assigned as an independent study project, which includes multiple-choice questions from the test bank and an essay question. Occasionally, this assignment corresponds with Spring Break.

**Weeks 32 – 33**

- Sustaining Wild Species
- Biodiversity and Extinction
- Wildlife Management
- Chapter 23–Chapter 24 (pages 630–646 and 652–655)

**Weeks 34 – 35**

- Environmental Worldviews
- Ethics and Sustainability, Review
- Chapter 28

**Weeks 36 – 39**

- AP Exam
- Ecological Planning Project

**Week 40**

Final Exams – Project Presentations

## Teaching Strategies

**Summer Reading Assignment and Quiz**
This assignment consists of excerpts from various environmental readings (e.g., *Biodiversity,* edited by E. O. Wilson; *Betrayal of Science and Reason: How Anti-Environmental Rhetoric Threatens Our Future,* by Paul R. and Anne H. Ehrlich; and *The Global Citizen,* by Donella H. Meadows), which are photocopied and distributed in June to the students who have enrolled in the course for the following year. Copies are also left in the guidance office for students who enroll during the summer. These readings touch on themes that are addressed throughout the course and require a commitment from the students because a quiz is given on the first day of school.

**Lecture**

Because this course closely parallels a college course, I usually lecture two times a week. Novice AP Environmental Science teachers often encounter difficulty developing lectures and I recommend that they use a reference text with an approach that is different from the text their class is using. By outlining parallel chapters in the reference text, the basis of a lecture emerges, with the same concepts but different examples and usually a different perspective. Using this approach, the teacher avoids the trap of lecturing from the book and "doing the reading" for the students. As the teacher gains experience (and time!), information from the Internet, current events, and additional examples, problems, and data can be infused. I occasionally project my lecture notes on overheads (or PowerPoint presentations) to assist the weaker students in their note-taking skills.

**Small Group Activities**

Problem solving, design projects, and Internet research are the basis for small group activities, which provide the opportunity for brainstorming, application, and synthesis of material from lectures and reading assignments. The groups must also present their findings to the rest of the class. Occasionally role-playing activities are employed to emphasize the many viewpoints and professional opinions involved in making environmental decisions.

**Field Trips**

Typically I have one field trip to the municipal sewage treatment plant; I also make use of virtual field trips on the Internet. Last year we began competing in the New Jersey State Envirothon and this involves a field trip to the New Jersey Resource Education Center in Jackson for an outdoor training session in addition to a trip to the competition, which is held at a different location in the state each year.

**State Envirothon**

Approximately half of the students in our AP Environmental Science classes have participated in this very worthwhile competition; the other half would, but have commitments that conflict with the Saturday competition. In New Jersey it is held the Saturday before the AP Environmental Science Exam and participating students have found the program very helpful. As a team, we meet after school weekly starting in January and then daily the week before the competition. Materials provided by the Envirothon enhance the AP Environmental Science program and the students respond positively to the outdoor, competitive atmosphere.

**Videos**

All videos are used in conjunction with a video quiz or a specific assignment, either a case study or a problem-solving exercise.

**Final Exam**

Because all students are required to take the AP Exam, I do not require a written final exam, but an alternate assessment project is assigned. After the AP Exam, I invite the city planner to be a guest speaker. She explains the master plan and zoning ordinances and also brings a full set of architectural prints for a recent construction project. Using the resources in *Planning for Change,* by James A. Lahde, students spend the next few weeks involved in activities that demonstrate the role of ecological principles in land use planning. Their final exam project involves locating a vacant property within the township, developing a proposal for its development that is environmentally sound and consistent with the local zoning ordinances, and identifying the environmental impacts of their development. Following guidelines in *Planning for Change,* students organize their project and present it during their exam time block. Depending on the size of the class, students may work alone or in groups of two or three. Presentations average about 15 minutes each; the exam block is two hours. Presentations may be in PowerPoint, video, poster, 3-D model, slides, photograph, or transparency formats.

## Lab Component

Laboratory experiences include experiments from lab manuals, data sets, fieldwork (fall and spring, as weather permits), and student-designed experiments. Students typically work in lab groups of two to four, depending on the nature of the activity.

## Student Activity

**How to Market Energy in an Energy-Challenged Age – Part 1**

In this part of the activity, students are required to write a three- to five-page paper on a specific topic related to energy efficiency, energy conservation, or energy alternatives. The specific topics are placed on folded file cards in a large beaker and each student draws a card, thereby selecting their topic. Suggested topics include Natural Gas Home, Solar Heating System, Energy Conservation Service, Microwave Cooking, Electric Car, Hybrid Car, Bicycle, Car Pooling, and Mass Transit.

Students are to research the following questions.

1. What sources of energy are required? How abundant are the supplies? What impact will this have on the cost of the energy supply?
2. What energy conversions must occur for your system to operate? How does the system work? What are the relationships among the various components of the system? What is its capacity? What is its life expectancy?

3. How does your system compare to a more conventional one (heating, cooking, and traveling)? Include cost in your comparison.
4. What kind of maintenance is required?
5. What kinds and levels of emissions (pollution) result?

Students are required to conduct their research on the Internet and document their sources.

**How to Market Energy in an Energy-Challenged Age – Part 2**
In the second phase of the activity, students are required to develop a short (not more than three minutes) advertisement for their energy product. The advertisement can take the form of a PowerPoint presentation, poster, magazine ad, or video. In order to do this, students must first consider the consumer impacts of their product, such as increased or decreased costs or savings; convenience, comfort, or quality of life; abundant or declining energy supplies; renewable versus nonrenewable energy sources; reliability; performance; and environmental impact. Next, students design their advertisement to appeal to a particular target audience. As was done for topic selection, target audiences are written on folded file cards and placed in a large beaker. Each student draws a card, thereby selecting the target audience they are to reach with their ad.

Each student receives a copy of the following target audiences and descriptions, which come from page 48 in Helen Carey's *Playing with Energy.*

- **Status Seeker.** Wants to be associated with the latest "in" things. Wears only name-brand clothing and will buy anything new or different, particularly if sold in limited editions. Has never shopped in a chain store.
- **Wild and Crazy.** Considers everything a joke and life is for fun. Spends money freely and resists having serious thoughts. Travels in large groups and cannot stand to be alone for more than 30 minutes.
- **Nostalgia Buff.** Longs for the "good old days" and does not trust anything new unless it relates to something from the past. Loves old movies, old houses, old clothing. Frequently shops in secondhand stores.
- **Engineering Nut.** Spends time taking things apart and analyzing how they work. Buys furniture and appliances in kit form and puts them together at home. Impressed by data, charts, and graphs, and spends hours using calculators and home computers.

- **Money Conscious.** Interested in the "bottom line" and bargains. Will spend hours searching for coupons and store sales and will double-check the waiter's bill when out for dinner.
- **Eco-Freak.** Interested in preserving the world as a wilderness area. Wears only denim shirts and hiking boots. Most comfortable in the outdoors and sleeping in a tent. Intense recycler and always asking, "What's the environmental impact?"
- **Social Butterfly.** Wants to know where the next party is and buys items in quantity and for convenience.
- **Just Plain Folks.** Blends into any crowd with indistinctive clothes, cars, and houses. Very family and home centered.

*Students may not share their topic or target audience with other members of the class because the class will be asked to identify each product and each target audience from the presentations.*

Students can practice identifying these target audiences from magazine ads. This is best done by holding up ads and having the class guess the target audience, with discussion if there is no consensus.

In addition to tallying the product and target audience "votes," the following questions are a useful guide for class discussion.

