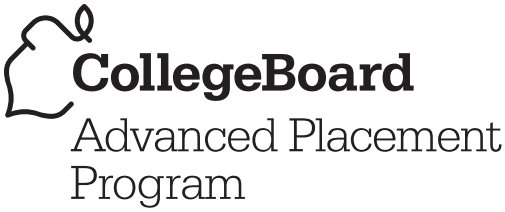

AP® Biology

Teacher's Guide

Carol Leibl
James Madison High School
San Antonio, Texas

connect to college success™
www.collegeboard.com

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The College Board: Connecting Students to College Success

The College Board is a not-for-profit membership association whose mission is to connect students to college success and opportunity. Founded in 1900, the association is composed of more than 5,000 schools, colleges, universities, and other educational organizations. Each year, the College Board serves seven million students and their parents, 23,000 high schools, and 3,500 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.

Contents

Welcome Letter from the College Board

Dear AP® Teacher:

Whether you are a new AP teacher, using this AP Teacher's Guide to assist in developing a syllabus for the first AP course you will ever teach, or an experienced AP teacher simply wanting to compare the teaching strategies you use with those employed by other expert AP teachers, we are confident you will find this resource valuable. We urge you to make good use of the ideas, advice, classroom strategies, and sample syllabi contained in this Teacher's Guide.

You deserve tremendous credit for all that you do to fortify students for college success. The nurturing environment in which you help your students master a college-level curriculum—a much better atmosphere for one's first exposure to college-level expectations than the often large classes in which many first-year college courses are taught—seems to translate directly into lasting benefits as students head off to college. An array of research studies, from the classic 1999 U.S. Department of Education study *Answers in the Tool Box* to new research from the University of Texas and the University of California, demonstrate that when students enter high school with equivalent academic abilities and socioeconomic status, those who develop the content knowledge to demonstrate college-level mastery of an AP Exam (a grade of 3 or higher) have much higher rates of college completion and have higher grades in college. The 2005 National Center for Educational Accountability (NCEA) study shows that students who take AP have much higher college graduation rates than students with the *same* academic abilities who do not have that valuable AP experience in high school. Furthermore, a Trends in International Mathematics and Science Study (TIMSS, formerly known as the Third International Mathematics and Science Study) found that even AP Calculus students who score a 1 on the AP Exam are significantly outperforming other advanced mathematics students in the United States, and they compare favorably to students from the top-performing nations in an international assessment of mathematics achievement. (Visit AP Central® at apcentral.collegeboard.com for details about these and other AP-related studies.)

For these reasons, the AP teacher plays a significant role in a student's academic journey. Your AP classroom may be the only taste of college rigor your students will have before they enter higher education. It is important to note that such benefits cannot be demonstrated among AP courses that are AP courses in name only, rather than in quality of content. For AP courses to meaningfully prepare students for college success, courses must meet standards that enable students to replicate the content of the comparable college class. Using this AP Teacher's Guide is one of the keys to ensuring that your AP course is as good as (or even better than) the course the student would otherwise be taking in college. While the AP Program does not mandate the use of any one syllabus or textbook and emphasizes that AP teachers should be granted the creativity and flexibility to develop their own curriculum, it is beneficial for AP teachers to compare their syllabi not just to the course outline in the official AP Course Description and in chapter 3 of this guide, but also to the syllabi presented on AP Central, to ensure that each course labeled AP meets the standards of a college-level course. Visit AP Central® at apcentral.collegeboard.com for details about the AP Course Audit, course-specific Curricular Requirements, and how to submit your syllabus for AP Course Audit authorization.

As the Advanced Placement Program® continues to experience tremendous growth in the twenty-first century, it is heartening to see that in every U.S. state and the District of Columbia, a growing proportion of high school graduates have earned at least one grade of 3 or higher on an AP Exam. In some states, more

than 20 percent of graduating seniors have accomplished this goal. The incredible efforts of AP teachers are paying off, producing ever greater numbers of college-bound seniors who are prepared to succeed in college. Please accept my admiration and congratulations for all that you are doing and achieving.

Sincerely,

Marcia Wilbur
Director, Curriculum and Content Development
Advanced Placement Program

Equity and Access

In the following section, the College Board describes its commitment to achieving equity in the AP Program.

Why are equitable preparation and inclusion important?

Currently, 40 percent of students entering four-year colleges and universities and 63 percent of students at two-year institutions require some remedial education. This is a significant concern because a student is less likely to obtain a bachelor's degree if he or she has taken one or more remedial courses.[1]

Nationwide, secondary school educators are increasingly committed not just to helping students complete high school but also to helping them develop the habits of mind necessary for managing the rigors of college. As *Educational Leadership* reported in 2004:

> The dramatic changes taking place in the U.S. economy jeopardize the economic future of students who leave high school without the problem-solving and communication skills essential to success in postsecondary education and in the growing number of high-paying jobs in the economy. To back away from education reforms that help all students master these skills is to give up on the commitment to equal opportunity for all.[2]

Numerous research studies have shown that engaging a student in a rigorous high school curriculum such as is found in AP courses is one of the best ways that educators can help that student persist and complete a bachelor's degree.[3] However, while 57 percent of the class of 2004 in U.S. public high schools enrolled in higher education in fall 2004, only 13 percent had been boosted with a successful AP experience in high school.[4] Although AP courses are not the only examples of rigorous curricula, there is still a significant gap between students with college aspirations and students with adequate high school preparation to fulfill those aspirations.

Strong correlations exist between AP success and college success.[5] Educators attest that this is partly because AP enables students to receive a taste of college while still in an environment that provides more support and resources for students than do typical college courses. Effective AP teachers work closely with their students, giving them the opportunity to reason, analyze, and understand for themselves. As a result, AP students frequently find themselves developing new confidence in their academic abilities and discovering their previously unknown capacities for college studies and academic success.

Which students should be encouraged to register for AP courses?

Any student willing and ready to do the work should be considered for an AP course. The College Board actively endorses the principles set forth in the following Equity Policy Statement and encourages schools to support this policy.

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1. Andrea Venezia, Michael W. Kirst, and Anthony L. Antonio. *Betraying the College Dream: How Disconnected K–12 and Postsecondary Education Systems Undermine Student Aspirations* (Palo Alto, Calif.: The Bridge Project, 2003), 8.

2. Frank Levy and Richard J. Murnane, "Education and the Changing Job Market." *Educational Leadership* 62 (2) (October 2004): 83.

3. In addition to studies from University of California–Berkeley and the National Center for Educational Accountability (2005), see the classic study on the subject of rigor and college persistence: Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment* (Washington, D.C.: U.S. Department of Education, 1999).

4. *Advanced Placement Report to the Nation* (New York: College Board, 2005).

5. Wayne Camara, "College Persistence, Graduation, and Remediation," *College Board Research Notes* (RN-19) (New York: College Board, 2003).

Equity and Access

> 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.

The fundamental objective that schools should strive to accomplish is to create a stimulating AP program that academically challenges students and has the same ethnic, gender, and socioeconomic demographics as the overall student population in the school. African American and Native American students are severely underrepresented in AP classrooms nationwide; Latino student participation has increased tremendously, but in many AP courses Latino students remain underrepresented. To prevent a willing, motivated student from having the opportunity to engage in AP courses is to deny that student the possibility of a better future.

Knowing what we know about the impact a rigorous curriculum can have on a student's future, it is not enough for us simply to leave it to motivated students to seek out these courses. Instead, we must reach out to students and encourage them to take on this challenge. With this in mind, there are two factors to consider when counseling a student regarding an AP opportunity:

1. Student motivation

Many potentially successful AP students would never enroll if the decision were left to their own initiative. They may not have peers who value rigorous academics, or they may have had prior academic experiences that damaged their confidence or belief in their college potential. They may simply lack an understanding of the benefits that such courses can offer them. Accordingly, it is essential that we not gauge a student's motivation to take AP until that student has had the opportunity to understand the advantages—not just the challenges—of such course work.

Educators committed to equity provide all students in a school with an understanding of the benefits of rigorous curricula. Such educators conduct student assemblies and/or presentations to parents that clearly describe the advantages of taking an AP course and outline the work expected of students. Perhaps most important, they have one-on-one conversations with the students in which advantages and expectations are placed side by side. These educators realize that many students, lacking confidence in their abilities, will be listening for any indication that they should not take an AP course. Accordingly, such educators, while frankly describing the amount of homework to be anticipated, also offer words of encouragement and support, assuring the students that if they are willing to do the work, they are wanted in the course.

The College Board has created a free online tool, AP Potential™, to help educators reach out to students who previously might not have been considered for participation in an AP course. Drawing upon data based on correlations between student performance on specific sections of the PSAT/NMSQT® and performance on specific AP Exams, AP Potential generates rosters of students at your school who have a strong likelihood of success in a particular AP course. Schools nationwide have successfully enrolled many more students in AP than ever before by using these rosters to help students (and their parents) see themselves as having potential to succeed in college-level studies. For more information, visit http://appotential.collegeboard.com.

Actively recruiting students for AP and sustaining enrollment can also be enhanced by offering incentives for both students and teachers. While the College Board does not formally endorse any one incentive for boosting AP participation, we encourage school administrators to develop policies that will

best serve an overarching goal to expand participation and improve performance in AP courses. When such incentives are implemented, educators should ensure that quality verification measures such as the AP Exam are embedded in the program so that courses are rigorous enough to merit the added benefits.

Many schools offer the following incentives for students who enroll in AP:

- Extra weighting of AP course grades when determining class rank
- Full or partial payment of AP Exam fees
- On-site exam administration

Additionally, some schools offer the following incentives for teachers to reward them for their efforts to include and support traditionally underserved students:

- Extra preparation periods
- Reduced class size
- Reduced duty periods
- Additional classroom funds
- Extra salary

2. Student preparation

Because AP courses should be the equivalent of courses taught in colleges and universities, it is important that a student be prepared for such rigor. The types of preparation a student should have before entering an AP course vary from course to course and are described in the official AP Course Description book for each subject (available as a free download at apcentral.collegeboard.com).

Unfortunately, many schools have developed a set of gatekeeping or screening requirements that go far beyond what is appropriate to ensure that an individual student has had sufficient preparation to succeed in an AP course. Schools should make every effort to eliminate the gatekeeping process for AP enrollment. Because research has not been able to establish meaningful correlations between gatekeeping devices and actual success on an AP Exam, the College Board **strongly discourages** the use of the following factors as thresholds or requirements for admission to an AP course:

- Grade point average
- Grade in a required prerequisite course
- Recommendation from a teacher
- AP teacher's discretion
- Standardized test scores
- Course-specific entrance exam or essay

Additionally, schools should be wary of the following concerns regarding the misuse of AP:

- Creating "Pre-AP courses" to establish a limited, exclusive track for access to AP
- Rushing to install AP courses without simultaneously implementing a plan to prepare students and teachers in lower grades for the rigor of the program

How can I ensure that I am not watering down the quality of my course as I admit more students?

Students in AP courses should take the AP Exam, which provides an external verification of the extent to which college-level mastery of an AP course is taking place. While it is likely that the percentage of students who receive a grade of 3 or higher may dip as more students take the exam, that is not an indication that the quality of a course is being watered down. Instead of looking at percentages, educators should be looking at raw numbers, since each number represents an individual student. If the raw number of students receiving a grade of 3 or higher on the AP Exam is not decreasing as more students take the exam, there is no indication that the quality of learning in your course has decreased as more students have enrolled.

What are schools doing to expand access and improve AP performance?

Districts and schools that successfully improve both participation and performance in AP have implemented a multipronged approach to expanding an AP program. These schools offer AP as capstone courses, providing professional development for AP teachers and additional incentives and support for the teachers and students participating at this top level of the curriculum. The high standards of the AP courses are used as anchors that influence the 6–12 curriculum from the "top down." Simultaneously, these educators are investing in the training of teachers in the pre-AP years and are building a vertically articulated, sequential curriculum from middle school to high school that culminates in AP courses—a broad pipeline that prepares students step-by-step for the rigors of AP so that they will have a fair shot at success in an AP course once they reach that stage. An effective and demanding AP program necessitates cooperation and communication between high schools and middle schools. Effective teaming among members of all educational levels ensures rigorous standards for students across years and provides them with the skills needed to succeed in AP. For more information about Pre-AP® professional development, including workshops designed to facilitate the creation of AP Vertical Teams® of middle school and high school teachers, visit AP Central.

Advanced Placement Program
The College Board

Participating in the AP® Course Audit

Overview

The AP Course Audit is a collaborative effort among secondary schools, colleges and universities, and the College Board. For their part, schools deliver college-level instruction to students and complete and return AP Course Audit materials. Colleges and universities work with the College Board to define elements common to college courses in each AP subject, help develop materials to support AP teaching, and receive a roster of schools and their authorized AP courses. The College Board fosters dialogue about the AP Course Audit requirements and recommendations, and reviews syllabi.

Starting in the 2007-08 academic year, all schools wishing to label a course "AP" on student transcripts, course listings, or any school publications must complete and return the subject-specific AP Course Audit form, along with the course syllabus, for all sections of their AP courses. Approximately two months after submitting AP Course Audit materials, schools will receive a legal agreement authorizing the use of the "AP" trademark on qualifying courses. Colleges and universities will receive a roster of schools listing the courses authorized to use the "AP" trademark at each school.

Purpose

College Board member schools at both the secondary and college levels requested an annual AP Course Audit in order to provide teachers and administrators with clear guidelines on curricular and resource requirements that must be in place for AP courses and to help colleges and universities better interpret secondary school courses marked "AP" on students' transcripts.

The AP Course Audit form identifies common, essential elements of effective college courses, including subject matter and classroom resources such as college-level textbooks and laboratory equipment. Schools and individual teachers will continue to develop their own curricula for AP courses they offer—the AP Course Audit will simply ask them to indicate inclusion of these elements in their AP syllabi or describe how their courses nonetheless deliver college-level course content.

AP Exam performance is not factored into the AP Course Audit. A program that audited only those schools with seemingly unsatisfactory exam performance might cause some schools to limit access to AP courses and exams. In addition, because AP Exams are taken and exam grades reported after college admissions decisions are already made, AP course participation has become a relevant factor in the college admissions process. On the AP Course Audit form, teachers and administrators attest that their course includes elements commonly taught in effective college courses. Colleges and universities reviewing students' transcripts can thus be reasonably assured that courses labeled "AP" provide an appropriate level and range of college-level course content, along with the classroom resources to best deliver that content.

For more information

You should discuss the AP Course Audit with your department head and principal. For more information, including a timeline, frequently asked questions, and downloadable AP Course Audit forms, visit apcentral.collegeboard.com/courseaudit.

Preface

Biology is dynamic, diverse, and full of unanswered questions. Every day new biological discoveries are made that inspire further research and learning. We can expect nothing less from a field that essentially encompasses how the world works. Teaching biology presents a wonderful opportunity for you to show your students tangible evidence of the concepts they are learning. As an AP Biology teacher, you can show students how to look more critically at the world around them. This is your opportunity to make class discussions, laboratory exercises, and textbook readings highly interactive. Encourage your students to ask questions, and foster lively exchanges in your class.

Covering all of the material in the AP Biology curriculum and adequately preparing students for the AP Exam are a new AP teacher's two biggest concerns. This Teacher's Guide will provide you with help on both fronts. It offers creative teaching strategies and advice for maximizing instruction time in and out of the classroom as well as information on laboratory facilities and preparation. Four sample syllabi show these strategies and labs in action to give you ideas for your own course. You will also find information on the format, content, and scoring of the AP Biology Exam, as well as tips for preparing students for it. Numerous resources you may find helpful when beginning an AP Biology course are identified throughout the Teacher's Guide.

While teaching the AP Biology course can be a daunting task for new AP teachers, any veteran AP teacher will tell you it is one of the most rewarding teaching experiences you can ever have. The impact you will have on your students is immeasurable, and they will thank you for your dedication and expertise. Enjoy this opportunity to challenge and engage your students with your unbridled enthusiasm.

It is also important to remember that you are not alone in your endeavor; because so many AP teachers will be retiring in the next 10 years, the number of new AP Biology teachers is rapidly increasing. Know that as you begin your experience as an AP Biology teacher, an established AP community is there to support and encourage you. It is my sincere hope that this Teacher's Guide will help you as you begin your course.

Carol Leibl

Carol Leibl has been an AP Biology teacher for over 20 years and currently teaches at James Madison High School in San Antonio, Texas. She has presented workshops for the College Board AP Program since 1985, has been a Reader for the AP Biology Exam since 1995, and has served on the AP Advisory Council for the Southwest Region of the College Board. In 1996, Leibl was named Teacher of the Year by the Texas Association of Biology Teachers and was a Tandy Winner. She holds an M.S. from the University of Texas at Austin.

Chapter 1
About AP Biology

Overview: Past, Present, Future

The first AP Biology Exam was administered in 1954 to a small group of students from a handful of elite schools.[1] The exam probably required students to know about the characteristics of various phyla of the two kingdoms, anatomy and physiology, evolution, and Mendelian genetics. Little was known then about DNA, RNA, and the workings of the organelles of the cell. Ecology was a subject in its infancy, with the first Earth Day still 16 years in the future, and the immune system merited only a few paragraphs in a textbook chapter on the circulatory system.

The launch of Sputnik I in 1957 instigated the space race of the 1960s and 1970s, focusing the nation's attention on science and science education. New programs were adopted (notably, in biology, the Biological Sciences Curriculum Study [BSCS] curriculum) to close the perceived science gap between the United States and the Soviet Union. Increased funding of biomedical research led to advances in molecular biology, genetics, and cell biology. The raising of the country's environmental awareness elevated the importance of the study of ecology at the high school level.

In the over 50 years since its first exam, the AP Biology program has encouraged thousands of enthusiastic and able students to receive outstanding science instruction while still in high school. Fewer than 100 students took the first AP Biology Exam; in 2006 more than 131,000 students took the AP Biology Exam in the United States and around the world.[2] The tremendous expansion and success of AP Biology is largely thanks to the interest and hard work of students who are willing to accept the AP challenge to go above and beyond a normal course of study; the tireless work and passion of AP teachers who instruct, excite, and prepare their students; and the dedication of the AP Biology Development Committee, which keeps the course and exam current, relevant, and reflective of the best and most demanding college curriculum.

Over the years two significant changes have been made to the College Board's original concept of offering a college-level introductory biology course to high school students. The first was the addition of laboratory exercises to the curriculum to ensure that students experience the hands-on discovery aspect of science. The second was the inclusion of major themes/concepts of biological science in the curriculum. Both changes have immeasurably strengthened the program, giving students the opportunity to do quantitative and qualitative biological science, ensuring they get the big picture and major insights into the science of life, and helping to make the content base of biology less overwhelming and yet more meaningful by weaving small pieces together into a relevant, understandable whole.

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1. The College Board, "The History of the AP Program," http://www.apcentral.collegeboard.com/apc/public/program/history/8019.html (accessed January 16, 2007).

2. The College Board, "2006: Biology Grade Distributions," http://apcentral.collegeboard.com/apc/members/exam/exam_questions/151230.html (accessed January 16, 2007).

Future developments that will affect AP Biology are on the near horizon. Many AP Biology teachers are retiring and hundreds of new AP teachers are taking their place in the ranks. Because the College Board wants all new teachers to feel confident and be enthusiastic about bringing AP Biology to their students, it offers valuable professional development opportunities like summer institutes, daylong and weeklong workshops, and teacher resources like this publication and AP Central to help new teachers develop and deliver a great AP Biology course. The College Board is also working diligently to enhance access to AP Biology for more students in high schools that have never offered AP courses in the past.

Another development is the upcoming redesign of the AP Biology program. In 2001 the National Research Council issued a report evaluating AP Biology from the perspective of the national science community.[3] This report led the College Board to obtain funding from the National Science Foundation for a project to redesign AP Biology. At the time of this writing, the project is in the preliminary stages of discussion about how AP Biology might be made even more exciting and challenging for both students and teachers. I can assure all current and near-future AP Biology teachers, however, that no alterations will be made to the AP Biology course, laboratories, or exam without comprehensive professional development efforts for teachers and adequate time to prepare for the changes that will be coming.