1. How did you recognize the target audience? Are you ever part of this audience?
2. What action does the advertisement require of the audience?
3. What are the advantages and disadvantages of this product?
4. What, if any, important information was left out of the advertisement?
5. Did you respond to the product or the "attitude" or "feeling" that was being promoted?
6. How can advertisements be used to promote environmentally friendly products and services?

The resource for the basis of this activity is *Playing with Energy,* edited by Helen Carey (Washington, DC: National Science Teachers Association, 1981).

## Student Evaluation

Each of the four marking period grades is determined in the following manner.

- **A Formal Lab Report** with background research is required each marking period and counts as one test grade.
- **A Lab Data Notebook** (a bound notebook, not a loose-leaf) is maintained for all laboratory work. It is collected weekly or biweekly and checked. Point deductions are totaled and a grade is assigned at the end of the marking period. It counts as one test grade.
- **One Project or Group Project/Presentation** is completed each marking period and counts as one test grade.
- **Classwork and Homework** are collected and graded as assigned; these are averaged together and count as one test grade.
- **Quizzes** are administered throughout the discussion of a topic or reading assignment. It is important that students review material regularly and keep current with their assignments. Video quizzes are administered during the viewing of each part of the Race to Save the Planet series. All quizzes are averaged together and count as one test grade.
- **Major Tests** are administered after each major unit (two or more chapters). The tests consist of 45 to 60 multiple-choice questions taken directly or modified from the author's test bank. Students are also given three to five essay questions the week before the test. They have a week to research, formulate, and organize their answers. On the day of the test, one student (a different student for each test) draws a number from a beaker of folded papers numbered from one to five. The number they draw is the only essay the class will answer—without their notes, of course! The procedure is repeated for each section and for make-up tests.

At the end of the marking period, *all test grades* are averaged to calculate the marking period grade.

As per school policy, each marking period counts as 20 percent of the final course grade, the midterm exam counts as 10 percent, and the final exam also counts as 10 percent of the final grade.

## Teacher Resources

**Textbooks**

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet.* 3rd ed. New York: John Wiley, 2000.

Miller, G. Tyler. *Living in the Environment: Principles, Connections, and Solutions.* 12th ed. Pacific Grove, CA: Brooks/Cole, 2002.

Raven, Peter H., and Linda R. Berg. *Environment.* 3rd ed. Fort Worth: Harcourt College Publishers, 2001.

**Laboratory Resources, Manuals, and Activities**

Bellamy, Mary Louise, and Kathy Frame. *Biology on a Shoestring.* Reston, VA: National Association of Biology Teachers, 1995.

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities.* 7th ed. New York: McGraw-Hill, 1999. Accompanies the textbook *Environmental Science: A Study of Interrelationships,* by Eldon Enger and Bradley F. Smith.

McConnell, Robert L., and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating.* 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2002.

Mitchell, Mark K., and William B. Stapp. *Field Manual for Water Quality Monitoring.* 9th ed. Dexter, MI: Thomson-Shore Printers, 1995.

Roa, Michael L. *Environmental Science Activities Kit.* West Nyack, NY: The Center for Applied Research in Education, 1993.

Rosenthal, Dorothy B. *Environmental Science Activities.* New York: John Wiley, 1995.

Tomera, Audrey N. *Understanding Basic Ecological Concepts.* Portland, ME: J. Weston Walch, 1989. The third edition is now available.

**Test Banks**

Clements, Richard K. *Instructor's Manual.* Pacific Grove, CA: Brooks/Cole, 2002. Accompanies the twelfth edition of the textbook *Living in the Environment: Principles, Connections, and Solutions,* by G. Tyler Miller. Includes test items.

**Resource Books**

deBettencourt, Kathleen B., et al. *Environmental Connections: A Guide to Environmental Studies.* Dubuque, IA: Kendall/Hunt, 2000.

Heathcote, Isobel W. *Environmental Problem-Solving: A Case Study Approach.* New York: McGraw-Hill, 1997.

Lahde, James A. *Planning for Change: A Course of Study in Ecological Planning Activities Manual.* New York: Teachers College Press, 1982. This title is out of print and has limited availability.

Newton, Lisa H., and Catherine K. Dillingham. *Watersheds 2: Ten Cases in Environmental Ethics.* Belmont, CA: Wadsworth, 1997. *Watersheds 3* was published in 2002.

Stevenson, L. Harold, and Bruce Wyman. *The Facts on File Dictionary of Environmental Science.* New York: Facts on File, 1991. A new edition was published in 2001.

Stiling, Peter D. *Ecology: Theories and Applications.* 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1996.

Wolf, Edward C. *Race to Save the Planet: Study Guide.* Belmont, CA: Wadsworth, 1996. A new edition was published in 2002.

The Worldwatch Institute. *State of the World: Report on Progress Toward a Sustainable Society.* New York: W. W. Norton, published annually. Graphs and tables are available on CD-ROM.

_____. *Vital Signs: The Environmental Trends that Are Shaping Our Future.* New York: W. W. Norton, published annually. Graphs and tables are available on CD-ROM.

**Videos**

*A Civil Action.* A & E American Justice series. New York: New Video Group, 1998.

*Day of Six Billion: A Global Youth Perspective.* Linda Harrar Productions, 1999. 22 minutes. A condensation of the PBS video *Six Billion and Beyond.*

*The Lorax.* Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. This is out of print but some libraries may have a copy.

*El Nino and the Link between Oceans, Atmosphere and Weather.* Produced in association with the National Center for Atmospheric Research, 1998. 22 minutes. This can be ordered from BuyIndies.com at www.buyindies.com or 877 889-7477, 646 638-4616.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

*The Rock Cycle.* Earth Science series. Chippewa Falls, WI: Scott Resources, 1990. This can be ordered from Scott Resources, Hubbard Scientific, and National Teaching Aids at www.shnta.com or 800 289-9299, 970 484-7445.

**Web Sites**

AP Central: apcentral.collegeboard.com
Resources for AP Environmental Science teachers.

Black Hawk Solid Waste Management: www.cedarnet.org/bhcswmc/index.htm
A virtual landfill tour in Waterloo, Iowa, with additional information, including costs.

CSIRO Atmospheric Research: www.dar.csiro.au
Atmospheric research data and information with an emphasis on El Nino and ozone depletion from the Commonwealth Scientific and Industrial Research Organization in Australia.

Environmental Literacy Council: www.enviroliteracy.org
Information on environmental issues and news, labs (not just AP), and reading lists.

Foundation for Teaching Economics: www.fte.org
Activities and current information with links for the environment and economics.

Johnstown Sewage Treatment Plant Virtual Tour: www.ctcnet.net/jra/plant.htm
A virtual tour of the Johnstown Sewage Treatment Plant (Pennsylvania) with additional information, including costs.

Ohio State University Geological Sciences H415, Science in the Courtroom: www.geology.ohio-state.edu/courtroom
A course taught by Professor Scott Bair at Ohio State University that is based on the "A Civil Action" case.

Population Connection: www.populationconnection.org
Up-to-date U.S. and world population data and fact sheets. Population Connection was formerly known as Zero Population Growth (ZPG).

Renewable Energy Policy Report and CREST (Center for Renewable Energy and Sustainable Technology): www.crest.org
Current information on energy sources, documents, fact sheets, databases, case studies, and links to trade and industry associations.

U.S. Census Bureau: www.census.gov
U.S. and state population data and related information.

U.S. Geological Survey: www.usgs.gov
U.S. geological survey information, real-time data, and education resources.

The WebQuest Page: webquest.sdsu.edu/webquest.html
A matrix of WebQuests organized by subject and grade (K–Adult), including many environmental science topics. Hosted by the Educational Technology Department of San Diego State University.

This chapter is not meant to be a comprehensive list of *all* of the resources that are available for use in an AP Environmental Science classroom. Instead, it gives an overview of some materials teachers may find useful. A continuing source for learning about more resources is the AP Central Web site. Some of the resources named in this teacher's guide are listed on AP Central, with descriptions and evaluations by environmental scientists and teachers of AP Environmental Science. Although sometimes daunting, an extensive bibliography in a College Board publication is helpful to AP teachers as they contemplate, organize, and design their course. It is important to understand, however, that inclusion of particular publications, films, videos, CD-ROMs, Web sites, or other media does not constitute endorsement by the College Board, ETS, or the AP Environmental Science Development Committee.

References in this teacher's guide were as up to date as possible at the time of publication, but some of the materials cited here may be subject to ongoing revision and updates while others may become out of date or go out of print. This is a problem that is inherent in dealing with material relating to such a dynamic topic as environmental science, where information is constantly being reassessed to stay current with the latest scientific thinking on many of the encompassing issues. All Web sites in this guide were active as of April 2003 and all URLs were correct and provided a direct link to the named organization or company.

Keeping up to date can be an arduous task for many teachers. It is suggested that readers of this teacher's guide become part of the electronic discussion group for AP Environmental Science, which links members of the teaching community together in a supportive and informative liaison. Individuals post questions relating to any aspect of the course and receive feedback on their query. For more information about the electronic discussion group, including how to join, please see Chapter II, "How to Begin an AP Course in Environmental Science."

## Textbooks

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet.* 4th ed. New York: John Wiley, 2003.

Chiras, Daniel D. *Environmental Science: Creating a Sustainable Future.* 6th ed. Boston: Jones and Bartlett, 2001.

Cunningham, William P., and Mary Ann Cunningham. *Principles of Environmental Science: Inquiry and Applications.* 2nd ed. Boston: McGraw-Hill Higher Education, 2004.

Cunningham, William P., Mary Ann Cunningham, and Barbara Woodward Saigo. *Environmental Science: A Global Concern.* 7th ed. Dubuque, IA: McGraw-Hill, 2003.

Enger, Eldon, and Bradley F. Smith. *Environmental Science: A Study of Interrelationships.* 8th ed. Boston: McGraw-Hill, 2002.

Miller, G. Tyler, et al. *Living in the Environment: Principles, Connections, and Solutions.* 13th ed. Belmont, CA: Brooks/Cole, 2003.

Raven, Peter H., and Linda R. Berg. *Environment.* 4th ed. New York: John Wiley, 2003.

Wright, Richard T., and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future.* 8th ed. Upper Saddle River, NJ: Prentice Hall, 2001.

## Resource Manuals for Laboratory Investigations

Brower, James E., Jerrold H. Zar, and Carl N. von Ende. *Field and Laboratory Methods for General Ecology.* 4th ed. New York: McGraw-Hill, 1997.

Bellamy, Mary Louise, and Kathy Frame. *Biology on a Shoestring.* Reston, VA: National Association of Biology Teachers, 1995.

Campbell, Gayla, and Steve Wildberger. *The Monitor's Handbook.* [Chestertown, MD]: LaMotte Company, 2002.

Enger, Eldon, and Bradley F. Smith. *Field and Laboratory Activities.* 7th ed. New York: McGraw-Hill, 1999.

Mitchell, Mark K., and William B. Stapp. *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools.* 12th ed. Dubuque, IA: Kendall/Hunt, 2000.

Roa, Michael L. *Environmental Science Activities Kit.* West Nyack, NY: The Center for Applied Research on Education, 2002. Distributed by Jossey-Bass.

Rocket, C., and Kenneth J. Van Dellen. Laboratory Manual for Miller's *Living in the Environment, Environmental Science, and Sustaining the Earth,* 4th ed. Belmont, CA: Wadsworth Publishing Company, 1993.

Rosenthal, Dorothy B. *Environmental Science Activities.* New York: John Wiley, 1995.

Tomera, Audrey N. *Understanding Basic Ecological Concepts.* Portland, ME: J. Weston Walch, 1989.

## Other Resource Publications

Allen, John L., ed. *Annual Editions: Environment 02/03.* 21st ed. New York: McGraw-Hill, 2002.

Bush, Mark B. *Ecology of a Changing Planet.* 3rd ed. Upper Saddle River, NJ: Prentice Hall, 2003.

Chiras, Daniel D., John P. Reganold, and Oliver S. Owen. *Natural Resource Conservation: Management for a Sustainable Future.* 8th ed. Upper Saddle River, NJ: Prentice Hall, 2002.

deBettencourt, Kathleen B., Matthew Feeney, A. Nicole Barone, and Keith White. *Environmental Connections: A Guide to Environmental Studies.* Dubuque, IA: Kendall/Hunt, 2000.

Goldfarb, Theodore D., ed. *Taking Sides: Clashing Views on Controversial Environmental Issues.* 9th ed. New York: McGraw-Hill, 2001.

Harte, John. *Consider a Spherical Cow: A Course in Environmental Problem Solving.* Sausalito, CA: University Science Books, 1988.

Heathcote, Isobel W. *Environmental Problem-Solving: A Case Study Approach.* New York: McGraw-Hill, 1997.

Kump, Lee R., James F. Kasting, and Robert G. Crane. *The Earth System.* Upper Saddle River, NJ: Prentice Hall, 1999.

Mackenzie, Fred T. *Our Changing Planet: An Introduction to Earth System Science and Global Environmental Change.* 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1997.

Malone, Lyn, Anita M. Palmer, and Christine L. Voigt. *Mapping Our World: GIS Lessons for Educators.* Redlands, CA: ESRI Press, 2002. Includes the ArcView 3.X CD-ROM and a one-year user license.

Mayer, J. Richard. *Connections in Environmental Science: A Case Study Approach.* Boston: McGraw-Hill, 2001.

McConnell, Robert L., and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating.* 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2002.

McKinney, Michael L., and Robert M. Schoch. *Environmental Science: Systems and Solutions.* 3rd ed. Boston: Jones and Bartlett, 2003.

Newton, Lisa H., and Catherine K. Dillingham. *Watersheds 3: Ten Cases in Environmental Ethics.* 3rd ed. Belmont, CA: Wadsworth, 2002.

Skinner, Brian J., Stephen C. Porter, and Daniel B. Botkin. *The Blue Planet: An Introduction to Earth System Science.* 2nd ed. New York: John Wiley, 1999.

Soltzberg, Leonard J. *The Dynamic Environment: Computer Models to Accompany "Consider A Spherical Cow."* Sausalito, CA: University Science Books, 1996. The book is accompanied by a computer disk.

Underwood, Larry. *Case Studies in Environmental Science.* 2nd ed. Pacific Grove, CA: Brooks/Cole, 2001.

Wackernagel, Mathis, and William E. Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island, BC, Canada: New Society Publishers, 1996.

**Contacting the Publishers**

Web sites for the publishing companies represented in this chapter are provided here for teachers who wish to contact a book's publisher directly.