A development that is ever present in the discipline of biology is the new knowledge that will continue to be discovered and that we will want to add to our lectures and laboratories. This will necessitate making adjustments to our courses to accommodate the new material. The theme of the one-hundred-and-twenty-fifth anniversary issue of *Science* magazine is "What Don't We Know?"[4] I encourage all AP Biology teachers to take a look at it and consider sharing it with their students. Of the 125 questions posed throughout the issue, approximately 68 are related in some way to biology. These range from "What is the biological basis of consciousness?" "How do proteins find their partners?" and "Can cancers be controlled rather than cured?" to "What are human races, and how did they develop?" Perhaps, as you present your view of biology as a dynamic, relevant, and knowable discipline, one or many of your students will consider a future as a biological scientist (some other kind of scientist is okay, too) and ultimately participate in discovering the answers to many of these fascinating questions.

The *AP Biology Course Description* and the AP Biology Exam have always reflected the growth and evolution of the course. While it works to develop each exam, the Development Committee is especially mindful of the ongoing modifications to the course. The committee sets criteria for itself when crafting the free-response questions, carefully considering every word, every punctuation mark:

- Does the question address a theme?
- Is there appropriate balance between depth and breadth of topic?
- Does the topic cut across the curriculum?
- Is the question clear, concise, and straightforward?
- Does the question give students a fair chance to succeed?
- Is the question worth asking?

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3. Committee on Programs for Advanced Study of Mathematics and Science in American High Schools. *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools: Report of the Content Panel for Biology*, edited by Jerry P. Gollub, et al. (Washington, D.C.: National Academy Press, 2002).

4. *Science* 309, no. 5731 (July 1, 2005).

The committee has also adopted the motto "Every test is a child" for the AP Reading as a reminder of who is most affected by the quality of its efforts.

Focusing the minds of young almost-adults on thinking the big, abstract thoughts amidst the increasing turmoil and complexity of high school life is a challenge for teachers. Most students do not come to school every day looking forward to wrestling with the idea of continuity and change over millions of years. They just want to make it through the day without appearing less than cool to their friends, avoiding trouble with their teachers, and successfully dealing with the myriad of other difficulties high school students face today.

The AP Biology teachers who guide these students are a hard-working and dedicated group. They participate in summer institutes and weekend workshops, dedicate large amounts of time to course preparation, come up with new and inventive ways to focus their students' attention on the daily course work, and cajole, entice, and encourage their students to give 110 percent in preparation and effort. Despite the increasing pressures of less time, more material to cover, and mandatory laboratory experience, the efforts of these educators have maintained the quality and integrity of the AP Biology program throughout all of the changes and challenges of the past 50 years.

The Development Committee and I are delighted that you have become part of the community of AP Biology teachers, a community that offers students the gift of knowing more about themselves and their world.

Robert E. Cannon
Former Chair, AP Biology Development Committee
Member, AP Biology Redesign Advisory Panel of the College Board
University of North Carolina at Greensboro

Course Description Essentials

Introduction to the Course

The AP Biology course gives high school students the opportunity to receive college credit for work completed in high school. It is often a student's second year of study in biology. In order to ensure that the course's curriculum content is equivalent to that of a two-semester, college introductory-level biology course, the College Board appoints a committee composed of college and university professors and high school teachers from around the country who represent a variety of academic institutions and demographics.

The AP Biology Development Committee regularly surveys professors from colleges and universities that accept the most AP candidates. The questionnaire asks professors to describe the content of their introductory-level course for biology majors. This information is analyzed, and a topic outline in the Course Description is compiled based on the responses the Committee receives. The topic outline not only reflects the content covered in the college courses that were surveyed but also provides a guideline for the percentage of time that teachers should devote to each topic. Each May the College Board administers and evaluates a national exam that assesses material found in a college introductory-level biology course for majors.

Introduction to the Course Description

The *AP Biology Course Description* is the foundation of any AP Biology program. This College Board publication provides important, basic information with which all AP Biology teachers should be intimately familiar. The Course Description

- Identifies the goals of the course
- Describes the difference between themes and topics and concepts
- Lists and explains the eight major themes of the course
- Breaks the themes into a topic outline with recommended percentages of course time to be spent on each topic
- Discusses the types of laboratory work the course should emphasize and briefly describes the 12 recommended labs in the *AP Biology Lab Manual for Students*
- Provides sample multiple-choice and free-response questions from an AP Biology Exam
- Offers general information about the College Board's AP Program

The Course Description can answer many of the questions new AP teachers may have about what constitutes an AP Biology program. It is also useful for helping school administrators understand the course's time and equipment needs. When discussing resource requirements with them, you will find that prefacing your request with "the guidelines from the College Board require X, Y, and Z for program success" is usually more effective than saying "I need X, Y, and Z to teach this course properly." The Course Description carries authority; do not be afraid to use it for support when you need something for your course.

You can download the most recent Course Description at no cost from AP Central at apcentral.collegeboard.com (go to *Course Descriptions* under *The Courses*). The Development Committee annually reviews the Course Description content; unless there are major revisions, it usually releases an updated Course Description every two years. All parts of a new Course Description are important and should be studied and reviewed. If your course curriculum and syllabus follow the Course Description, your students will learn what they need to know to do well on the AP Exam and succeed in future biology courses.

Major Themes

A goal of the AP Biology program is to give students an understanding of biology as a process rather than to make the course and learning process nothing more than an accumulation of discrete and unrelated facts to be memorized. To facilitate this goal, the Development Committee has identified eight major themes, "overarching features of biology that apply throughout the curriculum."[5] You can use these themes, which have been reprinted here from the 2006, 2007 Course Description, to "assist students in organizing concepts and topics into a coherent conceptual framework."[6]

I. Science As a Process—Science is a way of knowing. It can involve a discovery process using inductive reasoning, or it can be a process of hypothesis testing.

Example: The theory of evolution was developed based on observation and experimentation.

5. 2006, 2007 *AP Biology Course Description*, 4.

6. 2006, 2007 *AP Biology Course Description*, 7–8.

II. **Evolution**—Evolution is the biological change of organisms that occurs over time and is driven by the process of natural selection. Evolution accounts for the diversity of life on Earth.

Example: Widespread use of antibiotics has selected for antibiotic resistance in disease-causing bacteria.

III. **Energy Transfer**—Energy is the capacity to do work. All living organisms are active (living) because of their abilities to link energy reactions to the biochemical reactions that take place within their cells.

Example: The energy of sunlight, along with carbon dioxide and water, allows plant cells to make organic materials, synthesize chemical energy molecules, and ultimately release oxygen to the environment.

IV. **Continuity and Change**—All species tend to maintain themselves from generation to generation using the same genetic code. However, there are genetic mechanisms that lead to change over time, or evolution.

Example: Mitosis consistently replicates cells in an organism; meiosis (and hence sexual reproduction) results in genetic variability.

V. **Relationship of Structure to Function**—The structural levels from molecules to organisms ensure successful functioning in all living organisms and living systems.

Example: Aerodynamics of a bird's wing permits flight.

VI. **Regulation**—Everything from cells to organisms to ecosystems is in a state of dynamic balance that must be controlled by positive or negative feedback mechanisms.

Example: Body temperature is regulated by the brain via feedback mechanisms.

VII. **Interdependence in Nature**—Living organisms rarely exist alone in nature.

Example: Microscopic organisms can live in a symbiotic relationship in the intestinal tract of another organism; the host provides shelter and nutrients, and the microorganisms digest the food.

VIII. **Science, Technology, and Society**—Scientific research often leads to technological advances that can have positive and/or negative impacts upon society as a whole.

Example: Biotechnology has allowed the development of genetically modified plants.

The Topic Outline

The AP Biology course content is divided into three general content areas and given percentages for the amount of course coverage for which you should strive: *molecules and cells* (25 percent), *heredity and evolution* (25 percent), and *organisms and populations* (50 percent). The Course Description subdivides these three areas into a topic outline, also with percentages for coverage in both the course and on the exam. The topic outline gives all AP Biology teachers a common context from which to develop a conceptual understanding of modern biology.

The Development Committee modifies the topic outline when the results of the questionnaires it receives from college and university faculty indicate that changes to the introductory-level curriculum have been made. Although the topic outline from the 2006, 2007 *AP Biology Course Description* is reprinted here[7], you are advised to always be familiar with the most current Course Description.

Topic	*Percentage of Course*
I. Molecules and Cells	25%
A. Chemistry of Life	7%
Water	
Organic molecules in organisms	
Free energy changes	
Enzymes	
B. Cells	10%
Prokaryotic and eukaryotic cells	
Membranes	
Subcellular organization	
Cell cycle and its regulation	
C. Cellular Energetics	8%
Coupled reactions	
Fermentation and cellular respiration	
Photosynthesis	
II. Heredity and Evolution	25%
A. Heredity	8%
Meiosis and gametogenesis	
Eukaryotic chromosomes	
Inheritance patterns	
B. Molecular Genetics	9%
RNA and DNA structure and function	
Gene regulation	
Mutation	
Viral structure and replication	
Nucleic acid technology and applications	
C. Evolutionary Biology	8%
Early evolution of life	
Evidence for evolution	
Mechanisms of evolution	

7. 2006, 2007 *AP Biology Course Description* (New York: College Entrance Examination Board, 2005), 5–6.

III. Organisms and Populations 50%

A. Diversity of Organisms 8%
Evolutionary patterns
Survey of the diversity of life
Phylogenetic classification
Evolutionary relationships

B. Structure and Function of Plants and Animals 32%
Reproduction, growth, and development
Structural, physiological, and behavioral adaptations
Response to the environment

C. Ecology. 10%
Population dynamics
Communities and ecosystems
Global issues

Key Concepts and Skills

Key concepts are designated for each section of the topic outline, and the eight themes unify these concepts by making important connections between the topics. The themes build a framework for student learning by relating one concept to another. For instance, the theme of energy transfer is found in numerous examples in biology. In the first general content area, *molecules and cells*, energy is important in the process of active transport of the sodium/potassium ions across the membrane of a neuron. Energy is also important in *heredity and evolution*, the second general content area; the evolution of the first cells seems to violate the first law of thermodynamics, until it is understood that the earth is not a closed system but has a constant energy input from the sun. The theme of energy transfer is further illustrated in the third general content area in biology, *organisms and populations*, by the flow of energy in energy pyramids.

Directing your students' focus towards making connections using these themes may be one of the most challenging learning objectives of AP Biology, as most students will be experiencing this holistic approach for the first time. Making references to the themes often during the class is a simple yet effective approach. "How does the process of photosynthesis reflect the theme of structure and function?" for example, will redirect students from memorization of the names of the steps towards thinking about the structure of chlorophyll, chloroplasts, and the carbon-based products of photosynthesis. Theme-based homework questions such as: "How does meiosis relate to continuity or change?" or "Why is the immune system a good example of homeostasis?" promote student thought. Select the least obvious theme for each topic. Relating genetics to continuity and change is easy. Relating genetics to regulation or interdependence will necessitate more thought. Another example is to relate natural selection to science, technology and society, or regulation, rather than the more obvious continuity and change or structure and function. Some teachers have the students divide a large index card into four sections on each side, for a total of eight, one for each theme. Each day, the students are asked to classify the material covered that day into at least one of the sections and record it there. Lively discussions can begin class the next day as students compare their classifying decisions, either with a partner, a group, or the class.

The following table, reprinted from the 2004, 2005 *AP Biology Course Description*, shows how the themes can be applied to the three major subject areas.

Applying Themes
Examples for Three Major Subject Areas[8]

Theme	I. Molecules and Cells	II. Heredity and Evolution	III. Organisms and Populations
I. Science as a Process	How did Melvin Calvin and his students discover the sugar-producing cycle of photosynthesis?	How do we know DNA is the genetic material?	What can long-term ecological research teach us about human impact on the biosphere?
	Experiments with artificial membranes have added to our understanding of the structure and function of the plasma membrane.	X-ray diffraction, model building, and analysis of base pairing led to the development of the double helix model of DNA.	Measurements of rates of transpiration using parts of plants have helped biologists understand the role of the roots and the leaves.
II. Evolution	Chemical evolution on a young Earth set the stage for the origin of life.	Mutations and genetic recombination generate heritable variation that is subjected to natural selection.	When a population's local environment changes unfavorably, the population adapts, migrates, or dies.
	C_4 and CAM plants represent structural and biochemical adaptations for photosynthesis in hot and dry climates.	Natural selection occurred in early pre-life forms, as coacervates possessing enzymes for synthesis of various metabolites had more options for energy utilization and thus were more likely to survive.	The system of taxonomy used by most biologists today reflects our current understanding of phylogenetic relationships among organisms.
III. Energy Transfer	Plants transform light energy into chemical energy.	A cell must spend energy to transcribe and translate a gene because monomers are organized into complex macromolecules that have less entropy.	Energy flows from producers to consumers in an ecosystem.
	A proton gradient across membranes powers the synthesis of ATP in mitochondria, chloroplasts, and prokaryotes.	Energy released by the hydrolysis of ATP is used by cells in DNA synthesis, transcription, and translation.	Ion pumps in membranes reestablish a transmembrane resting potential after a neuron fires an impulse or a muscle fiber contracts.

8. 2004, 2005 *AP Biology Course Description*, (New York: College Entrance Examination Board, 2003), 16–19.

Theme	I. Molecules and Cells	II. Heredity and Evolution	III. Organisms and Populations
IV. Continuity and Change	The cell cycle clones a cell's DNA.	Like begets like, but not exactly, as mutations and sex generate new genetic combinations	Homologous structures are variations on a common ancestral prototype.
	The process of mitosis allows for genetic continuity from generation to generation while at the same time, through mutation, it provides for diversity.	Changes in gene pools over time can be explained in part by natural selection for the most fit genotypes.	Organogenesis results from differential gene activation in various regions of an embryo at various times.
V. Relationship of Structure to Function	The distinctive functions of starch and cellulose reflect structural differences in these two polysaccharides.	By discovering the structure of DNA, Watson and Crick deduced how genes replicate.	The large surface area of the mammalian small intestine increases absorption of nutrients.
	The membranous organization of the mitochondrion orders the process of cellular respiration.	The complementary nature of the two DNA strands explains replication.	Morphological adaptations of parasites to their hosts enhance their survival.
VI. Regulation	Control of the flow of molecules across the membrane maintains a favorable intracellular environment.	Regulatory mechanisms switch genes on and off in response to environmental cues.	The nervous and endocrine systems mediate an animal's responses to changes in the environment.
	Regulator molecules in the cell interact with some enzymes and control their activity by changing the shape of the enzymes.	A balanced polymorphism can exist within a population, in which two or more alleles can be kept in the gene pool by the action of predators that selectively prey on the most common phenotype.	Hormones regulate the growth and development of both plants and animals.
VII. Interdependence in Nature	At the metabolic level, photosynthesis and cellular respiration are complementary processes.	An organism's phenotype is the synergistic product of genes and environment.	Destruction of tropical forests has global consequences.
	Energy for many biosynthetic processes is provided by the hydrolysis of ATP. In turn, the synthesis of ATP is coupled to the oxidation of organic fuels.	The sporophyte and gametophyte generations of a plant are interdependent.	Competition, predation, and parasitism between populations in a food web contribute to the stability of an ecosystem.

Theme	I. Molecules and Cells	II. Heredity and Evolution	III. Organisms and Populations
VIII. Science, Technology, and Society	Advances in cancer research depend on progress in our basic understanding of how cells work. Various new techniques in microscopy have led us to a better understanding of basic cell structure and function.	DNA technology is a double-edged sword, promising health advances and posing new ethical issues. Biotechnology has provided new treatments for various genetic diseases, developed crops with better yields, and provided solutions for environmental problems.	More people utilizing more technology have generated many current global problems. An understanding of basic ecological principles can help us to assess the human impact on the biosphere and to begin to develop solutions to some human-caused environmental imbalances.

The AP Biology program encourages other skills, or student-learning outcomes, in the three general content areas and eight major themes encompassed by the AP Biology course. Such skills include those that are common to most science courses: observation, interpretation of data, application of knowledge to new experiences, development and testing of hypotheses, deductive reasoning, critical analysis, problem solving, communication, application, and the proper use of basic scientific terms and measurement units.

The comprehensive development of these skills involves varied teaching and learning strategies to meet the needs of students with an assortment of backgrounds and capabilities. These methods are common to most biology courses, and the experienced biology teacher is familiar with them. They can include demonstrations, manipulatives, audiovisuals, computer simulations, student reading and writing, and laboratory experiences. By using the appropriate strategies, you can increase teaching effectiveness and student learning in your AP Biology course. The AP Biology Electronic Discussion Group (EDG) as well as College Board workshops and AP Summer Institutes are great venues to learn new teaching strategies (see the "Professional Development" section in chapter 2 for more information).

The Laboratory Component

The integration of laboratory exercises that are representative of the laboratory experiments being done at the college introductory level is extremely important. Including lab work in the AP Biology program increases students' chances for receiving lab credit in addition to course credit for their AP work. In an effort to ensure that AP Biology teachers incorporate appropriate lab exercises into their curriculum, the College Board developed the *AP Biology Lab Manual for Students* and an accompanying publication for teachers, the *AP Biology Lab Manual for Teachers*. The AP Lab Manual contains 12 labs that complement the topic outline.

Lab 1. Diffusion and Osmosis. The experiments in this first lab include diffusion across a semipermeable membrane, using dialysis tubing to determine the rate of diffusion of various concentrations of sucrose solutions, determining the water potential of potato cells, and observing plasmolysis in onion cells.

Lab 2. Enzyme Catalysis. This lab uses catalase as the enzyme in the decomposition reaction of hydrogen peroxide. Students determine the amount of hydrogen peroxide that remains after different periods of time by titration with potassium permanganate and then calculate the rate of decomposition.

Lab 3. Mitosis and Meiosis. Students work on three exercises: calculating the amount of time cells spend in each phase of mitosis by examining an onion root tip, calculating the distance between a gene locus and the centromere in *Sordaria fimicola*, and using beads to simulate the process of meiosis.

Lab 4. Plant Pigments and Photosynthesis. In the first exercise students use paper chromatography to determine the R_f value of various plant pigments found in leaves. In the second exercise they use a chloroplast suspension and an indicator DPIP to investigate what factors affect the rate of the light-dependent reaction (Hill reaction).

Lab 5. Cell Respiration. This experiment determines the rate of cellular respiration of dormant and germinating peas at two different temperatures.

Lab 6. Molecular Biology. Students conduct two experiments. The first is a transformation experiment in which students insert an engineered plasmid into *E. coli*. In the second lab students digest *lambda* bacteriophage DNA with selected restricted enzymes and determine the length of DNA fragments with electrophoresis equipment.

Lab 7. Genetics of Organisms. This extended experiment involves using *Drosophila melanogaster* in genetic crosses. Students are expected to use the chi-square test when analyzing the results. This lab may take one to two days a week during a four- to six-week period to complete.

Lab 8. Population Genetics and Evolution. This simulation involves applying the Hardy-Weinberg equilibrium equation to collected data and modeling the effect of different factors on allele frequencies.

Lab 9. Transpiration. Students conduct two experiments. In the first they use a potometer to investigate the transpiration of an herbaceous plant under various conditions. In the second they assemble, stain, and examine wet mounts of thin stem sections.

Lab 10. Physiology of the Circulatory System. This lab consists of two experiments. The first measures the heart rate and blood pressure in a volunteer to determine that person's fitness index. The second uses *Daphnia* to investigate the effect of temperature on heart rate.

Lab 11. Animal Behavior. In this inquiry lab, students study the behavior of pill bugs as they respond to different environmental factors, and they observe the mating behaviors of *Drosophila melanogaster*.

Lab 12. Dissolved Oxygen and Aquatic Primary Productivity. Students determine the gross and net primary productivity of a given aquatic ecosystem as a function of differences in dissolved oxygen over time.

Students use an inexpensive wallpaper tray as a water bath for the cell respiration lab (AP Lab 5). When doing this lab with your students, be sure to allow the vials a full 15 minutes to stabilize. Use a thermometer in the tray to record possible temperature changes. (Photograph courtesy of Carol Leibl.)

The AP Lab Manual gives you an idea of the types of lab exercises that should be included in an AP Biology course. Each exercise identifies pre-lab and post-lab objectives. The pre-lab objectives include the knowledge and skills students should have before performing the exercise. The post-lab objectives list what students should have learned from the exercise.