Brooks/Cole-Thomson Learning
www.brookscole.com
800 354-9706

ESRI Press
gis.esri.com
800 447-9778

J. Weston Walch, Publisher
www.walch.com
800 341-6094

John Wiley and Sons
www.wiley.com
877 762-2974, 212 884-5000

Jones and Bartlett Publishers
www.jbpub.com
800 832-0034, 978 443-5000

Jossey-Bass
www.josseybass.com
877 762-2977, 415 433-1740

Kendall/Hunt Publishing Company
www.kendallhunt.com
800 228-0810, 563 589-1000

LaMotte Company
www.lamotte.com
800 344-3100, 410 778-3100

McGraw-Hill
www.mhhe.com
800 338-3987

National Association of Biology Teachers
www.nabt.org
800 406-0775, 703 264-9696

New Society Publishers
www.newsociety.com
250 247-9737

Prentice Hall
vig.prenhall.com
800 350-3693

University Science Books
www.uscibooks.com
703 661-1572

Wadsworth
www.wadsworth.com
800 354-9706

## Magazines

*E/The Environmental Magazine:* www.emagazine.com

*Environment:* www.heldref.org

*Mother Earth News:* www.motherearthnews.com

*National Geographic:* www.nationalgeographic.com

*Nature:* www.nature.com

*Science News:* www.sciencenews.org

*Orion Magazine:* www.orionline.org

*Worldwatch:* www.worldwatch.org

## Newspapers

Teachers are encouraged to check their local newspapers for articles related to environmental issues within their own communities. Many nationally acclaimed newspapers carry articles on the environment on a regular basis. Most major cities have their own daily newspapers and the following are but a few of them.

*The Atlanta Journal-Constitution:* www.accessatlanta.com

*The Baltimore Sun:* www.sunspot.net

*The Boston Globe:* www.boston.com/globe

*The Chicago Tribune:* www.chicagotribune.com

*The New York Times:* www.nytimes.com

*The Orlando Sentinel:* www.orlandosentinel.com

*The Philadelphia Inquirer:* www.philly.com/mld/inquirer

*The Salt Lake City Tribune:* www.sltrib.com

*The San Francisco Chronicle:* www.sfgate.com/chronicle

*The Seattle Times:* seattletimes.nwsource.com

*The St. Petersburg Times:* www.sptimes.com

*The Washington Post:* www.washingtonpost.com

All of these newspapers have their own Web sites which teachers can bookmark and refer to regularly. Other newspapers to check include *USA Today* (www.usatoday.com) and the *Christian Science Monitor* (www.csmonitor.com).

## Television and Radio

Most television stations and news channels have Web sites that can be used to keep the AP Environmental Science class up to date on current important environmental issues. Teachers should check the television listings for any new series that may be applicable to their course.

ABC News: abcnews.go.com

CBS News: www.cbsnews.com

CNN: www.cnn.com

Environmental News Network: www.enn.com

MSNBC News: www.msnbc.com/news

National Public Radio: www.npr.org (The NPR Web site has archived environmental news items.)

## Videos

There is an enormous selection of environmental films, in both videocassette and DVD formats, that are suitable for showing to an AP Environmental Science class. Which ones to choose depends on the teacher's preference. The syllabi included in this teacher's guide refer to many of the most popular choices. Teachers are also directed to the environmental science section of AP Central, which contains reviews of other suitable videos and DVDs. Organizations like the National Geographic Society (www.nationalgeographic.com), PBS (www.pbs.org), and The Discovery Channel (dsc.discovery.com) also produce a wide array of excellent materials. Here is a brief sampling of some media offerings. All are videocassettes unless noted otherwise.

*Amazing Earth.* Narrated by Patrick Stewart. Written and produced by Amanda Theunissen. Artisan Entertainment, 2001. DVD. Distributed by The Discovery Channel. 100 minutes.

The Blue Planet: Seas of Life series. 4 videos. Narrated by David Attenborough. A collaboration of The Discovery Channel and BBC. BBC Video, 2002. 392 minutes.

*Cane Toads: An Unnatural History.* Written and directed by Mark Lewis. New York: First Run Features, 1987. 48 minutes.

# Bibliography and Resources

*Drawbridge: The Life and Death of a Town.* Produced by Will Zavala in coordination with KTEH-TV. 2001. Distributed by Environmental Media.

*Galapagos.* Narrated by Kenneth Branagh. Produced by Al Giddings and Dave Clark of Mandalay Media Arts for the Smithsonian Institute's National Museum of Natural History, 1999. Distributed by IMAX. 39 minutes.

*The Great Barrier Reef.* Narrated by Phillip Clark and Rosalind Ayres. Directed by George Casey. 1999. Distributed by SlingShot. 39 minutes.

*The Greatest Places.* Narrated by Avery Brooks. Directed by Mal Wolfe. 2001. Distributed by SlingShot. 40 minutes.

*The Lorax.* Directed by Hawley Pratt. Twentieth Century Fox, 1972. 30 minutes. Out of print.

Race to Save the Planet series. 10 videos. Boston: WGBH Boston, 1990. 60 minutes each.

*Survival Island.* Narrated and written by David Attenborough. Produced by Christopher Parsons. A presentation of IMAX Corporation and Hakuhodo Incorporated, 1995. 35 minutes.

*Understanding Biodiversity.* Educational Video Network, 1996. 25 minutes.

*Understanding Ecosystems.* Educational Video Network, 1994. 30 minutes.

*The Water Rules.* KLVX Communications, 2000. Distributed by Environmental Media. 57 minutes.

*What's Up with the Weather?* Produced by Frontline and NOVA. Boston: WGBH Boston Video, 2000. 120 minutes.

*World Population.* Washington, DC: Population Connection, 2000. 7 minutes.

**Contacting the Multimedia Distributors**

The Discovery Channel
dsc.discovery.com
www.discovery.com
800 627-9399, 800 889-9950

Educational Video Network
www.edvidnet.net
800 762-0060, 936 295-5767

Environmental Media
www.envmedia.com
800 368-3382, 843 986-9034

First Run Features
www.firstrunfeatures.com
800 229-8575, 212 989-7649

IMAX
www.IMAX.com
905 403-6500

National Geographic Society
www.nationalgeographic.com
shopnationalgeographic.com
800 437-5521

PBS
www.pbs.org
shoppbs.org
teacher.shop.pbs.org
877 PBS-SHOP

Population Connection
www.populationconnection.org
800 POP-1956, 202 332-2200

SlingShot
www.slingshotent.com
818 973-2480

WGBH Boston
www.wgbh.org
888 255-9231, 617 300-5400

## Interactive Software

The following software packages provide opportunities for students to participate in simulated laboratory investigations and other studies.

*The BioQUEST Library VI.* Bioquest Curriculum Consortium, 2002. 2 CD-ROMs: 1 for PCs, 1 for Macs. For more information, visit www.bioquest.org or call Bioquest Curriculum Consortium at Beloit College 608 363-2743.

Bishop, Dwight, John Hirschbuhl, and Jim Jackson. *Environmental Science: Field Laboratory.* Wellesley, MA: Falcon Software. CD-ROM for Windows. For more information, visit www.falconsoftware.com or call 781 235-1767.

# Bibliography and Resources

*The Commons: An Environmental Dilemma.* Dubuque, IA: Kendall/Hunt, 1999. For more information, visit www.kendallhunt.com or call 800 542-6657.

*Coral Kingdom.* Digital Studios, 1996. CD-ROM for Windows and Mac. For more information, visit www.cyberlearn.com/coral.htm or call 800 499-3322, 831 688-3158.

*EcoBeaker HS™.* CD-ROM for Windows and Mac. For more information, visit www.ecobeaker.com or call 215 658-9104.

*Ecosystems.* Digital Studios. CD-ROM. For more information, visit www.cyberlearn.com or call 800 499-3322, 831 688-3158.

*Focus on the Environment.* EME Corporation. CD-ROM for Windows and Mac. For more information, visit www.emescience.com or call 800 848-2050, 772 219-2206.

*Food Chain.* High Performance Systems. CD-ROM. For more information, visit www.hps-inc.com or call 800 332-1202, 603 643-9636.