While the exercises in the AP Lab Manual are not mandatory, they are extremely beneficial in developing the analytical skills that are evaluated on the AP Exam. The AP Exam includes multiple-choice lab-set questions for which students are given laboratory scenarios with data and then asked to interpret the data and draw conclusions. In addition, one or more of the four free-response questions on the AP Exam are lab based. If any of these lab exercises are not included in your AP Biology curriculum, it is important that the labs you replace them with meet the AP laboratory objectives. For more discussion on the AP Lab Manual and the role of the labs in the course, see "The AP Biology Laboratory Experience" section in chapter 2 and the "Lab Component" sections in the sample syllabi in chapter 3.

Chapter 2
Advice for AP Biology Teachers

Teachers who are preparing to teach the AP Biology course for the first time have many questions about getting started. Am I qualified to teach the course? How do I get the parents on board? What textbook should I use? Is my lab space adequate? How can I cover the whole topic outline in the time I have? This chapter strives to answer these questions and many more. Here you will find everything from ideas for helping your students understand the themes, to suggestions for using the Internet effectively, to information on the variety of resources that are available to AP teachers.

Tips for New AP Biology Teachers

As a new AP Biology teacher, don't try to do it all. Do your best to hold to a schedule so you have time to cover the material in the topic outline and the labs. Each year you will learn ways to improve the course and make adjustments as needed. Above all else, teach those things you are truly passionate about because that will inspire your students the most.

—Mike Basham, El Dorado High School, Placerville, California

Being Part of an AP Biology Program

First things first with your new course—you, your students, and your students' parents. The most important attribute of both AP teachers and their students is the desire to make a time and effort commitment to a challenging and rewarding academic experience. The parents come along with the students, and you will find that welcoming them as partners in the learning process makes good sense. This section discusses teachers, students, and ways to enlist the support of your students' parents.

Who Is an AP Biology Teacher?

Because the AP Biology curriculum is the equivalent of a college introductory-level biology course, its demands are greater than those of a regular high school biology course, and its teachers must have a greater wealth of knowledge about the field. Research indicates that AP teachers usually have a master's degree in an academic discipline that is the same as the AP course they teach.[9] Such educational background is indeed beneficial in light of the great breadth and depth of an AP course. Teachers who lack a sufficient background for meeting the course requirements may need additional training and study to adequately teach AP Biology. This can involve taking supplementary courses at a local university.

9. Glenn B. Milewski and Jacqueline M. Gillie, *What Are the Characteristics of AP Teachers? An Examination of Survey Results*, Research Report 2002-10 ([New York: College Entrance Examination Board], 2002): 1, http://www.collegeboard.com/research/pdf/200210_20717.pdf (accessed January 17, 2007).

While having the necessary qualifications to teach an AP course is important, potential AP teachers should also realize that teaching an AP course requires an additional time commitment for course preparation and working with students outside of class. To some, the time required for extra planning and student interaction may initially feel like a sacrifice, but most AP teachers eventually realize and relish the rewards of teaching truly dedicated students who are willing to devote more time and effort to an advanced course.

Course Enrollment

An AP course is designed to be a college-level introductory course, with comparable expectations and demands on the students. It is not meant to be a first-year high school biology course. Most AP Biology courses enroll juniors and seniors, though a handful of schools allow exceptionally gifted sophomores to enroll.

Surveyed AP teachers report that the most important factor for students' ability to succeed in an AP course is academic preparedness.[10] It is not uncommon to have a prerequisite for AP Biology be the completion of first-year courses in both biology and chemistry. Chemistry is crucial for understanding the course's molecular physiological component. The inclusion of research, investigative, problem-solving, critical thinking, and communication skills identified by the College Board in its publication *AP Vertical Teams Guide for Science* in the first year of biology contributes to the AP Biology course; the development of these skills increases students' success in the course and in college.

It is important to make the course as accessible to as many students as possible. The College Board believes that all students who want to take an AP course and are prepared to do the work it requires should be encouraged to take the course. It also feels strongly that the ethnic, gender, and socioeconomic demographics of a school's AP program should reflect those of the school's student population. For an in-depth discussion of the College Board's policy, see "Access and Equity" at the beginning of this Teacher's Guide.

My science department uses the school's annual alumni day to familiarize its students with the benefits of enrolling in an AP course. On the first class day after the end of the winter break, we invite a panel of former AP students who are now college freshmen and sophomores to come back and share their college experiences and give advice to the current AP students. In general, the alumni say their AP courses were without a doubt the most valuable courses they took in high school because those courses' high expectations helped make the transition to college courses easier for them. These students also tell of the money they have saved in tuition by scoring well on the AP Exam and earning college credit. The panel is selected to be representative of the school by including many students of different backgrounds.

AP Class Size

The average enrollment for an AP course is 17 students; this is compared to the average enrollment of 24 students for regular classes.[11] Smaller classes are better for a number of reasons, which include meeting the instructional needs of students, supplying sufficient laboratory equipment, and enabling increased interaction of students in the formation of study groups. Rural and small schools may find that offering AP science courses on a rotating basis (e.g., every other year) increases enrollment to a satisfactory number over a period of time.

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10. Milewski and Gillie, 1.

11. Milewski and Gillie, 6, 8.

Parents and the AP Teacher

Parents can be useful allies in ensuring that students understand the challenges and rewards of an AP course. Most parents are anxious about their children's prospects for college admission and how prepared they will be for the demands of a college program, usually away from home. Most are concerned if their children make negative comments about the course or teacher as the curriculum becomes more challenging. Experienced AP teachers report that bringing in the parents or guardians as partners in their children's progress at the beginning of the course is highly beneficial.

Many schools hold a back-to-school night, which is a good time for AP teachers to meet parents and promote their courses. AP teachers at some schools work with their AP Coordinators to plan an AP Night. They design recruitment brochures to hand out, make copies of their syllabi available for parents to take home, and talk about the rigor and advantages of participating in the AP Program.

An evening meeting of one to two hours with just the parents of the students in your course is another good way to begin to develop a good relationship. Emphasize at the beginning of the meeting that you will not be discussing individual student progress or grades; instead, the focus of the meeting will be to share information about the school's AP program and your course. Offer parents the opportunity to make an appointment with you that evening if they wish to discuss their child's status in your class at a later date. If no type of formal meeting with parents is possible, a letter home to them that conveys the information you would have given them in a meeting can also be effective.

Whether in a meeting or a letter, you should review your course expectations and policies so that parents can communicate more effectively with their children about their schoolwork. Describing your goals for the course helps parents understand the reasons behind your expectations, decisions, and actions. Additionally, asking parents to sign an acknowledgement that they understand your objectives and rules and you expect them to be partners with you in their child's progress can go a long way toward avoiding future problems. Parents should come away from their initial contact with you understanding at least four course objectives. The AP Biology program seeks to

1. Give students the experience of a college-level curriculum;

2. Provide students with an opportunity to learn the factual information and laboratory skills of a college introductory-level biology course;

3. Help students develop the types of study skills that are necessary for success in any course at the college level; and

4. Prepare students to be able to demonstrate on the AP Biology Exam the information and concepts they have learned and the skills they have developed.

Remind parents that the opportunity to earn college credit is only a part of the total program that benefits their children in so many ways. College Board studies indicate that students who take an AP course are better prepared for and experience greater academic success in college, irrespective of the grade they earn on the AP Exam.[12] Encourage all parents to contact you with any questions they may have, give them copies of your syllabus and policies, and offer them the chance to review the textbook and other course materials.

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12. You can find some of these studies on the AP Research page on AP Central. From the main page click on *The Program*, then on *AP Research and Data*, and then on *AP Research*.

You will want to maintain contact with your students' parents throughout the school year, letting them know about the learning that is going on in your classroom and lab as well as information about the upcoming AP Biology Exam. This ongoing communication can take several forms. Choose those that best fit your style and time constraints.

- Articles in the school newsletter
- Periodic meetings with all of the parents
- Quarterly letters or e-mails
- Class assignments and general information posted on your course or the school's Web site

Preparing to Teach the Course

AP Biology teachers devote much consideration to choosing the right textbook for the course and to ensuring they have enough time to cover the entire curriculum before the AP Exam. This section offers classroom-tested suggestions for choosing your resources wisely and getting the most out of them. It also addresses the importance of communicating your expectations to your students and offers examples of some common policies for AP courses.

Selecting a Textbook

"Which textbook should I use?" is among the first questions new AP Biology teachers ask. Textbook selection is an enormous decision that has a considerable impact on the course. Especially for new teachers, the textbook can define the very nature of the course. It is crucial that the one you choose is both a college-level textbook and current. Five years is considered the maximum lifespan of an AP Biology textbook, and many publishers revise their textbooks on a four-year update cycle. Unfortunately, many school districts' buying cycles result in the purchase of textbooks with copyright dates that are up to eight years old.

In many cases the decision of which textbook to use was made by the previous AP Biology teacher or the purchasing practices of the school district or state. But at some point you will be in the position of being able to choose a new textbook. Consult the following sources when investigating and evaluating college-level textbooks for your AP Biology course.

- **Colleagues.** Ask other AP Biology teachers which textbooks they use and why. The AP Biology Electronic Discussion Group is a good place to go to get suggestions and hear other teachers' experiences with using a particular text. Visit http://apcentral.collegeboard.com/EDG to learn more about the EDG.
- **Teachers' Resources area.** You will find many insightful textbook reviews written by high school teachers and college and university professors in this part of AP Central (go to apcentral.collegeboard.com and click on *Teacher's Resources* near the top of the site's home page).
- **Publishers.** Call or write (on your school's letterhead) to the publishers of the textbooks you are considering and ask them to send you a review copy. Keep all of the review copies you receive and add them to your resource library.
- **Local colleges.** Visit the bookstores of the colleges and universities in your area and see which textbooks they use for their introductory-level biology courses.
- **State education agency.** Check with your state education agency to see if it maintains a state textbook adoption list. You may find some appropriate textbooks for your course on the list. Your agency may also be able to provide some funding for your textbook purchase.

- **AP Summer Institutes.** Summer institutes give teachers the chance to review many different textbooks. Most AP consultants for these professional development events ask publishers to send review copies to new AP teachers.

Your students' evaluation of various textbooks can be invaluable during the selection process because a textbook is useless unless students use it, and students are disinclined to adequately use a textbook they do not like. Once I have narrowed down my selection of textbooks to two or three, I ask some of my students to read a few selected chapters and give me their opinions. I present them with the following questions:

- Which textbook do you prefer and why?
- Which textbook explains concepts in terms you understand?
- Are the diagrams helpful and useful to your understanding of the material?
- Does the textbook have review material at the end of each chapter that helps you check your understanding of the material?
- Is the textbook's writing organized in such a way that the main ideas and points are clear and concise?
- What other comments do you have about this textbook?

I find there is usually a consensus about the textbook students feel best meets their needs. It is equally important that you are comfortable with and have confidence in the textbook you will be using because you will unconsciously transfer your assessment of the book to your students when you teach from it. If you like the textbook, then they will be more likely to like it as well, increasing its ability to serve as a valuable learning tool.

All textbooks come with some ancillary materials, including study guides, *PowerPoint*™ presentations, teacher's guides, and more. A textbook's CD-ROMs, Web pages, and audiovisual presentations are tremendous time savers and help teachers present a professional looking program. Before purchasing a textbook, contact its sales representative to ensure that you have seen all of its ancillaries. Sometimes the high school representative may not be familiar with the publisher's college textbooks, and you will need to speak with the college representative.

Make the Most of Your Class Time

The topic outline in the *AP Biology Course Description* is extensive, and one of the biggest concerns new AP Biology teachers have is how they are going to cover all of the material in the curriculum in just nine months. The majority of AP Biology teachers, both new and experienced, face the same time management and scheduling issues. Chapter 3 will tell you how to turn the topic outline into a workable course schedule. This section on time management, however, provides strategies for squeezing as much instruction time as possible out of the school year.

Staying on Schedule

Once you have parceled out your time and established the dates for when each unit begins and ends, be firm, both with your students and yourself. Expect a certain amount of resistance about the pace of the course if you are progressing at an acceptable speed to finish the curriculum on time. If your students are not feeling challenged to keep up with the pace, you are probably moving along too slowly. The temptation to spend extra time on material students do not seem to thoroughly understand is great, but it should be fought. New teachers report this as being one of their biggest mistakes during their first year of teaching

AP Biology. Since different students will find different topics challenging, it is in the best interest of the class to stay on schedule and to cover all of the material in the topic outline before the AP Exam. If students want extra help to better understand specific topics, you may want to make yourself available outside of class hours to work with students.

From the first day of school students should be encouraged to schedule their own time. New AP teachers have a tendency to attempt to do all of the scheduling and organizing for both themselves and their students. If you are working harder than your students at meeting their schedules, then it is time for a change. Help them plan ahead by letting them know the due dates for lab reports and homework at least one week in advance. Doing so enables them to share the responsibility for meeting time requirements.

Creating Additional Class Time

AP Biology teachers sometimes find it necessary to arrange for additional class time in order to cover all of the course material. When increasing your instructional time, first consider your educational setting and your students' needs. Some teachers gain class time by scheduling AP Biology for the first period and starting the class a little earlier several times a week. Another strategy is to schedule the class just before or after the lunch period, which provides similar flexibility. Because some school administrators may not understand the time requirements of an AP science course, you may find yourself having to explain why you are trying to squeeze extra hours out of the school day by starting early or borrowing time from the lunch period.

Maximizing Laboratory Time

Laboratory work presents one of the greatest challenges to time management. The keys to success are both teacher and student preparation. Insist that students come to lab prepared to begin the exercise. Students who are not prepared for a lab should not be allowed to participate in it because they can significantly slow down their classmates' progress and learning. Other ways in which AP Biology teachers can use lab time efficiently and effectively include the following approaches.

- **Pre-Lab Activities.** Requiring your students to complete a pre-lab activity ensures efficient use of lab time. The activity may include reading the lab procedure and the objectives listed under the "Before doing this lab you should understand" heading and answering questions on the objectives and procedure or taking a quiz. Some teachers require their students to write up the procedure in their own words and then use their written procedure as the only guide for their lab work. Another successful pre-lab strategy is to have students review the free lab tutorials on The Biology Place Web site (www.biology.com, click on *The Biology Place*) maintained by Pearson Education; you might even want them to take the short quiz at the end of each tutorial and e-mail you the results.
- **Breaking Up Labs.** Many teachers do not have double periods in which to complete lab work, and instead they must divide labs into smaller chunks. Some labs include more than one activity, which makes it easier to break an exercise up into several brief components and complete it over a number of class periods.
- **Alternate Types of Labs.** While not desirable, time constraints may make it necessary to do several of the lab exercises as computer simulations or dry labs.
- **Creative Scheduling.** Teachers who need additional lab time often arrange for their students to do lab work outside of the scheduled class period. My students meet before or after school on Tuesdays and Thursdays to do lab work, review for tests, and conduct software simulations or other similar learning activities. When my students sign up for AP Biology in the spring, they know in advance that such an extra time commitment will be required. Some teachers hold lab sessions in

the evenings once or twice a week. Many arrange for a Saturday or Sunday session at a local college where three or four labs can be completed using materials and facilities that are not available at their high schools. Some teachers negotiate for an "in-school" field trip, during which their students spend a full day completing several labs. These scheduling methods are consistent with those of biology courses in colleges and universities where laboratory sessions usually are not connected to the class lecture time.

- **Group Work.** When the available lab time is not sufficient for individual students to complete certain exercises, divide the lab work among groups of students. Each group completes one part of the lab and shares its data and observations in a post-lab debriefing with the entire class.
- **Lab Aides.** Lab preparation and cleanup is another time challenge. Ideally, your students can participate in this process, but time constraints can make this difficult. Some teachers assign a few students to come in for an extra hour or two to help prepare for and clean up each lab. Some teachers have official student lab aides who receive credit toward a service requirement. Some schools offer a lab-prep course that students can take for academic credit. Occasionally, parents may volunteer to come in and serve as lab aides.
- **Lab Kits.** The prepackaged lab kits you can buy from the major supply companies are great time savers. Some kits are turnkey, containing all of the materials that are needed for a lab, while others contain only items that are considered unique to that lab.

Lab Materials in Unconventional Places

I have been using germinating peas I buy from a health food store for the respiration lab in the AP Lab Manual. Being in California, we have all sorts of "weird" things in our organic markets. The peas are in the produce section and come in plastic containers. They save me from having to begin the germination process ahead of time and from dealing with the potential of fungal infection. You can also get a mixed selection of germinating seeds (lentils, beans, etc.) that can be used to compare respiration rates of different seeds. Overall, it works great.

—David Knight, University High School, Irvine, California

The Respiration Lab: Time-Saving Tips

If anyone has problems doing the AP Lab Manual's respiration lab in the allotted time, here is a suggestion: germinate the peas three days ahead of time and take readings every two minutes instead of every five. I've tried this and it works very well. It was the best data we'd collected in the eight years I've been teaching AP Biology.

This strategy offers the following advantages: only 10 minutes of data collection instead of 30, less time for temperature and pressure changes, less time for the respirometers to develop leaks, and students can actually see the water move up the pipette in the respirometers containing germinated peas.

—Steve Ianniello, Enka High School, Enka, North Carolina

Finding Time for Grading

Tests, quizzes, homework, and lab reports all need to be graded, and you have only so many hours in your day. You can take several approaches to minimizing your grading time while still continuing to assess your students' progress. Many teachers require only a formal lab report for select labs to ensure their students understand all of the parts of a lab report and can present them correctly. For other labs these teachers may

simply require their students to give an oral report or review, submit their data and conclusions, answer the review questions at the end of the lab activity, or some combination of these and other evaluative activities.

You may choose merely to note the completion of homework rather than grade it for correctness. By posting homework answers on either a bulletin board in the classroom or on the course Web site, you can have your students correct their own homework before turning it in for credit. This approach makes students partners in ensuring homework time is quality time. Many other assignments can also be self-corrected in the same fashion before being submitted for credit.

Reinforce Learning through Grading

I keep all tests and return essays and lab notebooks. When I grade tests I do not mark incorrect items; instead I put the total number correct in the upper right corner. I return the work to my students and they can correct their work for one half point; for changed correct scores I deduct one point. Since I've made no correction marks on their tests, they have to go through each item, thereby reinforcing and reviewing at the same time. Students can work together, but I find there is usually enough disparity in the answers to keep them honest. This is not an original idea (I wish it were), but one shared at an AP meeting I attended in Marquette.

—Donna M. Gilbertson, Beloit Memorial High School, Beloit, Wisconsin

Independent Reading Assignments

One way to maximize learning opportunities is to give students additional assignments and responsibilities. It is common in some schools to give an AP Biology summer assignment. In the Dallas Independent School District, for example, AP Biology teachers assign a unit on ecology for students to complete during the summer. When they return to school in the fall, students turn in their assignments and take a test on the unit. The one caveat is to be sure that you sufficiently assess your students' understanding of the material you have them study over the summer. I assign my students one unit or topic every six weeks during the school year to do on their own. This includes turning in an outline or notes on each chapter, attending a review session, and taking an exam. It is important to explain to your students the rationale behind the time expectations they must meet.

The Animal Behavior Lab: Practical Substitutions

My students do the animal behavior lab in the AP Lab Manual as a summer assignment (there are lots of isopods to be found in their own yards). They do not have access at home to the filter paper and petri dishes recommended in the lab manual, so I have them use plastic deli containers (or something similar) and white paper towels. This works like a charm—the isopods want to get under the paper towels just as much as they want to get under the filter paper. This lab has many variables, so the substitution of materials does not make a great difference in the outcomes students observe.

—Linda Wichers, Birmingham Seaholm High School, Birmingham, Michigan

Communicating Expectations to Students

As the AP teacher, you need to believe in your program. What you are offering has value, the demands on students' time and effort are there for a good reason, and students are expected to make their best effort to meet the course requirements. The phrase "no pain, no gain," is every bit as applicable to academics as it is to sports. Homework and class work should leave the brain a bit achy and tired, just as a good sports workout leaves the body a bit sore and weary. This sports analogy is a comparison most students can understand.

For many students the AP Biology course is their first encounter with both an academically rigorous course and the need to be a self-starter, two attributes that characterize a college course experience. Clearly defining the differences between traditional high school and AP courses and establishing expectations can make a big difference in the success of your program. Experienced teachers find that these expectations are best presented to students in a written document that alerts them to the work, time, and conduct that will be expected of them in the course. A typical document reads like this:

In the AP Biology course, you should expect to

- Do one hour of homework every night and come to class prepared
- Be prepared with assignments
- Show the extra commitment that lab work may require
- Follow the safety and behavior requirements of the course
- Attend any extra study/review periods that are held during the year
- Be responsible for making up any work that is missed
- Be present at the scheduled practice AP Exam in the spring
- Complete any summer or vacation assignments that may be required

The key message to convey to your students is that in a college-level course, the responsibility for success is transferred from the teacher to the student. Have students sign a course contract, or agreement, showing they are aware of and understand the conditions of the course and agree to abide by them. The first exam grade can often be a wake-up call for students who are used to getting As based on effort and cooperation rather than serious academic preparation and achievement. When students start using their "academic coping skills" and express to one and all that their teacher is too hard and is being unfair, the presentation of a signed contract will help ensure the support of parents and school administrators in maintaining the course standards and expectations.

Making Up Missed Work

Although most colleges have a policy of no make-up work, many high schools require teachers to give students an opportunity to make up missed work. At the beginning of the year, you need to have a clear policy in place for students who fail major tests or miss tests and lab activities. These students are going to be concerned about their grades and may ask for an opportunity to do make-up work.

Your first step should be to determine whether your school already has established policies. If it does, become familiar with them and distribute them in writing to your students. You may even want to post them on the course Web site along with the course syllabus and assignments. If your school does not have policies in place, you will need to develop your own.

Failing Major Tests

Teachers whose schools do not have a policy for retaking major tests have different strategies for accommodating students who have failed a test or exam.

- **No retests.** Some teachers do not provide any opportunities for students to improve their grades on a failed test and merely suggest they prepare better for the next one.

- **One retest.** In some cases, teachers give students an opportunity to retake a test after additional study. The time and resources required to construct a second test for the same material makes this a rare practice. But some teachers find they can offer an essay make-up test by using free-response questions from past AP Exams, even when the original test was multiple-choice.
- **Additional points.** A popular option is to offer additional points to students who write corrections for those questions they missed. As an alternative some teachers allow students to set up an appointment outside of class to explain answers they had incorrect on a test. This conversational method gives teachers the opportunity to make sure the student understands a problematic topic. If the teacher is satisfied with the interview, the student receives a grade adjustment. The teachers who follow this policy believe students learn more from correcting their errors, and the increase in their students' grades reflects that additional knowledge. Earned grade increases include raising the grade by one letter grade, raising the grade by half the difference between the failing grade the student earned and the highest grade earned on the test, and raising the grade to a minimum passing score. At schools where a D is considered a passing grade, some teachers extend the same opportunity to students who earn a D on an exam. Few teachers allow students to raise a C or B grade with make-up work.

Missing Major Tests

Most schools have a policy for missed exams: students are expected to make them up at the earliest possible time. Some schools differentiate between excused and unexcused absences. There are two typical approaches to make-up tests.

- **Advanced scheduling.** Many teachers require students who know they will be out on a particular day (e.g., for a sporting event or doctor's appointment) to schedule in advance of their absence a time to take a make-up test. The actual make-up time may be before or after the scheduled exam.
- **Take-home tests.** In extreme cases, a teacher may allow a student to take the missed test as a take-home exam under parental supervision. Emphasize to your students that scheduling and taking a make-up test is their responsibility, not yours.

Missing Labs

Unlike other activities, lab work requires specific equipment, techniques, and materials. Some materials, like a chloroplast suspension or virgin female fruit flies, are time sensitive. A variety of different policies for missed labs exist.

- **No make-up time required.** If a student has only missed one lab during the marking period, semester, or trimester, it does not have to be made up.
- **Using dry labs.** In many cases, a paper version of the lab can be used. Some examples of possible dry labs include counting *Sordaria* from photographs, using a computer simulation, doing transformation with a paper plasmid and DNA, and drawing conclusions and observations from data provided by the teacher.
- **Leaving one lab setup.** Some teachers put one setup for a lab on a side table for a given period of time, allowing students who missed the lab to come in on their own time to do it. In these cases, the student must arrange for a time when teacher supervision is available, possibly even when another class is having a lab session.
- **Running a make-up lab.** Some teachers run a make-up lab during the week of final exams or on a half day of school. Students sign up for the lab they missed and the teacher provides the materials and supervision.

- **Offering alternate labs.** Examples of alternate labs are giving students who missed the fly lab the opportunity to perform a genetics lab by counting corn kernels, or giving students who missed the enzyme lab a simpler enzyme lab to perform that does not require titration.

None of the policies described here are inherently "fairer" than any of the others and, of course, this list of policies is not all-inclusive. The key to a make-up policy is clarity and consistency. Knowing what the policy is at the beginning of the year and knowing that it will be consistently applied will elicit cooperation from many of the students and reduce the amount of negotiating they will try.

Accepting late work is a common mistake new teachers make. Late work is not accepted in college, and strict adherence to deadlines can be justified as a policy of an AP course. As with all things educational, there will be exceptions, but they should be made very judiciously. You may have to reconcile a no-late-work policy with existing practices at your school. Approaching your school's administrators at the beginning of the year about the different nature of an AP course may help prevent issues of conflicting late-work policies from arising later on. Avoid extending deadlines as well because this can send students a message that late work is acceptable.

Taking away too much responsibility from students for understanding the work is another pitfall to avoid. Your students should be working harder than you are to understand the material. Offering extra credit to raise a low test grade is a controversial issue, even among the most experienced teachers. Some say it has no place in an AP program; others say it enhances learning. Your school policies may require you to use your professional judgment on late work or extra credit.

Enthusiasm Is Contagious

Maintain your love of biology and let your enthusiasm show; that will generate motivation and appreciation in your students for all of the neat concepts and interrelationships of biology. Once you have ignited their joy of learning, stay organized, well structured, and dependable in the quality of the work you expect your students to maintain. Allow for partner activities once in a while. Group work will get students to think out loud and "talk biology," and (hopefully) it will make you smile.

—Lois Peterson, Albany High School, Albany, California

The AP Biology Laboratory Experience

Lab experience is integral to the AP Biology course because it completes the learning process that begins with the lectures and discussions in the classroom. Students must have lab experience if they are going to achieve the desired level of comprehension of a concept, theme, topic, or skill, let alone demonstrate to the college of their choice that they have had the equivalent of a complete college introductory-level biology course experience.

Imagine trying to understand the structures and function of the circulatory system by looking at photographs in a dissection manual; nothing compares with doing a dissection of a fetal pig yourself. Students can only learn so much from their textbook; the rest they must learn by doing. Furthermore, when students reach college, they will be expected to know how to design an experiment and evaluate it in a written report afterwards. They cannot learn this skill from reading a book. They must have the opportunity to put on a lab coat and see what works and what does not by doing an experiment from start to finish.

Students exchange gametes during the population genetics lab (AP Lab 8). When you do this lab, be sure to carefully explain and show your students the proper way to produce the next generation. (Photograph courtesy of Carol Leibl.)

The laboratory program you offer your students must address the objectives of the *AP Biology Lab Manual for Students*. You should also ensure that your students learn the same basic lab skills in the AP Biology course that they would learn in a college introductory-level biology course. They should leave your course with the ability to competently perform the following skills (listed in their order of importance):

- Record data and observations properly
- Use the correct form and content when writing a lab report
- Formulate a hypothesis
- Design a lab activity to test a hypothesis, including appropriate controls
- Demonstrate the proper care and use of both a compound and dissection microscope, including oil immersion
- Use the chi-square statistic to determine validity of data (AP Labs 7 and 8)
- Demonstrate safety and procedural techniques for working with microorganisms
- Use a spectrophotometer or a colorimeter
- Use a burette to perform a titration
- Run and interpret an electrophoresis gel
- Use a ventilation hood properly when working with hazardous materials
- Use properly and appropriately pipettes, graduated cylinders, and volumetric flasks
- Use properly and appropriately a balance that is precise to at least a centigram
- Prepare and stain wet-mount microscope slides (AP Lab 9)

Lab Facilities

Because the AP Biology course is the equivalent of a college introductory-level course, it is important that the lab facilities that are available to AP Biology students be as similar as possible to those they would be

using if they were taking the same course at a college or university. The list that follows enumerates the equipment your lab facilities should have in order to give your students a college biology lab experience.

- Running water
- Gas burners or hot plates for heating (alcohol lamps are not considered appropriate for a high school lab)
- Standard safety equipment, including a fire extinguisher, eye wash, shower, first aid kit, fire blanket, and sufficient exits and space per student to meet state safety requirements
- Adequate ventilation and ventilation hoods
- Adequate lighting
- High-quality microscopes for individual work, including oil immersion
- Spectrophotometer or colorimeter
- Burettes for titrations
- Adequate number of pipettes, petri dishes, beakers, and other standard lab glassware
- Incubator
- Appropriate storage areas for reagents and equipment
- Autoclave or sterilizer
- Adjustable water bath
- Electrophoresis equipment

Increasing numbers of college and high school science programs are using probeware in their labs. Probes to detect such properties as temperature, pH, CO_2 level, light intensity, and so on are attached either to computers, graphing calculators, or dedicated devices for data collection. Teachers report that students are able to obtain better data and focus on the meaning of the data when they use probeware.

Ironically, many college science programs are under pressure from their administrations to reduce costs by eliminating some of their lab experiences. However, institutions with good science programs still provide a complete lab experience. The AP Biology course should do so as well.

The Molecular Biology Lab: Tips

Keeping the hot water bath at 42 degrees for the molecular biology lab in the AP Lab Manual is a challenge. The water from my tap is warm enough for students to mix and get it, but I've heard of teachers who use an old Crock-Pot® that has the continuous dial to get variable temperatures. You just mark the Crock-Pot at the place where the dial setting produces 42 degrees. The trick is finding one of those old Crock-Pots. Scour garage sales and thrift shops, or ask around to find a packrat who keeps everything.

Once, in a pinch, I heated water in a microwave oven and let my students dilute it. I have never used a water bath but have had my students create their own in foam cups during the 10-minute wait period just before the heat shock. It's worked well for us. Students don't have to commute to the water bath, so there is a better chance of rapid transfers in and out of the water bath and back to the ice.

—Tricia Glidewell, Marist School, Atlanta, Georgia

The AP Lab Manual

The *AP Biology Lab Manual for Students* consists of 12 recommended labs developed by the AP Biology Development Committee. While most new teachers think of the AP Lab Manual as the preeminent guide, its labs are presented only as suggested ways in which to fulfill the objectives of the course's lab program. As you gain experience and confidence with the AP Biology course you will begin to develop a collection of favorite labs from a variety of sources, including some you write yourself. Experienced AP teachers are a knowledgeable source for successful student-tested lab activities, many of which can be done with minimal cost. The Teachers' Resources area on AP Central is a good place to look for critiques of other lab manuals.

A successful lab program is not limited to the completion of the 12 suggested labs in the AP Lab Manual. In fact, many teachers feel the 12 labs do not constitute a sufficient lab experience for first-year college students and supplement these labs with other lab work to give their students exposure to additional skills and inquiry opportunities. You will see in the sample syllabi in chapter 3 that this is a common practice with AP Biology teachers.

You are encouraged to include in your course more lab exercises than those in the AP Lab Manual; what is most important is that your students do labs that meet the pre- and post-lab objectives in the AP Lab Manual. Peruse the lab manual to familiarize yourself with the depth and sophistication that characterize lab exercises at this level. While some teachers use supplemental or replacement labs, they find it beneficial to refer to the Lab Manual for insight into what types of questions students should be answering. Labs that are too unsophisticated may not earn students college lab credit, even if they score well on the AP Exam.

Require your students to keep all of their completed lab work neatly organized in a notebook. Each lab should include a table of the data they collected, any calculations they made from the data, and the conclusions they have drawn from the data. This notebook may make the difference between your students receiving or not receiving lab credit at the college of their choice, regardless of their grade on the AP Exam.

Lab Safety

Lab safety is always a concern. AP Biology students work with materials that require specific safety instructions. Direct your students in proper handling and disposal techniques as part of the pre-lab instructions. All students should sign a safety agreement at the beginning of the year indicating that they understand and will follow all safety rules when they are in the laboratory. Many teachers give their students a pre-lab quiz that includes the safety issues that are particular to that lab. Introduce them to Material Safety Data Sheets (MSDS) as well, and show them how to use these documents to determine the safety hazards associated with specific chemicals.

Students should always wear safety goggles during lab activities that use glassware, reagents, hot liquids, or biohazards. Be sure that all goggles meet safety requirements for chemical splash goggles. Some goggles are designed only to protect the eyes from small particles resulting from impact or grinding activities. A class set of goggles that can be sterilized between uses is the common way to meet this safety requirement. Many AP teachers find that students are willing to purchase their own goggles to use throughout the year and then take on to college with them. Some schools have enough goggles to assign one to each student for the year. Either of these two approaches prevents the need to readjust and sterilize goggles between each use. Go over proper goggle fit with your students at the beginning of the year; students have a tendency to adjust their goggles to fit too tightly on their faces, resulting in the dreaded "goggle face" look.

Students use the modified Winkler method to determine dissolved oxygen in AP Lab 12. The initial kit can be reused with purchased refills of chemicals. (Photograph courtesy of Carol Leibl.)

The disposal of biohazard materials is part of the AP Biology course. Sterilization of bacterial plates and utensils before disposal is necessary. Check with your local hospital or colleges to see if they will be willing to add your relatively small amount of biohazardous waste to theirs for proper disposal. A number of supply companies sell lab safety materials, and several books and Web sites on the subject are identified in the resources section of chapter 5.

Working with Supply Companies

When stocking lab supplies before the school year begins, first go through the exercises in the lab manuals you intend to use and make a list of the materials you will need over the course of the year. Next, check your list against the lab supplies you have on hand. If you have inherited an AP Biology course from another teacher, you may discover you have more in your new classroom's cabinets than you realized.

Most scientific supply companies carry everything you need for all 12 of the labs in the AP Lab Manual. You can purchase items individually or in the form of prepackaged kits. If your budget allows, using prepackaged kits during the first year you teach the course is the easiest way to implement the experiments. For ideas on ways to stretch your laboratory budget, see the discussion on how to address limited resources in chapter 5. Chapter 5 also provides contact information for a number of supply companies.

The kits vary in what they provide, so you need to consider the following issues before deciding on purchasing kits.

- **Brand of kit manufacturer:** Some suppliers produce their own kits, others resell kits they purchase wholesale.
- **Completeness:** Some suppliers provide everything that is needed for each lab, except for items such as heat sources. If the lab calls for scotch tape, the kit includes scotch tape. Other kits will contain only items unique for that lab. For example, a complete kit for the enzyme catalysis lab (AP Lab 2) will contain enough materials, including cups, labels, and droppers to supply a designated number

of lab groups, usually two or six. A simpler kit may only provide the chemicals required for the lab, including the catalase, and you need to have the additional material—cups, beakers, droppers, and burettes—already available. The simpler kits will be less expensive, but be sure that you have or can obtain the additional materials needed.

- **Modified protocols:** Many suppliers have "tweaked" the various lab protocols and provide alternate instructions. For example, several complete kit suppliers for the enzyme lab provide syringes to be used instead of burettes for titration. These modifications may provide a better lab experience, but you need to be aware of the protocol differences before beginning the lab.
- **Total cost:** While some new teachers are trying to start an AP Biology program on a shoestring, there are others who are in a seemingly paradoxical situation; their lab room is practically empty, but there is a healthy amount of start-up money to purchase materials. Of course, in many cases, the new teacher has 24 hours to come up with a list. Many of the companies will offer the complete set of kits for the 12 labs at a significant price reduction, as much as 35 percent. If you decide to purchase kits, be sure to request a bid, even if you know where you have to purchase your materials due to district requirements. Kits that are resold by various suppliers are especially subject to discounts.
- **Restocking:** Most kit suppliers will sell refill kits for the consumables. In many cases, it is more effective to order a specialized refill chemical, such as DPIP for the photosynthesis lab (AP Lab 4), while it may be less expensive to purchase more common reagents, such as hydrogen peroxide for the enzyme catalysis lab, from the drugstore on your own.
- **Living Materials:** Most kits include a card to mail to the supply company for living materials. Ask about a supplier's reputation for on-time delivery of living materials. Most will reship overnight if you are unsatisfied with the initial delivery, but find out what is their policy before a problem occurs. The best strategy is to immediately send back the card upon receipt of the kit and then confirm two weeks before expected delivery date.

Create Your Own Lab Kits

If you can't purchase the kits, organize the 12 AP Labs in boxes. Designate a box for just your AP Biology course that contains the basics of each lab ready for you to pull out when preparing for the lab. Include a copy of the lab activity paperwork in the box. If funds are available, replenish the lab for the next year before you put it away.

—Bobbie Hinson, Providence Day School, Charlotte, North Carolina

The ordering of living materials requires good planning, and the cheapest product may not always be the best. In many cases, such as with fruit flies or *Sordaria* cultures, materials need to be ordered several weeks before the date of their intended use. Setting up a lab calendar for the year and telling your supplier the days you will need the materials allows them to provide the appropriate live materials in a timely manner. You usually need to specify a shipping date, and different companies may vary in how closely they can meet those dates and in the quality of the material they supply. Certain living material should not be shipped during certain times of the year, and a good company will inform you so. Some living material also requires a minimum notification time. Many times a local pet store is happy to help with items like crickets, "feeder" goldfish, and elodea.

Respiration Lab: Tips

For trays for the respiration lab in the AP Lab Manual I use very large, white, plastic trays that are deep enough for the experiment. Some students seem to have a problem sighting the water level, so I laminate sheets of different colored paper and place them under the respirometers to provide background contrast. It's interesting to see that some students prefer to have no background while others like having a different color. There doesn't seem to be a pattern. One modification I have made to this lab is to increase the equilibration time, and this seems to give more consistent results. Before I did this, we had those lively glass beads respiring faster than the old "dead" peas.

—Peter Gardiner, St. Michaels University School, Victoria, British Columbia, Canada

Approaches to Teaching the Course

Approaches to teaching the AP Biology course vary. For example, some courses use a phylogenetic approach in which various phyla are considered and each phylum's systems are studied, while other courses use a systems approach to biology in which different types of systems, like the circulatory or nervous system, are examined. Part of the study of the second approach includes a survey of the evolutionary development of a particular system in different phyla. Both the phylogenetic and the systems approaches allow for the incorporation of such AP Biology themes as structure related to function and evolution.

The Black Box Method

One of my favorite explorations of the scientific method is the black box. Find a box, like a cigar or gift box, that is roughly six cubic inches. Remove the lid and punch three holes on opposite sides of the box, just big enough to accommodate three wooden dowel rods (available at most hardware stores). Find some metal washers, shower curtain rings, or anything else that strikes your fancy. Insert a dowel through one hole, string some washers onto it, and insert it through the matching hole on the opposite side. Repeat for the other two rods. Tape the box closed and paint it black (black box, get it?).

Now the question is how to design ways to determine what's in the box without actually opening it. Let your students suggest a technique and explain how they will measure the result. For example, they might slowly pull one rod out of the holes and listen for things to drop. They might shake the box (I suggest putting at least one object in the box not on a rod).

This exercise demonstrates the way in which we've learned much of what we know about biology, especially those things we can manipulate but not see (e.g., atomic structure, genetic code, immune system, etc.). Try dividing the class into two teams with competing boxes and see which team can stump the other.

—Dwayne A. Wise, Mississippi State University, Mississippi State, Mississippi

Emphasizing the Themes

Perhaps nothing is as difficult for students to grasp as the idea that big picture themes are integrated into the curriculum. One way to emphasize themes is to have students explain to each other how different ideas and curriculum topics relate to one another. Ask pairs of students to write their own free-response, or essay, questions and scoring guidelines that stress the themes. This approach seems to be more effective than merely testing students with teacher-generated questions.

Another strategy is to give pairs of students one topic from a current unit, such as light reaction, chlorophyll, or carbon fixation if the unit is on photosynthesis, and ask them to decide which theme best applies to the topic. Write all of the topics on Post-it® notes, divide the blackboard vertically into eight

sections (one for each theme), and have each pair post its topic in the appropriate section on the board. After everyone has done this, ask each pair to explain why it chose the theme it did. A class discussion of how other themes might apply further helps focus students on thinking in a thematic way.