*Home Energy Conservation.* EME Corporation. CD-ROM for Windows and Mac. Includes "Home Heating Audit." For more information, call 800 848-2050, 772 219-2206, or visit www.emescience.com/sci-energy-homeenergyconservation.html.

Meadows, Dennis. *Fish Banks Ltd.* CD-ROM for PC and Mac. For more information, contact the University of New Hampshire Laboratory for Interactive Learning at 603 862-2244 or visit their Web site at www.unh.edu/ipssr. Also available from Education for a Sustainable Future at www.sustainabilityed.org/technology.htm.

*Task Force Environmental Investigation Kit.* Cyber Learning Collection series. Digital Studios, 1997. CD-ROM for Windows and Mac. For more information, visit www.cyberlearn.com. Also available from Eisenhower National Clearinghouse (ENC) at www.enc.org, or call 800 621-5785, 614 292-7784.

Wilson, Edward O., and Dan L. Perlman. Conserving Earth's *Biodiversity with E. O. Wilson.* Washington, DC: Island Press. CD-ROM for Windows and Mac. For more information, visit www.islandpress.org/wilsoncd or call 800 828-1302, 202 232-7933.

# Web Sites

The following is a rather extensive list of Web sites that will be of interest to AP Environmental Science teachers. It includes sites that are of general interest, agencies, government departments, and professional organizations. No attempt has been made to provide a detailed description of each site because doing so would make this list unwieldy. The sites' names generally give a good indication as to their content. Teachers are encouraged to visit each site individually to assess whether its information is pertinent to their needs. These sites are also good starting points for student research investigations.

**General Interest and Nongovernmental Agencies**

The Academy of Natural Sciences Estuarine Research Center: www.acnatsci.org/research/anserc

Access Excellence: The National Health Museum: www.accessexcellence.org

Adopt-a-Watershed: www.adopt-a-watershed.org

Air and Waste Management Association: www.awma.org

American Forests: www.americanforests.org

American Horticultural Society: www.ahs.org

American Lung Association: www.lungusa.org

American Meteorological Society: www.ametsoc.org

American Museum of Natural History Center for Biodiversity and Conservation: research.amnh.org/biodiversity

American Rivers: www.americanrivers.org

American Society for Horticultural Science: www.ashs.org

American Society of Limnology and Oceanography: aslo.org

American Water Works Association: www.awwa.org

# Bibliography and Resources

America's Parks Online: www.parksonline.org

The Biota of North America Program of the North Carolina Botanical Garden: www.bonap.org

Botanical Society of America: www.botany.org

Brooklyn Botanic Garden: www.bbg.org

Center for a Sustainable Future: csf.concord.org

Center for Clean Air Policy: www.ccap.org

Center for Health, Environment and Justice: www.chej.org

Center for International Forestry Research: www.cifor.cgiar.org

Center for Science in the Public Interest: www.cspinet.org

Chesapeake Bay Foundation: www.cbf.org

Clean Water Action: www.cleanwateraction.org

Colorado School of Mines: www.mines.edu

Community Transportation Association of America: www.ctaa.org

CONCERN, Inc.: www.health.gov/nhic

Conservation International: www.conservation.org

Consumer Federation of America: www.consumerfed.org

Critical Mass Energy and Environment Program: www.citizen.org/cmep

Defenders of Wildlife: www.defenders.org

Desert Research Institute: www.dri.edu

Desert USA (basic information on desert ecosystems): desertusa.com

Ducks Unlimited, Inc.: www.ducks.org

Earth First!: www.earthfirst.org

Earth Island Institute: www.earthisland.org

Earthscape: www.earthscape.org

Earthwatch Institute: www.earthwatch.org

EE-Link (environmental education resources): eelink.net

EnergyNet Community Web: www.energynet.net

EnvirLink: The Online Environmental Community: www.envirolink.org

Environmental Action Foundation: www.agc.org/Environmental_Info

Environmental Defense: www.environmentaldefense.org

Environmental Education site of the National Wildlife Federation: www.nwf.org/education

Environmental Law Institute: www.eli.org

Environmental Literacy Council: www.enviroliteracy.org

Environmental News Network: www.enn.com

Freedom from Hunger: www.freefromhunger.org

Friends of the Earth: www.foe.org

# Bibliography and Resources

GIS Café.com (technology updates): www01.giscafe.com

The GLOBE Program: Global Learning and Observations to Benefit the Environment: www.globe.gov

GREEN: Global Rivers Environmental Education Network: www.green.org

Greenpeace, Inc.: www.greenpeaceusa.org

How the Weatherworks™: www.weatherworks.com

Institute for Local Self-Reliance: www.ilsr.org

Institute of Global Environment and Society: grads.iges.org

Intellicast.com—Weather for Active Lives: www.intellicast.com (weather forecasts)

International Planned Parenthood Federation: www.ippf.org

The Izaak Walton League of America: www.iwla.org

The Jane Goodall Institute: www.janegoodall.org

The JASON Project™: www.jasonproject.org

Land Trust Alliance: www.lta.org

League of Conservation Voters: www.lcv.org

National Audubon Society: www.audubon.org

National Center for Atmospheric Research: www.ncar.ucar.edu

National Council for Science and the Environment: www.ncseonline.org

National Park Foundation: www.nationalparks.org

National Parks Conservation Association: www.npca.org

National Resources Defense Council: www.nrdc.org

National Tree Trust: www.nationaltreetrust.org

National Wildlife Federation: www.nwf.org

The Nature Conservancy: nature.org

NatureServe: A Network Connecting Science with Conservation: www.natureserve.org

North American Cartographic Information Society: www.nacis.org

The Ocean Conservancy: www.oceanconservancy.org

Pathfinder Science Digital Monarch Watch: pathfinderscience.net/monarch

PBS: Six Billion and Beyond: Population in the New Millennium (population information and population counter): www.pbs.org/sixbillion

Physicians for Social Responsibility: www.psr.org

Planet Drum Foundation: www.planetdrum.org

Planned Parenthood® Federation of America, Inc.: www.plannedparenthood.org

Population Action International: www.populationaction.org

Population Connection (formerly Zero Population Growth): www.populationconnection.org