Students Get Creative

I try to have a student-centered classroom, and while it's difficult in an AP course, it's not impossible. I don't cover ecology because we hit it hard in the first-year biology course, but I have my students create multimedia projects in place of a midterm exam. They choose an ecosystem within a biome and answer a whole series of questions about the ecosystem, covering everything from food web and populations studies to succession and conservation. This project brings together all the ecology and conservation stuff they should know. They enjoy it and get to be creative with it. They give oral presentations in class during midterms week, using their projects as visuals.

—Cheryl Hollinger, Central York High School, York, Pennsylvania

Including references to the themes in every class and on the exams keeps them in the forefront of student's minds. Ask them how two apparently unrelated topics like cellular respiration and evolution are interrelated. Have them brainstorm on whether any of the eight major themes do not apply to a specific topic, like trying to apply continuity and change to immunity (e.g., "What does curing a cold have to do with the extinction of the dinosaurs?") or interdependence in nature to ribosomes (e.g., "How can the little things inside of a cell have any relevance to communities and ecosystems?"). As they see that they are expected to be able to make these connections, your students will eventually begin posing their questions spontaneously.

Cooperative Learning Strategies

I use a lot of cooperative learning activities in my course. It doesn't have to be something complex; it can be as simple as a five-minute think-pair-share activity. I also use jigsaw-method activities, which are good for factual information that is straightforward; no way would I use it to teach photosynthesis or something else that is complicated, though! As a culminating activity/review I have my students act out the steps in photosynthesis and then write an essay about what their role was in the process. They tell me they understand it better afterward.

—Cheryl Hollinger, Central York High School, York, Pennsylvania

Get Hands On

Hands on! Although most AP Biology students are juniors or seniors, they need hands-on activities as much as the younger students. Use pop beads, tangle toys, and homemade models. You can even have them act out processes, something they'll remember for years to come!

—Bobbie Hinson, Providence Day School, Charlotte, North Carolina

Addressing Evolution

Many AP Biology teachers will be approached by students, parents, school administrators, and even fellow teachers with the request to either be exempt from the evolution material in the AP Biology curriculum or

to include the teaching of "alternative" theories or "serious gaps" in the theory of evolution. Arguing the merits of these requests is never fruitful and should be avoided. Explain that you are required to teach from a specific curriculum that covers a large amount of material in a limited period of time. The topic outline has been developed to provide students with a first-year college experience and contains the material that is necessary to ensure acceptance of AP credit at most institutions of higher education. To include additional information would reduce the amount of time that is available for the preparation of the required material and could jeopardize the AP course designation.

Practicing with Released Exams

Each of the Released Exams for AP Biology contains an actual AP Exam that was administered in the past. The multiple-choice questions and their answer key and the free-response questions and their scoring guidelines are reprinted in their entirety in these books. In addition, Released Exams contain sample student essay responses and commentary that explains why those responses received the scores they did.

Not only are Released Exams helpful for familiarizing new AP teachers with the format, breadth, and depth of an AP Exam, they are also invaluable tools for preparing students for the actual AP Exam. Many teachers use questions from the Released Exams on their unit tests to acclimate students to the exam's format and pacing. Some use the free-response questions for in-class activities designed to teach students strategies for answering essay questions. Students then use the scoring guidelines to grade their responses, which gives them a feel for what AP Readers look for in a response. Often teachers give students an entire Released Exam shortly before the AP Exam as a trial run. Released Exams can be purchased from the College Board Store (http://store.collegeboard.com). The section on preparing students for the AP Exam in chapter 4 has more ideas on ways to get your students ready for the AP Exam.

Using Review Books

A review book may provide supplementary material like topic outlines, practice questions, and sample tests. Some teachers collect a classroom set for their students to use. Others encourage their students to invest in a review book at the beginning of the school year to use as a study guide for each unit. Many teachers have reported that their students' enthusiasm for the value of these books encourages additional purchases by the other students. Be sure you understand your school district's policy about requiring or recommending student purchases before you decide how to phrase your encouragement of the purchase of review books.

Teaching with Technology

The continuing development and improvement of technology gives the AP science teacher an arsenal of teaching tools that enhance students' learning experience. The use of probeware, the Internet, computer simulations, and more, give students the opportunity to become accustomed to the technology they will use in their college science courses. This technology also enables AP teachers to use class and lab time more efficiently.

Probeware

The use of probeware saves teachers significant preparation and class time. It allows students to follow a simpler lab protocol to collect data more rapidly and with less possibility of error. Starting with a simple lab, students can quickly learn how to use the equipment, collect large amounts of data in a short time, and concentrate on analyzing the data rather than recording it. A shorter collection time gives students more

time to manipulate a variable by developing their own protocols. You can use probeware in the following ways in these AP Labs.

- **AP Lab 2, Enzyme Catalysis.** Data collection with a pressure sensor can be accomplished in 5 minutes per sample rather than 20, allowing students to study the rate of reaction under varying pH, temperature, or concentrations in one lab period.
- **AP Lab 4, Plant Pigments and Photosynthesis.** A set of 5 to 10 colorimeters can be purchased for the same price as 1 spectrophotometer and produce equally acceptable data.
- **AP Lab 5, Cell Respiration.** A CO_2 sensor can replace the complex apparatus the lab protocol calls for and remove the need for adjusting for changes in temperature and pressure. Five minutes of readings will produce more data than the 20 minutes called for in the original protocol.
- **AP Lab 9, Transpiration.** This lab can be done very efficiently with the use of a pressure sensor. As with all labs, the real-time graphing of the data allows teachers and students to instantly determine if the apparatus is set up properly and detect such problems as a leaky connection or a crushed stem.
- **AP Lab 12, Dissolved Oxygen and Aquatic Primary Productivity.** Using a dissolved oxygen probe in the primary productivity lab significantly shortens the time required to take a DO reading from approximately 10 minutes to less than a minute and by replacing the modified Winkler method, which also eliminates the need to use four hazardous chemicals.

The Internet

The World Wide Web has become an important resource for information, especially in a field as rapidly changing as biology. Anyone with a computer and Internet access can obtain large quantities of information on any topic almost instantaneously. Unfortunately, anyone with a computer and Internet access can also present large quantities of information almost instantaneously, with little or no regard to its accuracy. AP Biology students can make effective use of this resource if they learn to be true science skeptics about the information they find.

Most teachers are concerned about students accessing sites that contain information that is sexual, racist, or otherwise inappropriate for a classroom activity. The Dihydrogen Monoxide FAQ Web page (www.dhmo.org/facts.html), however, is an excellent example of the biggest peril of the Internet. This site is well laid out, has a professional appearance, and is 100 percent satire. When first presented with this site, students are quite incensed by its report about such a horrible and pervasive chemical, until one of them figures out it is actually a site about water. There are many other spoof sites that present questionable information in such a convincing way that otherwise skeptical students and adults readily accept it as valid.

Giving your students some basic guidelines for evaluating the authority and veracity of a Web site will make their Internet research more accurate.

- **Take the source into account.** Sites ending with the suffixes *.edu, .org*, and *.gov* are more reliable than *.com* sites, especially those that offer free Web space (e.g., angelfire.com, hotmail.com, etc.).
- **Consider the date.** It is not unusual to find sites that have not been updated for a year or more. Students should get in the habit of checking the "updated" line for each Web site they visit and asking themselves if they think more research on the topic has been done since then and whether that will affect the information they need to have now.
- **Verify with another source.** Finding the same information on two or even three unconnected and unrelated Web sites confirms its validity. Students should compare the sites' wording as well as their

content. If the wording is identical, the alternate source could simply be presenting cut-and-pasted information with no assessment of its veracity or value.

- **Check the information.** Sites that compile lists of false information, like Urban Legends Reference Pages (www.snopes.com) and urbanlegends.com (www.urbanlegends.com), often contain genuine facts about the origins and validity of the claims made by sham sites like the dihydrogen monoxide site.

Encourage your students to get into the habit of referencing all of the Internet material they cite. Such a citation should include both the Web site's URL and the date it was accessed. The date is an important part of the citation because Web content is ephemeral, modified on a daily basis, and often disappears altogether. You can find examples of citation formats in most of the recently published style manuals for the sciences. It is important to also remind your students that what they read on a Web site is considered copyrighted and published material. Not crediting the ideas or text they quote from a Web site constitutes plagiarism.

Unguided Internet Research Projects

Most students are very proficient at surfing the Internet and can be given clear, concise assignments to complete on their own. Some students may have Internet access at home, but others may have to use the computers in either their school or public library. At the beginning of the school year, survey your class to find out what kinds of Internet access each student has. Do this before you make any decisions on how to conduct a specific project. If access is truly limited for most of your students, you may need to arrange for all Web-based activities to be part of class time under your supervision, either in your room, a computer lab, or the school library.

Try unguided research projects on the following subjects with your students.

- **Biomes.** Assign groups of students to research different biomes and present their findings to the class.
- **Cells, organs, systems.** Ask students to write and present a report on cell organelles, organ systems, and comparative anatomy (e.g., a report on how different animal phyla accomplishes circulation).
- **Diseases.** Give each student a current disease or health issue to research.
- **Pollution.** Have students collect data on pollution and cleanup efforts in different parts of the world.
- **Population.** Direct students to collect and compare population data and trends.
- **Species.** Have students present a report on a specific species, including its taxonomy, lifestyle, and evolutionary history.

Independent Study

To cover the chapters on plants and animals, I have my students do independent study assignments, one for each marking period. The information they must find is pretty extensive, like body plan, number of cell layers, type of digestive system, and so on. I know I can't get to that stuff in class and it would be boring to teach. However, later in the year, after we do evolution and taxonomy, I might have them do a scavenger hunt, using their assignments to identify specimens and pictures.

—Cheryl Hollinger, Central York High School, York, Pennsylvania

Teacher Support

As a new AP Biology teacher you may sometimes feel as if you have been set adrift without oars. However, a variety of resources exist to help ground and steady you in the first years of teaching the course and in the years after. During your first year as an AP teacher you will have questions about many things—what constitutes a reasonable homework load for this course, how to plan effective review sessions, what kind of policies for tests, make-up work, and grading work best, and more. In addition to the other AP teachers in your school, you have a wide array of professional development, print, Internet, and professional organizational resources upon which to lean.

Fostering Relationships with Other Teachers

One of your most important resources is your fellow AP teachers. These colleagues will have suggestions for time management strategies, preparing students for the AP Exam, and dealing with the challenges presented by seniors that all AP teachers share. Together you and the other AP teachers in your school can collectively enhance your students' learning experience by

- creating a uniform set of guidelines for all of the AP courses, guidelines that reflect the course's rigor and level of instruction;
- swapping class time occasionally with AP teachers of other subjects to give both of you a turn at having a longer class period;
- offering support to middle school, ninth-, tenth-, and eleventh-grade science teachers, who may have even fewer resources than you and would be happy to talk with you about what they cover in their classes in exchange for the use of your microscopes or pH test kits, for example; and
- having a monthly meeting to discuss new ideas or common problems.

Your school's AP Coordinator is as much a resource as the other teachers. Meet with the AP Coordinator to gain a better understanding of the logistics of the program, such as when the exams are ordered, how payment and registration works, how the exam is administered, and what exam-specific policies will affect your students. The AP Coordinator is the conduit for any information coming from the College Board to you and is also likely to be familiar with your state's programs for providing funds for materials, workshops, and student exam fees.

AP Vertical Teams®

Some schools have an established AP Vertical Team, a team of science teachers from the different grade levels. Participating in a vertical team is an excellent way to develop and maintain collegial and supportive relationships with the other science teachers in your school. Vertical teams provide a number of benefits for both students and teachers.

- **Consistent approach.** When all of the science teachers have a consistent approach, they do not find themselves in the position of having to reintroduce students to concepts, topics, and themes they already know but by different names. For example, when all of the science teachers use the terms *nuclear envelope, plasma membrane,* and *cell wall* throughout the vertical curriculum, instead of the various other terms that can be used to identify these cell parts, students progress through the school's sciences courses with a common language.
- **Integration of curricula.** When all of the science teachers are working together and coordinating their courses to maintain a cohesive continuum, the curricula shares common characteristics

that carry over from one course to the next. Specific topics like pH, cell cycle, protein synthesis, enzymes, genetics, and evolution can be spiraled through the science vertical curriculum, with increasing sophistication with each step up the learning ladder. AP Biology teachers who participate in a vertical team have a very good idea of the types of classroom and lab experiences their students bring with them to the AP Biology course. Because they are aware of the classroom practices of the science teachers on the team, the AP teachers know what information and skills they need only review, not teach, to their students; this is a great time saver.

- **Accelerated learning.** The AP teachers on a vertical team can encourage the other teachers to engage in more inquiry, lab activities, and skills development (e.g., graphing and research) with their students. This produces AP students with a greater knowledge of and comfort with advanced concepts and skills.
- **Resource sharing.** A vertical team approach to teaching enables equipment to be shared by the different levels of instruction. Such resource sharing allows middle school, ninth-, tenth-, and eleventh-grade teachers to perform labs they normally could not do otherwise and familiarizes students from an early age with the use of certain kinds of equipment. By the time they reach the AP level, they are comfortable with the equipment, and time does not have to be taken to introduce them to it.
- **Early recruitment for AP.** Science teachers who belong to a vertical team are more able to identify prospective AP students in their early school years, sometimes as early as sixth grade. Often students with potential fall through the cracks for various reasons, including lack of motivation. Giving these students the goal of enrollment in an AP course may keep them interested and academically active.
- **Professional validation.** The vertical team approach offers AP teachers the opportunity to validate the information and knowledge of their middle school and high school colleagues, who do not always get the professional recognition they deserve for their mastery of the subject they teach.

How can you start an AP Vertical Team for science teachers at your school? One of the best ways is to contact the middle and high school teachers in your school or district and express an interest in lending support and, perhaps, some resources, such as a roll of pH paper or the opportunity to borrow microscopes. Your initial interaction should involve learning about what your colleagues are teaching at the introductory levels. Find out how they are teaching concepts and skills and the sorts of problems they face. NCLB (No Child Left Behind) exams are now a very real part of life for middle and high school teachers, and they may appreciate your experience with preparing for an end-of-year exam.

Do not attempt to start a vertical team by explaining what other teachers need to cover in order to "prepare" their students for your course. This approach may be taken as criticism and adds another layer of pressure to already harried teachers. Instead, ask what you can do to help them achieve their goals for their students.

After your initial contact, enlist the support of your school's administrators, citing the benefits you and the other science teachers have gained thus far by your informal meetings. Specify the additional benefits to the school's science program if its teachers are formally given the time to meet regularly and collaborate. Some of these benefits could include greater lab experience in the lower grades, more efficient use of budgets and existing facilities, and increased enrollment in the AP courses, especially for underrepresented students.

The College Board offers support for AP Vertical Teams by holding workshops and conferences like "Setting the Cornerstones®: Building the Foundation of AP Vertical Teams," and by providing resources

like the *AP Vertical Teams Guide for Science*, which can be purchased from the College Board Store (store.collegeboard.com). For more information on AP Vertical Teams for science, visit AP Central at apcentral.collegeboard.com and click on *Pre-AP;* then click on *Teachers' Corner for Pre-AP* and then on *Science*.

Professional Organizations

Professional organizations are your way of keeping up with new advances in biology and biology education, resources, workshops, and opportunities to acquire new skills and materials. State and local organizations provide the chance to network with other AP Biology teachers, sharing resources, ideas, and encouragement. Membership in at least one organization should be a goal for every new AP teacher.

The National Association of Biology Teachers and the National Science Teachers' Association are the two national science organizations that are most relevant to AP Biology teachers. Their Web sites provide extensive support for new teachers, electronic resources, job banks, and venues for interacting with fellow professionals. These Web sites may be used without charge and should be on the favorites list of every biology teacher. Local, state, and regional organizations are also good resources.

- **National Association of Biology Teachers (NABT).** The NABT serves biology educators from the elementary to the college level. It publishes *The American Biology Teacher* and *New and Views*, which feature articles written by fellow teachers and information on grants, study opportunities, and the latest teaching practices. Through its Web site (www.nabt.org) teachers can find classroom activities, access NABT publications, and participate in several electronic discussion groups. The annual conference, with sessions for all grade levels (K–16), is held each fall in a different region of the country and attended by approximately 3,000 teachers. If only one professional membership is feasible, this is probably the organization you should join.

- **National Science Teacher's Association (NSTA).** The NSTA (www.nsta.org) is a much larger organization that serves all science educators. Offering the same opportunities and services as the NABT, the NSTA publishes four periodicals: *Science and Children* for elementary educators, *Science Scope* for middle school educators, *The Science Teacher* for high school science educators, and the *Journal of College Science Teaching* for college educators, as well as the monthly e-letter *NSTA Reports*. Membership includes a subscription to one of these magazines. The NSTA publishes position papers on such topics as lab safety, dissection, and teaching evolution, often jointly with the NABT. In addition to an annual national conference in the spring, three regional conferences are held each year in the fall. These are much larger than the NABT annual fall conference and they do not focus solely on biology education.

- **Local, Regional, and State Organizations.** Many states and metropolitan areas have professional organizations for biology and/or science teachers, make a variety of resources available, and hold annual conventions. Membership costs are usually quite reasonable, and joining is an excellent way to develop relationships with experienced colleagues near you. An Internet search using your state's name and *biology teacher* should yield the URLs for science education organizations in your state.

Professional Development

AP teachers report that their ongoing participation in professional development workshops and summer institutes contributes greatly to the success of their AP courses. All new AP teachers are strongly encouraged to attend an AP Summer Institute before they begin teaching an AP course for the first time.

If this is not possible, then plan to attend one-day workshops and conferences throughout the first year and go to a summer institute the following summer.

- **AP Summer Institutes.** Endorsed by the College Board and held at various educational institutions, these intensive weeklong workshops give teachers the opportunity for an in-depth study of course curriculum and a discussion of how to teach an AP course, as well as increased confidence in their ability to teach an AP course. Summer institutes for AP Biology focus on instructional skills, the 12 AP Labs, and course content. As important as the information imparted during the workshop is the opportunity participants have for interacting with one another over the course of the week. Many AP teachers retake summer institutes a year or two into teaching AP Biology and report that their experiences were even more valuable the second time. AP teachers who serve as College Board consultants generally lead the sessions. All summer institutes are monitored by the College Board to ensure quality and consistency. Contact the individual hosting institutions directly for cost and registration information. The hosting institution will be able to tell you if you will earn continuing education units (CEUs) for its summer institute.
- **One-Day Workshops.** A College Board-sponsored one-day AP Biology workshop gives new AP teachers an overview on how to begin an AP Biology course. Because they last for just one day, their focus tends to be on a few selected teaching strategies and ways to create an environment that enhances learning. An AP Biology teacher who is an approved College Board AP Consultant usually leads these. CEUs are awarded for both College Board one- and two-day workshops in varying amounts based on the length of the workshop.
- **Two-Day Workshops.** College Board two-day workshops differ from one-day workshops in that teachers are offered a number of concurrent sessions to attend. Directed by experienced AP teachers and university faculty in the field, these run the gamut from the latest breakthroughs in biology, to the integration of technology into the AP curriculum, to an assessment of the most recent free-response essay standards from the most recently administered AP Exam, and other topics of interest to AP teachers. Two-day conferences have something for every AP teacher, from the novice to the experienced. Like the one-day workshops, they are held year-round in almost every state.

You can discover what types of College Board–sponsored professional development opportunities are being offered in your area by visiting AP Central and looking under the Professional Development menu (click on *About Institutes and Workshops*). For registration information, go to the College Board's Meeting Registration page (from the main page, www.collegeboard.com, click on *For Educators*, then on *Events*, and then on *Meeting Registration*), or call your College Board Regional Office. If your school has not offered to send you to a Summer Institute or workshop, ask to be sent. The training, resource sharing, and networking opportunities these events provide are invaluable. For more information, see the professional development section in chapter 5.

Funding a Workshop Experience

Your school may provide funds for your attendance at a summer institute, one- or two-day workshop, or other continuing education or professional development event. Ask your AP Coordinator, principal, or district supervisor about available funding. Some states recognize the benefits of AP Summer Institutes and reimburse school districts for the cost of sending teachers to them. Contact your College Board Regional Office or state education agency for more information about reimbursements. Your College Board Regional Office can also give you information about the College Board Fellows program, a competitive grant program that provides stipends for high school teachers who are planning to teach AP courses in schools that serve minority and/or low-income students who have been traditionally underrepresented in AP courses. The stipends assist teachers with the cost of attending an AP Summer Institute.

Various continuing and one-time programs also offer teachers opportunities for public recognition and grants for professional development and classroom materials. Most of the teachers who receive these awards usually apply with the belief that they will not qualify. Some of the programs are specifically for beginning teachers, while others require new teachers to submit their applications for several years in a row before granting them an award. These programs can be found on the Internet and in professional journals and mailings. Two of the better known are the Toyota TAPESTRY Grant Program and the Outstanding New Biology Teacher Achievement Award.

- **Toyota TAPESTRY Grant Program.** Fifty grants of up to $10,000 or 20 smaller grants for $2,500 are available to K–12 teachers. For more information go to www.nsta.org/programs/tapestry/.
- **Outstanding New Biology Teacher Achievement Award.** This award goes to a new (less than three years' experience) grades 7–12 biology/life science teacher who demonstrates creativity in teaching or contributes to the profession in a significant way. For more information go to www.nabt.org.

College Board Resources

The College Board provides support for AP teachers not just in the form of workshops but also with print, Internet, and personnel resources. New AP Biology teachers find the AP Biology Course Home Page and the AP Biology Electronic Discussion Group on AP Central to be particularly helpful for learning more about the course and exam, outside resources, and successful teaching strategies. The *AP Biology Course Description*, which is discussed at length in chapter 1, and the Released Exams, which are described in this chapter, are also publications that new teachers find useful.

AP Central (apcentral.collegeboard.com)

The College's Board Web site for all AP teachers offers a wealth of information and resources, including general information about the AP Program, course home pages, sample syllabi, past AP Exam questions with their answers and scoring guidelines, reviews of hundreds of print and multimedia resources, access to each course's electronic discussion group, the most current Course Descriptions, information about summer institutes and workshops, articles written by other teachers on topics of interest, general information and much, much more.

To use AP Central, all you need to do is become a registered user. Registration is free and allows you to select the AP courses you are interested in and even create a personal profile page (accessible from the blue *My AP Central* button on the main page). You should visit AP Central at least once a week because the site is updated regularly.

AP Biology Course Home Page

To get to the AP Biology Course Home Page, the portal to all course-specific resources, from the main AP Central page, click on *The Courses* and then on *Course Home Pages*. Here you will find a variety of information about the course and how to teach it.

- **AP Biology Course Information.** This page provides links to the full *AP Biology Course Description* (download it for free as a .pdf file), information about the AP Biology Development Committee, answers to frequently asked questions, and information on workshops for the current year.
- **Exam Information.** Find what you need to know about the exam and how to prepare your students for it by visiting this section. It has information on the format and scoring of the AP Biology Exam, the free-response questions with scoring guidelines and student samples going back to 1999, and study guides.

- **Teaching Resource Materials.** Follow these links to resources developed and field tested by experienced AP Biology teachers, such as demonstrations, curricular strategies, hands-on activities, a "great books" list, the Biology Web Guide (links to recommended biology Web sites), biology textbooks and their publishers, and sample syllabi.
- **Pre-AP.** AP Biology teachers find that many of the hints, tips, and strategies provided in this group of links are useful.
- **Lab Resources.** This will take you to information on a variety of topics, including general AP Lab tips, rules and safety, equipment, lab and activity hints, contact information for biological supply companies, and strategies to use with the 12 labs in the AP Lab Manual.
- **College Board Products.** This link to the College Board Store leads to publications that support the AP Biology course, as well as the list of errata for the AP Lab Manual.
- **Teachers' Resources Reviews.** At the time this Teacher's Guide was published, the Teachers' Resources page had several hundred reviews of a wide variety of biology resources—print, multimedia, and Internet. Each review, which has been written by teachers and professors of biology, critiques the resource and identifies how teachers can use it for teaching the course.
- **Feature Articles.** Written by teachers, professors, and scientists, these articles provide timely information at a level that is appropriate for use in the AP Biology classroom. Examples of some of the topics covered are "Achieving Gender Equity in the Science Classroom," "DNA and Computers: A Marriage Made in Heaven," "Causes and Consequences of the Black Death," "An AP Reading: Summer Camp at Clemson University," and "AP Biology Readers Revisit Mitotic Spindle Formation."
- **Field Trips.** Get ideas for field trips with your students by reading about the field trips other AP Biology teachers have planned.

AP Biology Electronic Discussion Group

New teachers need advice and support from their more experienced peers. You may be the only AP Biology teacher at your school, and advice may be difficult to obtain. But, you can create an instant community of support by becoming a member of the AP Biology Electronic Discussion Group (EDG). This feature, which can be accessed from the AP Biology Course Home Page, allows you to post questions for the entire AP Biology community to answer.

Participating in this discussion group is a great way to get tips and information that will make your course run more smoothly. If you have questions about a lab exercise, someone in the EDG may have a better, faster, or cheaper way to accomplish it. It is exciting to learn a colleague's perspective on teaching new concepts. You will be amazed and thrilled to know that so many other AP teachers are interested in the success of your course and are willing to share their expertise with you. In time, you too will feel confident about offering your own suggestions and know-how to other AP teachers. We are all in this together, and the EDG can have only a positive effect on your course.

Advanced Placement Digital Library (APDL)

This collaborative project between Rice University and the College Board began in 2002 and is funded by the National Science Digital Library. The Advanced Placement Digital Library (APDL) is a collection of Internet resources that teachers can use to supplement their teaching and facilitate their students' learning of difficult concepts in AP Biology. The library's contents are based on the topic outline in the Course Description and are continually growing.

What makes this digital library unique is that independent reviewers who are experienced AP teachers and college professors assess the resources. Their reviews contain a synopsis of each Web site and comments on its usefulness. The reviewers also suggest ways in which teachers can integrate a resource into the AP Biology curriculum. The Web sites are cataloged according to their format (e.g., animation, lab, digital library, etc.). At the time this Teacher's Guide was written, the APDL was housed at Rice University, but the College Board has committed to housing it at AP Central in the future. APDL can be found at http://apdl.rice.edu/DesktopDefault.aspx. You must be a registered user to access the site, but registration is free of charge.

College Board Regional Offices

Your College Board Regional Office is a good place to go to get clarification on AP-related issues, learn about other resources and funding, and find out about the workshops being offered in your area. Regional Office personnel are always happy to talk with you about any questions or comments you may have about the AP Biology course or AP Program. See the inside back cover of this Teacher's Guide for a complete list of the Regional Offices.

Chapter 3
Course Organization

Syllabus Development

Before the school year begins is the best time to plan your course syllabus. Translating the Course Description's topic outline into a schedule of dates, units, readings, lectures, labs, and activities often feels like a considerable task to new AP Biology teachers. How many days should I spend on diversity of organisms? How will I get all 12 AP Labs scheduled before May? The suggestions in the following sections will help with your planning.

Stay Organized

Organization is the key. If you aren't organized, work on it each year. Map out a basic syllabus for the entire year and stick to it as much as possible. Keep notes on what worked and what didn't. This makes planning for the next year much easier.

—Bobbie Hinson, Providence Day School, Charlotte, North Carolina

Following the Formula

Your first step is to determine the number of instructional days in your school year. These are the days that are left after subtracting the days you will lose from the school calendar to bad weather, state and other testing, holidays, breaks, class meetings, all-day field trips for other courses, AP Exam review sessions, assemblies, and senior skip day. Be aware of the number of hours of class time you have during the school year as well. Coverage of some of the topics may take only hours instead of days.

Teachers on AB block schedules whose classes meet every other day for a 90-minute period have less instructional time than teachers on a traditional schedule whose classes meet every day for a 55-minute period. While it may seem difficult to cover the entire AP Biology curriculum on an AB block or comparable schedule, it can be done. The key is to know exactly how much time you have to work with during the school year and planning your coverage of the topics carefully, not wasting time on in-depth coverage where the topic outline percentages indicate none is needed.

Planning Class Time

We use our local community college, Montgomery College, as a model for figuring out how much time to allow for teaching AP or dual-credit courses. College science classes meet 6 hours a week for 16 weeks, a total of 96 classroom hours. We are on an alternating block schedule with 90-minute classes that meet 5 times in 2 weeks, an average of 3 hours and 45 minutes per week. Some arithmetic yields the conclusion that we need about 26 weeks to clock 96 classroom hours.

We need to allow some extra time for high school activities like pep rallies and state-mandated achievement tests. Our semesters are 18 weeks long, so our school made the decision to make courses that are a semester long in colleges run a full year at the high school. This gives us more time to cover some topics in greater detail, do a research project, and so on. Your decision might be different if you have more classroom hours per week.

—Alexa Noble, Oak Ridge High School, Conroe, Texas

Once you know how many instructional hours or days you have for the school year, multiply them by the percentages in the topic outline to get roughly the total number of instructional hours or days for each topic. Use these blocks of hours or days to sketch out your course schedule for the year, unit by unit. Be sure to remember to include sufficient lab time in each unit. Also, plan on padding each unit with one or two days of unscheduled time to absorb the time that will be taken by fire drills, pep rallies, assemblies and other unanticipated disruptions.

Now that you have determined your course schedule and decided how much time you will allocate to the units, divide each unit into doable chunks with their own lecture topics, lab work, and assignments. Assignments should be scheduled several weeks in advance so that students can plan their time to meet required deadlines. You may find you are unable to fill in all of the assignments for the full year at the beginning of the course. If this is the case, be sure to stay at least one unit ahead of time in your ongoing planning. Similarly, at the beginning of the year you may not be able to predict every special activity you will offer. Try to give your students as much advanced notice as possible, however, about before- and after-school activities or special assignments for vacations or long weekends, even if you may have to change the date later.

Presenting a Syllabus to Your Students

The final step in developing a syllabus is putting it on paper to give to your students on the first day of class. Students appreciate a comprehensive syllabus, one that is more than just a list of dates, topics, and readings; they like to know what to expect each day in a way that lets them plan ahead.

Your syllabus can contain any of the following elements. The more details you include, the better your students know what to expect, and when, from you and the course.

- List of the general themes covered by the course
- List of the course objectives
- List of your learning expectations for your students
- Outline of the semester by topic

- Daily schedule of lecture topics, textbook readings, in-class activities, lab work, and homework assignments
- Due dates for all of the homework, lab reports, and research papers
- Dates of holidays and semester breaks
- Dates for the end of each grading period
- Date of the AP Exam
- Titles of the course textbook, lab manuals, and other materials students need for the course
- Grading scale for the course
- Policies for late and missed work, absences, and behavior

When students understand your rationale behind the pacing of the course and your policies for make-up work they can take partial custody of their own success in both the course and the exam. With this sort of partnership students can help the class move along when you are tempted to break from the schedule and linger on a topic you feel a few are not grasping.

Some teachers like to provide this information in a series of handouts: one handout for general information about the course, one for a semester outline, and one for each unit that they give to their students just before the next unit begins. Some teachers enliven their syllabi with funny or meaningful quotations by scientists about the study of biology. Others insert questions pertaining to a unit of study for their students to ponder as they do the reading, or a thought for the day to kick-start a class discussion. Let your personality and enthusiasm for the course come through in your syllabus.

You are not limited to just paper when it comes to presenting your syllabus. Many teachers now put their syllabi and assignments on student-accessible Web sites. While these links are subject to change, doing an Internet search with the phrase *AP Biology assignments* should yield at least a half-dozen active sites with a variety of styles and presentations you can use as examples for your own site. Sending an e-mail to a teacher whose site you find particularly helpful may provide you with a professional friend and mentor for your first few years as well.

Four Sample Syllabi

The four sample syllabi in this chapter demonstrate how three experienced AP Biology teachers and a team of college professors approach the teaching of an introductory-level college biology course. Their syllabi will give you ideas for how to pace your course and develop your own syllabus. You will immediately notice that each of the course outlines is vastly different from the others; some follow the Course Description and begin with the chemistry of life, while others begin with ecology or another topic. Yet each depicts a biology course that is stimulating and challenging to students.

You may also notice that all of the high school curriculums are vague about specific dates for specific units. These are subject to change due to the usual special assemblies, snow days, and other interruptions that are so much a part of the typical high school week. The AP teachers who contributed the syllabi in this chapter usually assemble specific assignments several weeks in advance, but not so far ahead that major changes need to be made due to an unanticipated change in the school's schedule.

The syllabi here are not meant to be strictly followed but instead are to be used as a springboard for ideas for your own course. You are encouraged to use these syllabi to help you find an approach that best suits your students and your teaching style. More sample syllabi are available on the AP Biology Course Home Page on AP Central.

Important Note: The AP Course Audit

The syllabi included in this Teachers Guide were developed prior to the initiation of the AP Course Audit and the identification of the current AP Biology Course Requirements. These syllabi contain rich resources and will be useful in generating ideas for your AP course. In addition to providing detailed course planners, the syllabi contain descriptions of classroom activities and assignments, along with helpful teaching strategies. However, they should not necessarily be used in their entirety as models that would be authorized under the guidelines of the AP Course Audit. To view the current AP Course Requirements and examples of syllabi that have been developed since the launch of the AP Course Audit and therefore meet all of the AP Biology Course Requirements, please see the Resources for Teachers page AP Central (http://apcentral.collegeboard.com/courseaudit/resources).

Syllabus 1

Syllabus 1 is representative of many college syllabi. Learning objectives include not just content and the science process but also learning skills. Students are presented with a class schedule that correlates with the chapters in the textbook. Completing specific reading assignments, answering the

A small vial of mineral oil acts as a morgue for F_2 fruit flies after students count them for the genetics of organisms lab (AP Lab 7). These students are prepared with a way to reanesthetize those flies that start walking around on the microscope. (Photograph courtesy of Carol Leibl.)

end-of-chapter questions, and using supplementary study materials are left up to the students. Rollins College expects its students to be increasingly able to perform long-term independent assignments as they progress from freshmen to seniors, though all professors have established ways to provide students with extra help when necessary. One of our goals as AP teachers should be to prepare our students to succeed in this type of learning environment. The two general biology courses are taught as a team by five professors. While individual sections reflect the personality and preferences of that professor, all of the five sections are coordinated by common objectives and time frames in a way that is similar to the way AP Biology teachers use the *AP Biology Course Description* to produce their own curriculum.

Syllabus 2

Syllabus 2 shows an approach taken by John McMillian, a teacher in an inner-city magnet school. The curriculum includes a heavy emphasis on developing study skills and self-confidence. While the tests are all multiple-choice, class time is spent on developing students' abilities to demonstrate their knowledge on free-response questions, a skill John feels needs extensive development in this student body. John also provides detailed lecture notes to compensate for students who have poor note-taking skills.

Syllabus 3

Syllabus 3 describes an almost ideal teaching situation, with dedicated students, sufficient time and resources to complete the program, and an active, supportive parent body. The students come to AP Biology with the skills that are necessary to write an essay question response, so the emphasis of the course is on practice and preparation. The teacher, Susan Offner, relies heavily on the free-response questions in the Released Exams to prepare her students for the AP Exam, providing her students with the relevant questions for each unit. Although some teachers worry that making old exam questions accessible to their students affects the teacher's ability to use those questions as exam material, Susan finds that it levels the playing field, providing all of her students with equal access to the questions. Note that Susan requires a summer assignment, one of the strategies for "covering it all" in the "Make the Most of Your Class Time" section in chapter 2.

Syllabus 4

Syllabus 4 is taught at a private school in the Miami area. The classes are small, and sufficient time is available for the teacher, Marguerite Graham, to use individualized learning strategies and class discussions rather than lectures. Like John, she provides her students with lecture notes. Central to Marguerite's personal philosophy is her clear statement of high expectations for her students; students often raise or lower their efforts based on their teacher's expectations, and experienced teachers know to set the bar high at the beginning of the course. Even though Marguerite offers a full curriculum of lab work, including a field trip, she requires just four formal lab reports, which saves her preparation and grading time.

Syllabus 1

Eileen Gregory, Steve Klemann, Judy Schmalstig, Jim Small, and Paul Stephenson
Rollins College
Winter Park, Florida

University Profile

Location and Environment: Rollins College is Florida's oldest college. Its campus of Mediterranean-style buildings is situated on the shores of beautiful Lake Virginia and within the Orlando metropolitan area. The college offers 28 majors and is best known for its small classes and student interaction with an outstanding faculty who have collectively won numerous national awards for innovative teaching. While close to 40 percent of the students come from Florida, an almost equal number come from the northeastern United States. For the tenth consecutive year, "America's Best Colleges," an annual rankings report published by *U.S. News & World Report* magazine, has ranked Rollins College second among regional universities in the South and first in Florida.

Type:	Nonsectarian, independent, coeducational liberal arts college
Total Enrollment:	1,750 students in the arts and sciences program
Ethnic Diversity:	Hispanics comprise 10 percent of the total student population; African Americans, 6 percent; Asian Americans, 4 percent; Native Americans, 1 percent; others, 3 percent; and unreported, 4 percent.

Personal Philosophy

The key characteristics of the biology faculty at Rollins College are our love for biology and our enthusiasm about the opportunity to share that love with our students. We also believe that, while there are fundamental concepts all biologists need to know, true understanding of those principles can best be developed through discussion and investigation. Thus, the lecture portion of our courses is often a class discussion.

Philosophy of the Department

The Biology Department's guiding principles are excellence, innovation, and community. We provide a strong and distinctive undergraduate education that enables students to explore diverse intellectual traditions and empowers our graduates to pursue productive careers. We are dedicated to scholarship, academic achievement, and environmental stewardship.

The departmental goals are to ensure that students who graduate with a biology degree from Rollins College have had learning experiences in the major subfields of biology and have developed proficiency in the methodologies used in theoretical, laboratory, and field studies. Additionally, the department provides opportunities for student investigations, enabling students to develop the necessary skills to design and conduct scientific investigations and draw valid conclusions. In essence, students who graduate from our program will be able to function as biologists.

Class Profile

The introductory biology sequence, General Biology I and II (BIO 120 and BIO 121), has been designed to provide students who are majoring in biology or biochemistry/molecular biology with a fundamental background in the biological sciences; approximately 60 percent of these students plan on entering a health-related professional school after graduation. Because most of the students who are enrolled in the course sequence have completed AP or honors biology courses in high school, emphasis is placed on skills development, especially analytical, communication, and laboratory skills. General Biology I is open to any student who has an interest in biology, but students who do not intend to major in the sciences are advised to enroll in other courses that are specially designed for them. Students must successfully complete General Biology I before they may enroll in General Biology II.

Rollins awards students who earn a grade of 4 on the AP Biology Exam with four semester hours of general college credit. This credit exempts them from the life science general education requirement for graduation but does not count toward the biology or biochemistry/molecular biology majors. Students who earn a 5 on the exam are exempt from the life science general education requirement and one term of the general biology course sequence; some of these students choose to skip one of these courses. Those who do complete both terms, however, regularly comment that, while some of the material repeated what they had studied in their AP Biology course, the study and time management skills they learned in General Biology I and II made taking both courses extremely valuable.

Both General Biology I and General Biology II meet 3 times a week for 50 minutes each meeting and once a week for a 4-hour laboratory. The two courses are organized into 3 sections each with a maximum of 24 students per section. This arrangement maintains a small class size and enables us to give students individualized attention. The Biology Department offers General Biology I in the spring, which allows freshman to take the first term of general chemistry during the fall semester and adjust to college life before enrolling in both chemistry and biology in their second semester. Enrollment for General Biology I is 60 to 70 students; General Biology II enrolls 50 to 60 students. Over 80 percent of the students in General Biology I also take General Biology II in the fall. Also in this course are a few students whose AP credit exempted them from General Biology I.

Course Overview

General Biology I and General Biology II compose a two-semester introductory-level sequence that introduces students to the main themes of biology that serve as a foundation for their advanced courses in this field. The three overarching goals of the sequence are (1) to learn general principles of biology that will allow students to study specific topics, (2) to provide an overview of biology and its many disciplines, and (3) to begin the process of becoming a scientist. The two courses are designed to ensure that all students who major in biology leave the college with an understanding of two major groups of organisms, plants, and animals.