The Population Institute: www.populationinstitute.org

Population Reference Bureau: www.prb.org

Population Resource Center: www.prcdc.org

Project for Public Spaces: Urban Parks Online: pps.org/upo

Project WILD: www.projectwild.org

Public Lands Information Center™: www.publiclands.org

Public Citizen: www.citizen.org

Rachel Carson Council, Inc.: members.aol.com/rccouncil/ourpage

Rainforest Action Network: www.ran.org

Rainforest Alliance: www.rainforest-alliance.org

Renew America: sol.crest.org/environment/renew_america

Resources for the Future: www.rff.org

Rocky Mountain Institute: www.rmi.org

The Rodale Institute: www.rodaleinstitute.org

Save Our Streams: www.saveourstreams.org

Science NetLinks: www.sciencenetlinks.com

Sea Shepherd Conservation Society: www.seashepherd.org

Sierra Club: www.sierraclub.org

Society of American Foresters: www.safnet.org

State PIRGs (public interest research groups): www.pirg.org

The Stream Study (using macroinvertebrates): www.people.virginia.edu/~sos-iwla

The Student Conservation Association, Inc.: www.thesca.org

Sustainable Agriculture Network: www.sare.org

Terraserver (aerial photographs): terraserver.microsoft.com

The Trust for Public Land: www.tpl.org

Union of Concerned Scientists: www.ucsusa.org

The U.S. Long-Term Ecological Research Network: www.lternet.edu

Volcano World: volcano.und.nodak.edu

Water Environment Federation®: www.wef.org

Water Environment Research Foundation: www.werf.org

Wild Ones—Native Plants, Natural Landscapes: www.for-wild.org

The Wilderness Society: www.wilderness.org

Wildlife Habitat Council: www.wildlifehc.org

Wildlife Management Institute: www.wildlifemanagementinstitute.org

The Wildlife Society: www.wildlife.org

World Population Clock: www.ibiblio.org/lunarbin/worldpop

World Resources Institute: www.wri.org

World Wildlife Fund: www.wwf.org

Worldwatch Institute: www.worldwatch.org

# Bibliography and Resources

**Government Agencies**

Bureau of Land Management: www.blm.gov

Bureau of Transportation Statistics: www.bts.gov

Clean Cities Program: www.ccities.doe.gov

Forest Products Laboratory: USDA Forest Service: www.fpl.fs.fed.us

(NASA) Teaching Earth Science: www.earth.nasa.gov/education

National Hurricane Center: www.nhc.noaa.gov

National Oceanic and Atmospheric Administration: www.noaa.gov

National Park Foundation: www.nationalparks.org

The National Park Service: www.nps.gov

National Resources Conservation Service: www.nrcs.usda.gov

National Response Center: www.nrc.uscg.mil/nrchp.html

National Weather Service: www.nws.noaa.gov

Occupational Safety and Health Administration: www.osha.gov

Office of Biological and Environmental Research: www.er.doe.gov/production/ober/ober_top.html

Smithsonian Institution: www.si.edu

United Nations Environment Programme: www.unep.org

U.S. Army Corps. of Engineers: www.usace.army.mil

U.S. Census Bureau: www.census.gov

U.S. Department of Agriculture: www.usda.gov

U.S. Department of Energy: www.energy.gov

U. S. Department of Transportation: www.dot.gov

U. S. Environmental Protection Agency: www.epa.gov

U. S. Fish and Wildlife Service: www.fws.gov

U. S. Geological Survey: www.usgs.gov

U. S. Nuclear Regulatory Commission: www.nrc.gov

USDA Forest Service: www.fs.fed.us

**Professional Organizations and Programs for Teachers**

American Association for the Advancement of Science: www.aaas.org

American Chemical Society: www.chemistry.org

Foundation for Teaching Economics: www.fte.org

Institute of International Education (Fulbright Program): www.iie.org

National Association of Biology Teachers: www.nabt.org

National Environmental Education and Training Foundation: www.neetf.org

The National Science Foundation's Funding page: www.nsf.gov/home/menus/funding.htm

National Science Teachers Association: www.nsta.org

North American Association for Environmental Education: naaee.org

The Paul F-Brandwein Institute (fellowships): www.brandwein.org

SchoolGrants (K–12 grant opportunities): www.schoolgrants.org

U.S. Department of Education's Grants and Contracts page: www.ed.gov/topics/topics.jsp?&top=Grants+%26+Contracts

U.S. Department of Education's Office of Educational Technology page: www.ed.gov/technology

The Woodrow Wilson National Fellowship Foundation: www.woodrow.org

## Equipment Suppliers

Ben Meadows Company
www.benmeadows.com
800 241-6401
mail@benmeadows.com

Carolina Biological Supply Company
www.carolina.com
800 334-5551, 336 584-0381
carolina@carolina.com

Connecticut Valley Biological
www.ctvalleybio.com
800 628-7748, 413 527-4030
connval@ctvalleybio.com

Data Harvest Educational
www.dataharvest.com
800 436-3062
craig@dataharvest.com

Edmund Scientific
www.scientificsonline.com
800 728-6999

Electronic Educational Devices, Inc.
www.doubleed.com
877 928-8701, 303 282-6410
info@doubleed.com

Fisher Science Education
www1.fishersci.com
800 766-7000, 630 655-4410

Flinn Scientific, Inc.
www.flinnsci.com
800 452-1261
flinn@flinnsci.com

Forestry Suppliers, Inc.
www.forestery-suppliers.com
800 752-8460, 800 647-5368

Frey Scientific
www.freyscientific.com
800 225-FREY
catalog@freyscientific.com

Hach Company
www.hach.com
800 227-4224, 970 669-3050
orders@hach.com

LaMotte Company
www.lamotte.com
800 344-3100, 410 778-3100

NASCO Scientific
www.enasco.com
800 558-9595
custserv@eNASCO.com

PASCO Scientific
www.pasco.com
800 772-8700, 916 786-3800
custserv@pasco.com

Vernier Software & Technology
www.vernier.com
888 837-6437, 503 277-2299
info@vernier.com

WARD'S Natural Science
www.wardsci.com
800 962-2660, 585 359-2502

# Purpose

The College Board's Advanced Placement Program offers students worldwide the opportunity to take college-level courses and exams while in secondary school. Students who take AP courses and exams enter a world of rigorous academic challenges, the rewards of which can include not only college credits, but also an open door to future intellectual opportunities. The AP Program is open to any secondary school that elects to participate. Similarly, the courses and exams are open to all students who are willing to accept the challenge of a rigorous academic curriculum.

The AP Program is a collaborative effort between motivated students, dedicated teachers, and committed high schools, colleges, and universities. The AP Program serves these constituencies by:

- providing teacher professional development opportunities, consultants, and course descriptions;
- supplying, scoring, and grading exams that are based on the learning goals described in AP Course Descriptions;
- sending exam grades to AP students, their schools, and the colleges they designate;
- preparing AP publications and online materials;
- supporting related research; and
- offering consultative services to colleges that wish to recognize and foster AP achievement in secondary schools.

Each year, an increasing number of parents, students, teachers, and colleges and universities turn to AP as a model of educational excellence.

# History

The College Board's Advanced Placement Program began in 1955 as a way to give qualified college freshmen the opportunity to be exempted from course work already mastered in high school. A number of individuals and institutions, including the Ford Foundation and Kenyon College, had observed that too many college freshmen were not being challenged by their college courses. They reasoned that, were there to be an examination that measured college-level achievement, qualified high school students could receive advanced standing in college and thus proceed to more challenging courses earlier in their college careers.

The president of Kenyon College, Keith Chalmers, selected 12 colleges and 12 secondary schools to write course descriptions for 11 subjects, each of which would represent a consensus of the individual introductory courses in these subjects offered by the institutions. Educational Testing Service was given the responsibility of developing the corresponding examinations.

In 2003, more than 1 million students representing more than 14,000 secondary schools took more than 1.7 million AP Examinations. These students had their grade reports from the exams sent to more than 3,400 colleges.

By challenging and stimulating students, the AP Program provides access to high-quality education, accelerates learning, rewards achievement, and enhances both high school and college programs.

## Why Take the AP Exam?

AP Exams are best known for the opportunity they give high school students to earn college credit while still in high school, giving them the chance to save on college tuition and even graduate early from college. Most U.S. colleges and universities have an AP policy granting incoming students academic credit and/or placement for qualifying AP grades. A large number of U.S. colleges and universities also allow students to begin as sophomores on the basis of a sufficient number of qualifying AP grades. This overwhelming acceptance of AP is the result of nearly half a century of collaboration between the Program and university faculty and staff. AP brings to colleges the world's most academically motivated and prepared students. As numerous studies have shown, AP students outperform their non-AP peers on virtually every standard.