In General Biology I we study cell structure and function, metabolism, and the mechanisms of evolution, using plants as examples. We then go on to examine the whole plant in details of structure and physiology. Throughout the course the practice of science is emphasized in class discussions and in laboratories, where students learn the basic laboratory skills that are necessary for carrying out simple experiments. While the first course uses plants as its main focus, the second course uses zoological examples to demonstrate biological principles. General Biology II completes the year of general biology by covering such topics as genetics, animal diversity, development, anatomy and physiology of animals, and general ecology.

It is hoped that the students who complete the two courses will understand and be able to apply basic biological concepts that will be built upon in more advanced biology courses. They should also be able to perform scientific experiments, collect data, analyze it, and communicate the results in a standard format. In both lower- and upper-level biology courses professors provide problems and applications of the major concepts in the reading assignments, and class time is spent solving these problems, applying the material, and elaborating on this information. In the advanced courses students are responsible for identifying the key concepts, and classes are used for group discussions of the topics and their applications.

Most biology courses at Rollins incorporate multiweek investigative activities. As the level of the course increases, so does the difficulty and independent nature of these exercises. By their senior year students have developed a level of independence that permits them to design their own investigations with faculty direction. As such, they are well prepared to enter graduate or professional school or the workforce. Graduates of our program consistently tell us that the opportunity to develop research skills was one of the most valuable aspects of their educational experience.

Specific Goals for General Biology I

Knowledge

- All living organisms have evolved from common ancestors through processes that include natural selection and genetic drift acting on heritable genetic variation.
- Three types of cells have evolved: bacteria, archaea, and eukaryotes.
- Lipids assemble with proteins to form membranes, which surround cells to separate them from the environment. Membranes also form distinct compartments within eukaryotic cells.
- Basic molecules are shared by all organisms, yet no two cells are alike.
- Living systems are far from equilibrium. They utilize energy, largely derived from photosynthesis, which is stored in high-energy bonds or ionic concentration gradients. The release of this energy is coupled to thermodynamically unfavorable reactions to drive biological processes.
- Information encoded in DNA is organized into genes. RNA functions as informational intermediates to encode proteins.
- Proteins control biological processes, such as chemical reactions, transport, and signaling.
- Diversity of organisms arises from adaptation to different environmental conditions.
- Novel properties of organisms emerge as simpler units assembled into more complex structures.
- Communication networks within and between cells, and between organisms, enable multicellular organisms to coordinate development and function.
- In multicellular organisms, cells divide and differentiate to form tissues, organs, and organ systems with distinct functions. These differences arise primarily from changes in gene expression.

Skills

- Develop study and time management skills.
- Integrate and remember factual information and concepts.
- Develop a sense of the process of science.

- Learn basic laboratory skills, including the use of balances, glassware for volume measurement, spectrophotometer, and microscopes.
- Learn simple chemical and biological assays for measurement of photosynthesis and respiration and how to present the data.
- Use the scientific method to design and perform simple experiments.
- Recognize patterns and identify differences in plant structures.

Course Planner

The textbook for both of the courses described in this syllabus is Scott Freeman's *Biological Science*. The lab manual for General Biology I is the sixth edition of Warren D. Dolphin's *Biological Investigations*. General Biology I students may also purchase the optional text, *A Photographic Atlas for the Biology Laboratory*. For General Biology II, from August 26 to October 7, students use Peter Abramhoff and Robert G. Thomson's *Laboratory Outlines in Biology, VI*. After October 10 they use the third edition of Warren F. Walker and Dominque G. Homberger's *Anatomy and Dissection of the Rat*. In accordance with the State of Florida and Rollins College regulations, all students are required to wear protective clothing and eyewear in the laboratory. They can buy inexpensive lab coats and eyeglasses from the campus bookstore.

General Biology I Lecture Schedule

Week Beginning	Topic	Chapter Readings
Jan. 12	Introduction, Scientific Method Atoms, Molecules, Energy	1 2
Jan. 19	*No class on Monday, Martin Luther King Jr. Day* Redox Reactions, Functional Groups, Water, Bonding Macromolecules	 2 3
Jan. 26	Macromolecules Membranes and Transport	3 4
Feb. 2	Cell Structure **Exam 1** (Monday)	5 1–4
Feb. 9	Respiration and Fermentation Photosynthesis	6 7
Feb. 16	Photosynthesis Mitosis Meiosis	7 8 9
Feb. 23	Evidence for Evolution Evolutionary Processes **Exam 2** (Monday)	21 22 5–9
Mar. 1	Speciation History of Life	23 24
Mar. 8	*Spring Break—Enjoy!*	
Mar. 15	Protists Land Plants **Exam 3** (Friday)	27 28 21–24
Mar. 22	Land Plants The Fungi	28 29

Mar. 29	Plant Form and Function Water and Sugar Transport	31 32
Apr. 5	Plant Nutrition Sensory Systems in Plants **Exam 4** (Monday)	33 34 27–32
Apr. 12	Signaling: Plant Hormones Plant Reproduction	35 36
Apr. 19	Plant Defense Systems	37
Apr. 26	Review (last day of class)	
Apr. 30 and May 3	**Final Exam** (30% comprehensive, 70% Chapters 33–37)	

Laboratory Schedule

The exercise numbers refer to the exercises in the *Biological Investigations* lab manual. The handouts are exercises that are readily available on the Internet or teacher-generated rewrites of computer software instructions for the *Evolving Examples of the Effects of Natural Selection* program.

Date	Lab	Assignment
Jan. 15	Scientific Method and Quantitative Techniques	Exercises 1 and 5
Jan. 22	Plant Morphology Start experiment with *Brassica*	Handout
Jan. 29	Microscopy and Cells Transport and Osmosis	Exercises 2 and 3 (plant cells only) Handout
Feb. 5	Metabolism, Photosynthesis, Respiration	Handout
Feb. 12	Metabolism Extension (lab report required)	
Feb. 19	Mitosis and Meiosis (with pipe cleaners)	Exercises 8 and 9 (process only)
Feb. 26	Mating Game, Beans in the Field	Exercise 12, Handout
Mar. 4	Evolving computer simulation (data collection during lab time in the computer lab; analysis done as homework, collected, and graded)	Handout
Mar. 11	*Spring Break*	
Mar. 18	Protista and Seedless Plants	Exercises 14 and 15
Mar. 25	Fungi and Seed Plants	Exercises 16 and 17
Apr. 1	Plant Anatomy	23, 24, 25
Apr. 8	**Lab Practical Exam** (set up a salt stress experiment; lab report required)	Handout
Apr. 15	Analyze salt stress experiment Set up a hormone experiment	Handout Handout
Apr. 22	Plant Reproduction and Development Analyze plant hormone experiment (answer questions on the handout)	Exercise 26 Handout

General Biology II Lecture Schedule

Week Beginning	Topic	Chapter Readings
Aug. 23	Mendel and the Gene	10
Aug. 30	How Do Genes Work? DNA Synthesis Transcription and Translation **Quiz 1** (Friday)	11 12 13
Sept. 6	*No class on Monday, Labor Day* Control of Gene Expression in Bacteria Control of Gene Expression in Eukaryotes	 14 15
Sept. 13	Development **Exam 1** (Monday)	18 and 19 10–15
Sept. 20	Development Animals **Quiz 2** (Friday)	19 and 20 30
Sept. 27	Animal Form and Function Water and Electrolyte Balance	38 39
Oct. 4	Animal Nutrition **Exam 2** (Monday) *No class on Friday, fall break begins*	40 18–20, 30, 38–39
Oct. 11	Animal Nutrition Gas Exchange and Circulation **Quiz 3** (Friday)	40 41
Oct. 18	Nervous Systems Sensory Mechanisms	42 43
Oct. 25	Sensory Mechanisms Chemical Signals **Exam 3** (Wednesday)	43 44 40–43
Nov. 1	Chemical Signals Animal Reproduction **Quiz 4** (Friday)	44 45
Nov. 8	Animal Reproduction Immune System	45 46
Nov. 15	Population Ecology **Exam 4** (Monday)	48 44–46
Nov. 22	Species Interactions	49
	No class on Wednesday and Friday and no lab on Thursday, Thanksgiving break	
Nov. 29	Species Interactions Community Ecology	49 50
Dec. 6	Ecosystems Final Exam (30% comprehensive, 70% Chapters 48–51)	51

Laboratory Schedule

From August 26 until October 7 the exercise numbers refer to the exercises in the *Laboratory Outlines in Biology, VI* lab manual. After October 7 they refer to the exercises in the *Anatomy and Dissection of the Rat* lab manual. The handouts are exercises that are readily available on the Internet or teacher-generated rewrites of computer software instructions for the *SIMFLY* program.

Date	Lab	Assignment
Aug. 26	Mendelian Genetics I—*SIMFLY*	Handout
Sept. 4	Mendelian Genetics II—*SIMFLY*	Handout
Sept. 9	DNA Analysis	Handout
Sept. 16	Investigating Early Events in Animal Development	Handout
Sept. 23	**Lab Exam 1** Poriferia, Cnidaria, and Ctenophora	Exercise 25
Sept. 30	Acoelomates and Pseudocoelomates	Exercise 26
	Mollusca	Exercise 27
Oct. 7	Annelida	Exercise 28
	Onychophora and Arthropoda	Exercise 29
Oct. 14	Echinodermata	Exercise 30
	Hemichordata and Chordata	Exercise 31
Oct. 21	**Lab Exam 2** Population of Duckweed (lab report required) Rat Dissection: External Anatomy and Skeletal Systems	Exercise 1, Handout
Oct. 28	Muscles	Exercise 2
Nov. 4	Digestive and Respiratory Systems	Exercise 3
Nov. 11	Circulatory and Urogenital Systems	Exercises 4 and 5
Nov. 18	Nervous and Sensory Systems	Exercises 6 and 7
Nov. 25	*Thanksgiving Break*	
Dec. 2	**Lab Exam 3** Cemetery Demography (lab report required)	Handout

Teaching Strategies

To succeed in the field of biology, and in both courses, it is important for students to develop good communication, analytical, and time management skills. For this reason, skills development is an important component of General Biology I and General Biology II. Students are expected to read the material before they come to class because we ask questions and require them to present material in class. For some chapters, they are to use the reading as reference, meaning the material covered in class is most important and the text is intended to further explain that material. Therefore, students must not merely read their assignments but *study* them. We instruct them first to examine the reading for the big picture and then work toward a more refined understanding of the material that allows them to master it; doing so enables students to come to class prepared for thoughtful discussion.

Past experience has shown that many students lack the necessary skills for learning independently by reading the text. In General Biology I we teach students how to annotate their textbooks, giving them the following instructions:

> Since class meetings are discussions of reading assignments, you need to come to class prepared. Preparation is more than reading through the text once. You need to be thinking about the concepts

> and asking questions while reading. To facilitate active reading of the text, we will be introducing a method of text annotation. While reading the text, you will be summarizing *in your own words* the material that is new to you and writing out your own questions in your notebook. During class, this summary can be added to or corrected. The questions raised during your reading can serve as a basis for class discussion. The combined result of text annotations and class notes will be an excellent summary of the material for you to study from for exams. You should strive to (1) put the material in your own words, not just restructure the sentences; (2) organize the concepts into a logical and hierarchical order; and (3) apply and/or react to the material.

While General Biology I and General Biology II share a common syllabus with regard to content and laboratory exercises, we have the freedom to conduct our own sessions as we wish. Since all of us have different teaching styles, approaches to specific topics and student assessment varies from section to section. Usually, though, class sessions consist of minimal lecturing and instead focus around a series of questions that either we or our students pose. Students work in class on using the concepts in the reading assignment to answer these questions. This is sometimes done individually but more often in small groups or by the class as a whole.

When lectures are used they are accompanied by *PowerPoint* presentations that focus on the textbook's diagrams. We do this to help students understand the role of figures and diagrams in the dissemination of scientific information. These presentations use SMART Board™ technology that allows us to "draw" on the diagrams. Sometimes we present diagrams with missing information that students then insert on the board. We also use demonstrations and modeling to help students understand complex and/or abstract concepts. One simple example is pulling most of the tape out of a cassette tape to model the complex folding that must occur to the DNA in order for it to fit into the nucleus. Some sections use a personal response system (PRS) that allows students to test their knowledge and us to quickly assess their understanding. All *PowerPoint* presentations and PRS questions are posted to a Blackboard Learning System™ so that students have ready access to this information.

In General Biology II, to stress the importance of developing the ability to identify key concepts and condense material, we allow students to use a single 3 × 5 inch index card on which they have written helpful information for the biweekly quizzes. This has two goals. First, students must learn how to summarize concisely the large amount of material that is covered in science courses. Second, it emphasizes that it is not the facts that are crucial to being a successful biologist, it is the ability to apply those facts that is most important. We have observed that few students actually refer to their note cards during a quiz; instead, they find that the act of constructing the card has helped them learn the material in such a way that they do not need the cards to do well on the quizzes.

Students in both courses usually do not realize that others in the class are also struggling to master the material, so we encourage them to study in groups, ask questions in class, see us regularly during office hours, and participate in the one-hour weekly review sessions we offer every week. Some of us e-mail sample test questions, study suggestions, and homework hints to students. In addition, advanced junior and senior biology students are available for tutoring in the evenings.

Lab Component

Rollins's lab facilities are basic general biology labs with high lab benches that seat 12 students each. We have sufficient equipment for each student or pair of students. The equipment runs from compound microscopes to spectrophotometers; equipment for electrophoresis, PCR, and gel-imaging systems are readily available. All labs are taught by full-time faculty; Rollins does not use student assistants.

General Biology I and General Biology II each have a four-hour lab every week. The labs are primarily lab-based and students generally work in pairs; however, individual work is required for some of the exercises. Some years we schedule a field trip for the ecology unit. Almost every year students take a trip to a local cemetery to collect data concerning life span, sex, and age, and to perform statistical analysis for an epidemiology unit. Computer simulations are used for the evolution lab (Evolving) and the genetics lab (*SIMFLY*).

To prepare for a successful laboratory, students are directed to read the assigned laboratory exercise and appropriate text material. After completing the exercises, the whole lab section convenes to discuss the outcome of the laboratory. A set of questions or applied problems related to that day's laboratory is assigned and collected at the beginning of the following Monday's class.

We require all students to purchase Victoria E. McMillan's *Writing Papers in the Biological Sciences*, the writing guide all biology courses at Rollins College use. Students' lab reports must be written in a style that is suitable for publication in a biological research journal. The length of the lab reports varies depending on the amount of data that needs to be presented and analyzed, but most are five to six typed pages long, including figures and tables. Students have one week to complete each lab report. We grade the reports and return them, giving students an additional week to make revisions and submit their final draft.

Student Evaluation

The focus on skills development in General Biology I is reflected in the assessments used for lab activities. At the end of most lab periods students receive a homework assignment that is due the next day in class. These lab applications require students to apply the knowledge they gained from completing the lab to answer one or two questions about the concepts that were covered in the lab. The single lab practical exam for this course assesses students' skills as well as content knowledge.

While General Biology I has a heavier emphasis on skills development, General Biology II is more content heavy. Because of the large amount of material in General Biology II, we give frequent quizzes to keep students on track. Students in this course are first-term sophomores and it is assumed that they know how to study by this point; thus, the assessment technique reflects more what they will be doing in the upper-division biology courses. They are expected to prepare for class and be active participants in class discussions. The lab exams are more content oriented and less focused on laboratory techniques. Because diversity is covered only in the lab portions of the course (diversity has been removed from the lecture portion due to time constraints) and because this material is very content dense, General Biology II has more lab exams than General Biology I.

Both courses make use of traditional examinations throughout the terms. Their purpose is to assess students' ability to explain and apply the concepts that have been covered in class. The exams are composed primarily of multiple-choice questions but also contain essay questions and questions pertaining to the lab exercises. The final exams are comprehensive and provide an opportunity for students to demonstrate their understanding of the material that has been covered over the course of the entire semester.

Students who miss more than three classes have their grade for the course lowered by 1 percent for each absence beyond the first three. No absences are allowed for laboratories. For every missed laboratory, students have their grade for the course lowered by 2 percent for each absence. Students are also expected to honor the college's academic honesty policy. Violation of the policy results in a failing grade for the assignment, and the student's conduct is reported to the Dean of Faculty.

Assessment Summary for General Biology I

	Percent of Total Grade
Exams (four exams worth 11% each)	44
Lab applications (10 applications worth 2% each)	20
Final exam	16
Current scientific discovery poster and biology article summaries and critiques	10
Lab practical	5
Lab report on metabolism extension	3
Lab report on salt stress experiment	2
	100

Assessment Summary for General Biology II

	Percent of Total Grade
Exams (four worth 10% each)	40
Labs	30
Lab exams (three worth 7% each)	
Lab report on population of duckweed (worth 3%)	
Lab report on cemetery demography (worth 3%)	
SIMFLY exercise (worth 3%)	
Final exam	15
Four lecture quizzes	10
Classroom performance	5
	100

Teacher Resources

Abramhoff, Peter, and Robert G. Thomson. *Laboratory Outlines in Biology, VI*. 6th ed. New York: W. H. Freeman, 1995.

Dolphin, Warren D. *Biological Investigations: Form, Function, Diversity, and Process*. 6th ed. Boston: McGraw-Hill, 2002.

Freeman, Scott. *Biological Science*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2002.
We used this textbook for the syllabus in this Teacher's Guide. We have since switched to Neil A. Campbell and Jane B. Reece's *Biology*.

McMillan, Victoria E. *Writing Papers in the Biological Sciences*. 3rd ed. Boston: Bedford/St. Martin's, 2001.

Small, James W. *SIMFLY: Mendelian Genetics Instructional Program*. CD-ROM. N.p,: n.d.
Ward's Natural Science no longer carries this software. For a free copy of the program, send a blank CD-ROM and a self-addressed, stamped envelope to James W. Small, Department of Biology, Rollins College, 1000 Holt Avenue, Winter Park, FL 32789-4499.

Thelen, Thomas H. Evolving Examples of the Effects of Natural Selection. CD-ROM. N.p.: n.d.

VanDeGraaff, Kent M., and John L. Crawley. *A Photographic Atlas for the Biology Laboratory*. 5th ed. N.p.: Morton Publishing, 2005.

Walker, Warren F., and Dominque G. Homberger. *Anatomy and Dissection of the Rat*. 3rd ed. New York: W. H. Freeman, 1998.

Student Activities

Assignments

General Biology I and General Biology II strive to turn students into more active consumers of the scientific literature. Two assignments we give in the General Biology I course to acquaint students with the literature involve creating a poster of a major research discovery and presenting weekly critiques of articles. The instructions we give students for these two assignments follow.

Major Scientific Discoveries of the Twentieth-Century Poster

Decide on one major research discovery in the past century that relates to the course and prepare a poster presentation describing the discovery, its impact on human society, the person(s) involved, when and where it occurred, and any other pertinent information. Perform a database search on the discovery you have chosen to find information. The posters will be displayed in the laboratory rooms and the hallways.

Current Biology Articles Summaries and Critiques

You are responsible for finding at least one article about a particular subject and writing a summary and critique of the article. Eight summaries will be due over the 15-week semester. Choose a topic that is related to the textbook readings. For example, the first reading covers biological molecules; thus, you could choose an article on a medicinal plant, the role of cholesterol in heart disease, or the genetical engineering of a plant to produce a product like polyester. Use the three following ways to find articles.

1. **Library Databases.** Use ProQuest® Direct and FirstSearch® on the Olin Library Web site to find articles on different topics.
2. **Web Searches.** Use Internet search engines to find online information. However, be careful with Internet sources because many are not reliable. Use only online copies of journals or government Web sites like the Center for Disease Control or the U.S. Department of Agriculture.
3. **Periodical Collection.** Find hundreds of articles in the periodicals collection on the lower level of Olin Library. Acceptable journals are *Scientific American*, *Bioscience*, *Discover*, *Science News*, the science section of the *New York Times*, *National Geographic*, *National Agricultural News*, and others with a similar level of detail. Examples of unacceptable sources are printouts from Web sites that have no source, paragraph articles from the newspaper, and gardening magazines.

Write a summary of the main points of the article and the supporting evidence. Include your critique of the article and its scientific merit. Your critique might include answers to the following questions: What

did the article make you think about related to the course or your own experience? Did the author(s) use emotionally charged wording that affected your response? Did the author(s) provide enough evidence to convince you of the main points? What does this information mean to society, medicine, the environment, and so on?