What is less known is that many AP students who receive credit for their AP achievements also use this opportunity to take more advanced courses or to broaden their intellectual horizons, rather than to graduate in less than four years. Some students, for example, take a term or year to study or travel abroad. Others have taken double majors or a combined BA/MA program, while still others have exercised the option to take more advanced courses in disciplines where they received a firm grounding from AP. In fact,

a recent investigation of the college course-taking patterns of former AP students confirmed that college students who have succeeded on an AP Exam generally take more upper-level courses within the discipline of that AP Exam than college students who did not take that AP Exam in high school.[1]

Because college and university policies are determined by individual institutions, students should be encouraged to check the policies of the institutions that interest them. Students can check college catalogs or use collegeboard.com's "College Search" feature to learn more about a specific university's AP policies.

The cost of taking the AP Exam may present an obstacle to some students, but it is important to remember that a financial benefit may come later. The College Board offers reduced fees to students who can demonstrate financial need, and in more than 40 states, state and federal funding is available to help cover AP Exam fees. For further information on federal and state financial assistance, visit AP Central.

[1]Morgan, Rick, and Behroz Maneckshana. *AP Students in College: An Investigation of Their Course-Taking Patterns and College Majors.* Princeton, NJ: Educational Testing Service (2000).

A number of AP resources are available to help students, parents, AP Coordinators, and high school and college faculty learn more about the AP Program and its courses and exams. To identify resources that may be of particular use to you, refer to the following key.

| | | | |
|---|---|---|---|
| **Students and Parents** | **SP** | **AP Coordinators and Administrators** | **A** |
| **Teachers** | **T** | **College Faculty** | **C** |

## Ordering Information

You have several options for ordering publications:

- **Online.** Visit the College Board Store at store.collegeboard.com.
- **By mail.** Send a completed order form (available for downloading via AP Central) with your payment or credit card information to: Advanced Placement Program, Dept. E-02, P.O. Box 6670, Princeton, NJ 08541-6670.
- **By fax.** Credit card orders can be faxed to AP Order Services at 609 771-7385.
- **By phone.** Call AP Order Services at 609 771-7243, Monday through Friday 8:00 a.m. to 9:00 p.m. ET. Have your American Express, Discover, JCB, MasterCard, or VISA information ready. This phone number is for credit card publication orders only.

Payment must accompany all orders not on an institutional purchase order or credit card, and checks should be made payable to the College Board. The College Board pays UPS ground rate postage (or its equivalent) on all prepaid orders; delivery generally takes two to three weeks. Please do not use P.O. Box numbers. Postage will be charged on all orders requiring billing and/or requesting a faster method of delivery.

Publications may be returned for a full refund if they are returned within 30 days of invoice. Software and videos may be exchanged within 30 days if they are opened, or returned for a full refund if they are unopened. No collect or C.O.D. shipments are accepted. Unless otherwise specified, **orders will be filled with the currently available edition**; prices and discounts are subject to change without notice.

In compliance with Canadian law, all AP publications delivered to Canada incur the 7 percent GST. The GST registration number is 13141 4468 RT. Some Canadian schools are exempt from paying the GST. Appropriate proof of exemption must be provided when AP publications are ordered so that tax is not applied to the billing statement.

## Print

Items marked with a computer mouse icon can also be downloaded for free from AP Central.

**Bulletin for AP Students and Parents** **SP**

This bulletin provides a general description of the AP Program, including how to register for AP courses, and information on the policies and procedures related to taking the exams. It describes each AP Exam, lists the advantages of taking the exams, describes the grade reporting and award options available to students, and includes the upcoming exam schedule. The *Bulletin* is available in both English and Spanish.

**AP Program Guide** **A**

This guide takes the AP Coordinator step-by-step through the school year—from organizing an AP program, through ordering and administering the AP Exams, payment, and grade reporting. It also includes information on teacher professional development, AP resources, and exam schedules. The *AP Program Guide* is sent automatically to all schools that register to participate in AP.

**College and University Guide to the AP Program** **C, A**

This guide is intended to help college and university faculty and administrators understand the benefits of having a coherent, equitable AP policy. Topics included are validity of AP grades; developing and maintaining scoring standards; ensuring equivalent achievement; state legislation supporting AP; and quantitative profiles of AP students by each AP subject.

**Course Descriptions** **SP, T, A, C**

Course Descriptions provide an outline of the AP course content, explain the kinds of skills students are expected to demonstrate in the corresponding introductory college-level course, and describe the AP Exam. They also provide sample multiple-choice questions with an answer key, as well as sample free-response questions. Note: The *Course Description for AP Computer Science* is available in electronic format only.

**Released Exams** **T**

About every four to five years, on a rotating schedule, the AP Program releases a complete copy of each exam. In addition to providing the multiple-choice questions and answers, the publication describes the process of scoring the free-response questions and includes examples of students' actual responses, the scoring guidelines, and commentary that explains why the responses received the scores they did.

**Teacher's Guides** **T**

For those about to teach an AP course for the first time, or for experienced AP teachers who would like to get some fresh ideas for the classroom, the Teacher's Guide is an excellent resource. Each Teacher's Guide contains syllabi developed by high school teachers currently teaching the AP course and college faculty who teach the equivalent course at colleges and universities. Along with detailed course outlines and innovative teaching tips, you'll also find extensive lists of suggested teaching resources.

**AP Vertical Team Guides** **T, A**

An AP Vertical Team (APVT) is made up of teachers from different grade levels who work together to develop and implement a sequential curriculum in a given discipline. The team's goal is to help students acquire the skills necessary for success in AP. To help teachers and administrators who are interested in establishing an APVT at their school, the College Board has published these guides: *Advanced Placement Program Mathematics Vertical Teams Toolkit; AP Vertical Teams Guide for English; AP Vertical Teams Guide for Fine Arts, Volume 1: Studio Art; AP Vertical Teams Guide for Fine Arts, Volume 2: Music Theory;* and *AP Vertical Teams Guide for Social Studies.*

## Multimedia

**APCD® (home version), (multi-network site license)** **SP, T**

These CD-ROMs are available for Calculus AB, English Language, English Literature, European History, Spanish language, and U.S. History. They each include actual AP Exams, interactive tutorials, and other features, including exam descriptions, answers to frequently asked questions, study-skill suggestions, and test-taking strategies. There is also a listing of resources for further study and a planner to help students schedule and organize their study time.

The teacher version of each CD, which can be licensed for up to 50 workstations, enables you to monitor student progress and provide individual feedback. Included is a Teacher's Manual that gives full explanations along with suggestions for utilizing the APCD in the classroom.

# Additional Resources

**AP Central**

AP Central (apcentral.collegeboard.com) is the College Board's online home for AP professionals. The site is free for all users, and offers the most current information on AP. Featuring content written *by* AP professionals *for* AP professionals, AP Central provides a unique set of resources, such as electronic discussion groups (including one for AP Coordinators), publications for download, and statistical information.

**AP Potential**

AP Potential is a Web-based product that promotes access to AP by helping schools identify "diamond-in-the-rough" students. Studies have shown that performance on the PSAT/NMSQT® can be used to identify students who may be successful in AP courses. Using such data, AP Potential provides school and district offices with a roster of potential students by name and suggested AP course, giving principals and administrators useful information for expanding AP programs, adding courses, or increasing enrollment in current AP offerings.

# AP Teacher Professional Development and Support

There are currently more than 100,000 AP teachers worldwide. With the tremendous growth of the AP Program, more teachers will be joining the AP ranks each year. The College Board and the AP Program offer these teachers a wide variety of professional development opportunities.

**Workshops and Summer Institutes**

Although AP teachers usually have significant formal education in the subjects they teach, many can benefit from the workshops and institutes organized annually by the College Board. Professional development workshops are typically offered throughout the academic year and range from one to three days in length. Each workshop concentrates on the teaching of a specific AP subject with the focus on instructional strategies and the management of an AP course.

AP Summer Institutes are intensive, subject-specific courses usually conducted over the course of a week that provide in-depth preparation for teaching AP courses. The workshops and institutes are also a forum for exchanging ideas and information about AP. The booklet *Graduate Summer Courses and Institutes*, which provides a list of institutes and their dates and locations, is sent to each participating school in February. The Institutes & Workshops area of AP Central has a searchable catalog of professional development opportunities. Information can also be obtained from the College Board Regional Offices.

**College Board Fellows Program**

The College Board Fellows program provides stipends for secondary school teachers planning to teach AP courses in schools that serve minority students who have been traditionally underrepresented in AP classes, or who teach at schools in economically disadvantaged areas. The $800 stipends assist teachers with the cost of attending an AP Summer Institute. To qualify, a school must have approximately 50 percent or more minority students and/or be located in an area where the average income level is equivalent to, or below, the national annual average for a low-income family of four (approximately $31,000). The summer institutes provide an excellent opportunity for teachers to gain command of a specific AP subject and to receive up-to-date information on the latest curriculum changes. Stipend applications are available at fall AP workshops, at AP Central, or from the College Board Regional Offices.

**Pre-AP®**

Pre-AP® is a suite of K-12 professional development resources and services. The purpose of Pre-AP Initiatives is to equip all middle and high school teachers with the strategies and tools they need to engage their students in active, high-level learning, thereby ensuring that every middle and high school student develops the skills, habits of mind, and concepts they need to succeed in college. Pre-AP Initiatives is a key component of the College Board's K-12 Professional Development unit.

Pre-AP rests upon a profound hope and heartfelt esteem for teachers and students. Conceptually, Pre-AP is based on the following two important premises. The first is the expectation that all students can perform at rigorous academic levels. This expectation should be reflected in the curriculum and instruction throughout the school such that all students are consistently being challenged to expand their knowledge and skills to the next level.

The second important premise of Pre-AP is the belief that we can prepare every student for higher intellectual engagement by starting the development of skills and acquisition of knowledge as early as possible. Addressed effectively, the middle and high school years can provide a powerful opportunity to help all students acquire the knowledge, concepts, and skills needed to engage in a higher level of learning.

Because Pre-AP teacher professional development supports explicitly the goal of college as an option for every student, it is important to have a recognized standard for college-level academic work. The Advanced Placement Program (AP) provides these standards for Pre-AP. Pre-AP teacher professional development resources reflect topics, concepts, and skills found in AP courses.

The College Board does not, however, design, develop, or assess courses labeled "Pre-AP." Courses labeled "Pre-AP" that inappropriately restrict access to AP and other college-level work are inconsistent with the fundamental purpose of the Pre-AP initiatives of the College Board.

As in all its programs, the College Board is deeply committed to equitable access to rigorous academic experiences. We applaud the efforts of our many colleagues making that happen in so many different ways in classrooms around the world.

**Pre-AP Fellows Program**

The Pre-AP Fellows program was created to promote the expansion of AP through Pre-AP teacher professional development. Grants are available to support AP Vertical Teams from minority-dominant and/or low-income school districts that wish to attend an approved Pre-AP Summer Institute. The Institute will offer Pre-AP professional development to educators using the two components of Pre-AP Initiatives: Building Success and Setting the Cornerstones. Interested educators should contact their College Board Regional Office for additional information. Applications will be distributed in the fall by College Board Regional Offices and will also be available at AP Central.

# Chapter IX Conclusion

When reflecting on my role as an environmental educator, I sometimes think of the line in the classic Charles Dickens novel *A Tale of Two Cities* in which he states, "It was the best of times, it was the worst of times." This famous quote relates to the French Revolution, fought over 200 years ago, but I like to think of it in terms of teaching environmental science in the twenty-first century. Is the glass half-full or half-empty? It's all in how you view it!

The global environment continues to come under threat as a result of an ever-increasing population consuming an ever-decreasing amount of the world's resources. Examples of recent detrimental environmental events are many: the killer London fog of 1952, the Exxon *Valdez* oil spill, Chernobyl, Bhopal, Love Canal, the Cuyahoga River, the famines in Africa, the Dust Bowl, the AIDS epidemic, the decline in the bald eagle population. Any of these could send shivers down the environmental spine of any of today's students, who come to us from middle school having already heard of environmental threats like global warming, acid rain, and ozone depletion. This, then, is the challenge to environmental science teachers—to discuss major environmental issues in such a way that students do not become disheartened and feel that they cannot devise solutions for the future. We do not want our students to throw their hands in the air and give up hope. We must, therefore, present the facts in a way that empowers our students to take a firm grasp on their environmental future and step boldly forward with an air of optimism that will not result in them thinking that "it *is* the worst of times."

So the good news for teachers is . . . we have the AP Environmental Science course to help us. First and foremost it is a *science* course, not an issues course or an ethics course or an environmental studies course, but a *science* course! Understanding the science behind ozone depletion, for example, may help people to take action to avoid, minimize, prevent, or even reverse any detrimental effects. If you think about it, the ozone story is one of hope for the future. The ozone layer will likely recover, thanks to the international cooperation that came about through the Montreal Protocol of 1987 and the Copenhagen Protocol of 1992. Due to the Clean Air Act and the Clean Water Act, we have made great strides in "cleaning up our act" with regard to air and water resources, though we still need to implement protocols that reduce the amounts of nitrogen compounds entering the troposphere and the oceans. Your AP students should be able to determine some strategies to accomplish this. By presenting the scientific facts as we currently understand them, we will enable our students to develop a higher level of environmental literacy and decision-making ability as they become the global citizens of tomorrow's world. For me, teaching the AP course is "the best of times."

So, allow your students to develop their own view of the environment. If you enjoy learning about the latest environmental issues yourself, your enthusiasm will rub off on your students. Stay abreast of current environmental news and advances in the field; the media is abundant with daily reports. A network of colleagues who teach the course can also be a great resource and support. Incorporate as many lab and field activities as you can into your course, and your students will (eventually) thank you for it!

# College Board Offices

**National Office**
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; 877 274-6474 (toll-free in U.S. and Canada)

**Middle States Regional Office**
Serving Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, and Puerto Rico
2 Bala Plaza, Suite 900, Bala Cynwyd, PA 19004-1501
610 667-4400
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
1560 Sherman Avenue, Suite 1001, Evanston, IL 60201-4805
847 866-1700
E-mail: mro@collegeboard.org

**New England Regional Office**
Serving Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
470 Totten Pond Road, Waltham, MA 02451-1982
781 890-9150
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, Suite 700, Duluth, GA 30096-5599
770 908-9737
E-mail: sro@collegeboard.org

**Southwestern Regional Office**
Serving Arkansas, New Mexico, Oklahoma, and Texas
4330 South MoPac Expressway, Suite 200, Austin, TX 78735-6734
512 891-8400
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 95110-1087
408 452-1400
E-mail: wro@collegeboard.org

**AP International**
45 Columbus Avenue, New York, NY 10023-6992
212 713-8091
E-mail: apintl@collegeboard.org

**AP Canada**
1708 Dolphin Avenue, Suite 406, Kelowna, BC, Canada V1Y 9S4
250 861-9050; 800 667-4548 (toll-free in Canada only)
E-mail: gewonus@ap.ca

**Pre-AP**
45 Columbus Avenue, New York, NY 10023-6992
212 713-8213
E-mail: pre-ap@collegeboard.org

**apcentral.collegeboard.com**

18098-024149 • U103E3 • Printed in U.S.A.
I.N. 997785