Turn in your typed summary and critique along with a copy of the article. Articles will be shared in class on Friday of each week.

Lab Activities

Much of the active learning that students do in General Biology I and General Biology II takes place in the labs. The following is a sampling of the types of laboratory activities that students do in the two courses.

- **Metabolism Extension Lab (February 12).** The week before this lab, students learn several methods for measuring metabolic rates. We then require them to design their own experiment that uses one of these techniques to discover more about one of these metabolic processes. They must write a lab report on this project in a style that is suitable for publication.
- **Mating Game (February 26).** The mating game is a Hardy-Weinberg experiment that is described in many lab manuals. Students receive cards with either an *A* or an *a* written on them. They "mate" with others in the class by exchanging one of their cards. The game is repeated with small sample size, nonrandom mating, and migration to show how these affect the allelic frequencies.
- **Beans in the Field (February 26).** In this predator–prey lab students receive different utensils (e.g., plastic knives, forks, spoons, and tweezers), which they use to try to collect as many colored beans (green, red, blue, and white) as possible from a grassy field. The experiment is repeated for at least three generations to show the selective pressures/effects against both the predator and the prey.
- **Evolving (March 4).** The Evolving Examples of the Effects of Natural Selection program allows students to collect large amounts of data. It offers a series of exercises that use various factors (e.g., camouflage) to demonstrate natural selection and evolution. For example, in one exercise students click on a flower to pollinate it; they do this until 20 flowers have been pollinated. Some of the flowers are very visible and others are camouflaged. The number of pollinated flowers determines the appearance of the next generation. After repeating the exercise for five generations, students can see that effect. The program keeps track of the phenotypic and genotypic frequencies, and students analyze this data. They can repeat the experiment but change the color of the field the flowers are growing in or other factors that might affect pollination. Students do the data collection during the lab period and complete the analysis part of the assignment as homework. Their analysis is collected and graded.
- **Mendelian Genetics I and II (August 26 and September 4).** *SIMFLY* is a computer program written by James Small, one of our faculty members. It generates data from fruit fly crosses for students to analyze. The program has several modes. One allows students to practice crosses and analysis of the data. Another allows the computer to test students' ability to determine the genotype of parents by analyzing their offspring. A third mode is for advanced genetics courses and brings in crossing over and mapping. Other "prettier" virtual fly lab programs are commercially available, but *SIMFLY* is free and requires more analysis; the computer merely rapidly generates scientifically correct data for a large number of crosses, but the analysis must be done entirely by the students. *SIMFLY* is a great program because it makes students think.

Syllabus 2

John McMillian
Central High School
Philadelphia, Pennsylvania

School Profile

School Location and Environment: Chartered in 1836 and organized in 1838, Central High School is the second oldest public high school in the United States. Central was originally an all-boys school; in 1983 it began to admit girls, who now comprise a little more than half of the student population. The Central student population represents a wide variety of racial, ethnic, geographic, and economic groups. This level of diversity fosters an atmosphere of multicultural opportunities, cooperation, and interaction at the school.

The student body is selected from schools in the city of Philadelphia and surrounding suburbs on the basis of superior academic record and the passing of an entrance examination. Central is the only high school in the country that, by an Act of Assembly in 1849, has the authority to confer Bachelor of Arts college degrees on those graduates who meet the requirements. Central produces graduates who progress to extraordinarily high achievement levels. The October 2004 issue of *Philadelphia Magazine* named Central as one of its 20 best high schools; its September 2005 issue ranked Central in its top 50 public schools in the tristate area. Central has also received the U.S. Department of Education's Academic Excellence Award.

Grades:	9–12
Type:	Coeducational, college-preparatory magnet school
Total Enrollment:	2,320 students
Ethnic Diversity:	African Americans comprise 33 percent of the student population; Asian Americans, 21 percent; and Hispanics, 5 percent.
College Record:	Over 98 percent of the students matriculate to four-year colleges or universities.

Personal Philosophy

Even though the amount of information covered in an AP Biology course is enormous, I design my course in a way that makes it more manageable. The students who take the course at my school are already able to learn and retain huge amounts of information as well as analyze data and apply the information they have learned in a laboratory setting to problem solving. These skills are emphasized in several science courses that the students must take before enrolling in AP Biology, including Biology (9th grade, full year), Fundamentals of Science (9th grade, half year), Chemistry (10th grade, regular or AP, full year), Physics (11th grade, regular or AP, full year). My goal is to provide them with the tools they need to understand biological concepts in a timely manner and to help them perform well on any biology inventory. It is expected that each student will derive the same pleasure, love, and enthusiasm that I have for studying living things and to use what they have learned to speak intelligently about cutting-edge topics in the biological sciences and other related fields of study. I also make an effort to encourage my students to pursue careers in the biological sciences.

Class Profile

Central offers two sections of AP Biology. The first, the AP Biology section, meets for five one-hour periods a week with labs integrated into regular class meetings. The second, the AP/IB Biology section, which includes all of the AP labs and many others, meets for eight periods a week and has a designated lab period. There is more content to cover in AP Biology, but IB Biology students are required to complete a variety of assignments that must be submitted to an external agency for grading. Additionally, the lab requirement for IB Biology is more intense than for AP Biology. In IB/AP Biology the students will learn the AP Biology curriculum and perform the IB labs. Students have the option of taking both IB and AP Biology Exams in the AP/IB Biology course only.

Both sections are yearlong and have between 26 and 33 students. AP Biology is open to juniors, but eligible seniors are given first priority. Since 1993 only seniors have enrolled in the course. The school year runs from September to June.

Course Overview

My AP Biology course conforms to the standards instituted by the College Board for all AP courses and covers all of the topics in the *AP Biology Course Description*. These include biochemistry, cell structure and function, metabolism, genetics, molecular basis of inheritance, DNA technology, evolution, microbiology, classification, plants, animals, animal physiology, and ecology. This is a laboratory course in which students are expected to use collected data to solve biological problems.

The objectives of the course are that each student shall

- Demonstrate skills in using various types of biological instrumentation,
- Learn how to read and critique papers written by scientists in the field of biology,
- Practice finding and using patterns in collected data to solve scientific problems, and
- Exhibit mastery of the major principles of biology.

Ideally, each unit takes two weeks to complete and typically is organized like this:

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Lecture 1	Lecture 2	Lecture 3	Lecture 4	Review
Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
AP Lab	AP Lab	Other Lab	Recitation/Lab	Unit Exam
			Free-Response Question Practice	

The textbook for the course is the fifth edition of Neil A. Campbell and Jane B. Reece's *Biology*. Students use the *AP Biology Lab Manual for Students* for most of the laboratory exercises. Some of the labs are teacher-generated and some come from other sources, which are fully identified in the teacher resources section of this syllabus.

Course Planner

Lecture and Lab Schedule for AP Biology

Unit	Lecture and Lab Titles	Readings	Month
	First Report Period		
1	Chemistry of Life • Structure of an atom • Types of chemical bonding • Functional groups • Classification and formation of macromolecules • Characteristics of enzymes • Water *Lab:* Enzyme Catalysis (AP Lab 2) *Lab:* Molarity: An Expression of Concentration (teacher generated)	Chapters 2, 4, 5 Hough and Kahn article	Sept.
2	Cellular Structure and Function • Fluid mosaic model of the plasma membrane • Types of cellular transport • Subcellular organization • Prokaryotic and eukaryotic cells *Lab:* Diffusion and Osmosis (AP Lab 1) *Lab:* Compound Microscope (from Harley and Prescott) *Lab:* Donnan Equilibrium (from Abramoff and Thomson)	Chapters 3, 7, 8 Perk article Razin and Rottem article Reijngoud article	Sept.
3	Communication No labs	Chapters 11, 39, 45	Oct.
4	Metabolism • Free energy changes • Molecules and reactions involved in metabolism • Fermentation and cellular respiration • Light-independent and light-dependent reactions *Lab:* Cell Respiration (AP Lab 5)	Chapters 6, 9, 10 Katz and Rognstad article Krebs and Johnson article Micks and Gibson article	Oct.
	Second Report Period		
5	Cellular Reproduction • Stages involved in mitosis • Stages involved in meiosis • Alternation of generations • Spermatogenesis and oogenesis *Lab:* Mitosis and Meiosis (AP Lab 3) *Lab:* Embryology of the Sea Urchin (teacher generated)	Chapters 12, 13, 46, 47 Pickett-Heaps article	Nov.
6	Mendelian and Non-Mendelian Genetics • Inheritance patterns: monohybrid, lethal, sex-linked, codominance, multi-hybrid crosses *Lab:* Genetics of Organisms (AP Lab 7)	Chapters 14, 15	Nov.
7	Molecular Genetics • RNA and DNA structure and function • Structure of prokaryotic and eukaryotic chromosomes • Gene regulation in prokaryotic and eukaryotic cells *Lab:* Molecular Biology (AP Lab 6)	Chapters 16, 17, 19 Blackburn article	Dec.

8	Recombinant DNA Technology • Recombination technology *Lab:* Electrophoresis of Dyes (teacher generated)	Chapters 18, 20, 21	Dec.
Winter Break			
9	Evolution • Chemical evolution *Lab:* Population Genetics and Evolution (AP Lab 8) *Lab:* Coacervates (from McMullen, Newton, and Becker)	Chapters 22, 23, 24, 25 Pruitt article	Jan.
Third Report Period			
10	Microbiology *Lab:* Gram Staining (from Harley and Prescott)	Chapters 26, 27, 28, 31	Jan.
11	Plants *Lab:* Plant Pigments and Photosynthesis (AP Lab 4) *Lab:* Photosynthesis and pH (Neumann and Jagendorf)	Chapters 29, 30, 35, 36	Feb.
12	Control Systems in Plants No labs	Chapters 37, 38, 39	Feb.
13	Invertebrates *Lab:* Dichotomous Key to the Insects (Keeton, Dabney, and Zollinhoffer) *Lab:* Dissection of the Earthworm and Clam (teacher generated)	Chapters 32, 33	Mar.
14	Vertebrates *Lab:* Dissection of the Frog (teacher generated)	Chapters 34, 40	Mar.
Fourth Report Period			
15	Comparative Anatomy and Physiology *Lab:* Sheep's Brain and Cow's Eye (from Marieb)	Chapters 41, 42, 43, 44 Simanton article	Apr.
Spring Break			
16	Ecology *Lab:* Dissolved Oxygen and Aquatic Primary Productivity (AP Lab 12) *Lab:* Biotic Index (from Burd, Carey, and Fowler)	Chapters 50, 51, 52, 53, 54, 55	Apr.
17	Review for the AP Exam and final exam		May

Teaching Strategies

I have written a total of 55 detailed outlines that correspond to the topics covered in the textbook and each item on the topic outline in the Course Description (see the sample lecture outline section of this syllabus for an example). I give these to my students throughout the year to use in class as lecture aids. My lectures, which cover selected concepts from each textbook chapter, are supplemented with diagrams, explanations, visuals, examples, and demonstrations. I ask students to add any information they have obtained from the lecture directly to the outlines. They also work on questions I pose in class that can be answered by the information covered in the outlines.

In addition to the textbook readings, I regularly assign primary research articles as required reading for homework. Most of the articles are considered classics in the field (see the teacher resources section of this syllabus for a partial list). Periodically I show DVDs, most of which deal with diversity of life, and I also invite guest lecturers to speak to the class. These have included a variety of alumni, like Leslie New of the Philadelphia Zoo and Nobel Prize winner Howard Temin.

Students are not required to take the exam but an overwhelming majority of them do. I use a variety of strategies to prepare them during the school year for the AP Biology Exam in May.

- **Oral Unit Questions.** During the review period, students orally answer as quickly as possible a series of questions relating to a particular unit. At the conclusion of the question–answer session, they answer 10 multiple-choice questions in writing.
- **Multiple-Choice Questions.** Students complete 50 multiple-choice questions during each unit exam. Multiple-choice questions test at the higher educational objectives of synthesis, analysis, judgment, and comprehension. I generally square the final test average in the first two report periods. By squaring the test averages, I am able to use very demanding questions on each unit exam without sacrificing students' grade-point averages in these report periods.
- **Free-Response Questions.** I use Released Exams from 1986, 1990, 1994, 1999, and 2002 in class as practice exams. I also write my own free-response questions. Students use a scoring guideline to grade these free-response writing assignments, and I read their responses as well.
- **Other Test Prep Aids.** I encourage my students to seek sources such as AP Biology Web sites created by teachers or test preparation books that provide them with additional practice tests.

We usually have two weeks between the AP Exam and the end of the school year. During that time the seniors are busy preparing for final exams. Graduation practice and related end-of-year activities take up time after finals.

Lab Component

My lab facilities consist of eight lab tables that seat four students each. The room was originally designed as a laboratory for chemistry and physics students, but now it is used only for both biology lectures and laboratory exercises. There is generally enough equipment and materials for students to work in groups of two.

Students work in pairs to complete each lab during two one-hour periods. On the first day of a lab, each group gathers materials, sets up the lab, prepares stock solutions, cultures the specimen, and begins some parts of the lab. They complete the lab on the second day. Students work on labs with very little assistance from me. When possible, the AP Labs are modified to use smaller quantities of perishable and nonperishable items in the exercises. Some of the units do not have labs. We lose time throughout the year as a result of senior activities, time that can be made up during the units that do not have scheduled labs.

We complete one field lab on scatology/evolution at the Philadelphia Zoo. Students look at animal scats to identify relationships between various caged animals. Animal keepers and other zoo professionals talk with the students about the animals' diet, health, and behavior. No write-up is involved with this activity.

Students gain a deeper understanding and appreciation of topics they explore through firsthand observations during laboratory investigations. They perform two types of lab activities, those in the *AP Biology Lab Manual for Students* and those I have designed or taken from other sources. The AP Lab Manual labs are familiar to most AP Biology teachers, so what follows are brief descriptions of only those labs I have developed or taken from other sources.

- **Molarity: An Expression of Concentration (Unit 1).** In this teacher-generated investigation, students learn how to prepare molar concentrations of reagents that will be used in their laboratory program. They also explore methods involving microcentrifugation.

- **Compound Microscope (Unit 2).** The major theme of this exercise from *Laboratory Exercises in Microbiology*, is to identify the parts of a compound microscope and apply the basic principles of microscopy to make observations in the laboratory.
- **Donnan Equilibrium (Unit 2).** Students discover how a stationary ionic compound influences the distribution of mobile ions across a semi-permeable membrane.
- **Embryology of the Sea Urchin (Unit 5).** Students observe the development of a fertilized egg over a period of time in this teacher-generated lab.
- **Electrophoresis of Dyes (Unit 8).** Dyes in a mixture have different charges and masses. Students determine how these dyes separate in a gel matrix during electrophoresis in this teacher-generated lab.
- **Coacervates (Unit 9).** A population study of coacervates forms during this lab based on an article in the June 1982 issue of *Journal of Pharmaceutical Science*.
- **Gram Staining (Unit 10).** Students study the classification of selected bacteria based on color, shape of cells, and cellular arrangement during gram staining in this lab from *Laboratory Exercises in Microbiology*.
- **Photosynthesis and pH (Unit 11).** I based this lab on an article in a 1964 issue of *Archives of Biochemistry and Biophysics*. Students measure the pH of a spinach chloroplast suspension while it is exposed to different wavelengths of light.
- **Dichotomous Key to the Insects (Unit 13).** In this exercise, which comes from *Laboratory Guide of Biology Science*, students use a dichotomous key of the insects to classify insects.
- **Sheep's Brain and Cow's Eye (Unit 15).** Students use directional terms to identify parts of a sheep's brain and a cow's eye. This lab comes from *Human Anatomy and Physiology*.
- **Biotic Index (Unit 16).** In this lab from *Biotic Index: A Water Quality Measurement*, students evaluate the quality of several water samples based on the diversity of organisms living in them.

All labs count and are graded individually. Therefore I consider all lab work my students complete and submit to be formal lab work. For the AP Labs students answer the questions in the AP Lab Manual and submit their lab manuals to me for grading. For the other labs I require a special format. Instead of repeating the same instructions, a flow diagram of the laboratory's protocol is placed under the materials and methods section of the report. Students usually use data, submitted in tabular form or graphs with interpretation to follow, to answer lab questions or to solve a problem.

Student Evaluation

Students are evaluated on their performance on the unit exams, free-response questions, labs, and the homework they complete. I assign a certain number of points for each assignment students complete for credit. Their final grade average is determined by the percent of the total points earned during the report period.

Assignment	Points	Percentage of Grade
Unit Exams and Final Exam	100	67%
Free-Response Questions	25	16%
Labs	10	9%
Homework	5	8%
	140	100%

Letter grades are assigned to these percentages according to the grading standards specified by the School District of Philadelphia's Board of Education.

A	90–100
B	80–89
C	70–79
D	65–69

- **Unit Exams.** Each unit exam consists of 50 multiple-choice questions, all of which have been designed to test students' ability to classify, analyze, evaluate, and synthesize data that relates to the major concepts covered in each unit. Students also take a final exam, which covers all of the concepts studied during the lectures for the entire school year. It consists of 100 multiple-choice questions and counts as a single test grade.
- **Free-Response Questions.** I provide in-class opportunities for students to practice answering and scoring free-response questions, which count as one-fourth of an exam grade.
- **Labs.** For the labs from the AP Lab Manual, I grade students on the quality and clarity of their answers to the lab manual questions. For the labs I have developed or taken from other sources, I use a point system to grade students' work:

Skill Demonstrated	Points
Student used data to answer the lab problem	3
Student organized data in a table or graph	3
Student's paper shows a flow diagram of methods	3
Student's paper is well organized	1

- **Homework.** Homework assignments stress procedural skills, critical thinking, vocabulary, word problems, analogies, outlining, and analysis. I assign homework nightly and grade it myself.

Teacher Resources

Textbook

Campbell, Neil A. *Test Bank for "Biology."* CD-ROM. Menlo Park, Calif.: Benjamin Cummings, n.d.
This is the test bank that accompanies the textbook.

Campbell, Neil A., Jane B. Reece, and Lawrence G. Mitchell. *Biology*. 5th ed. Menlo Park, Calif.: Benjamin Cummings, 1999.
This textbook is widely used by U.S. universities and colleges for their first-year biology courses. By the time this Teacher's Guide has been published, my school will have updated the textbook to the seventh edition.

Sources for Labs

Abramoff, Peter, and Robert G. Thomson. *An Experimental Approach to Biology*. San Francisco: W. H. Freeman, 1966.

Burd, Larry, Virginia Carey, and Donald Fowler. *Biotic Index: A Water Quality Measurement*. University Park, Penn.: Stone Valley Outdoor School of the Pennsylvania State University, n.d.

The College Board. *AP Biology Lab Manual for Students*. New York: College Entrance Examination Board, 2001.

Harley, John P., and Lansing Prescott. *Laboratory Exercises in Microbiology*. N.p.: William C. Brown, 1993.

Keeton, W., W. Dabney, and R. Zollinhoffer. *Laboratory Guide of Biological Science*. N.p.: W. W. Norton, 1968.

Marieb, Elaine N. *Human Anatomy and Physiology*. Redwood City, Calif.: Benjamin Cummings, 1989.

McMullen, J., D. Newton, and C. Becker. "Pectin-Gelatin Complex Coacervates I: Determinants of Microglobule Size, Morphology, and Recovery as Water-Dispersible Powders." *Journal of Pharmaceutical Science* 71 (June 1982): 628-32.

Neumann, J., and A. T. Jagendorf. "Light-Induced pH Changes Related to Phosphorylation by Chloroplasts." *Archives of Biochemistry and Biophysics* 107 (1964): 109-19.

Journal Articles

Blackburn, Elizabeth. "Telomeres." *Trends in Biochemical Sciences* 16 (October 1991): 378-81.

Hough, L., and R. Khan. "Intensification of Sweetness." *Trends in Biochemical Sciences* 3 (March 1978): 61–63.

Katz, J., and R. Rognstad. "Futile Cycling in Glucose Metabolism." *Trends in Biochemical Sciences* 3 (August 1978): 171-74.

Krebs, H., and W. A. Johnson. "The Role of Citric Acid in Intermediate Metabolism in Animal Tissues." *Enzymologia* 4 (1937): 148-56.

Micks, D. W., and F. J. Gibson. "The Characterization of Insects and Ticks by Their Free Amino Acid Patterns." *Annals of the Entomological Society of America* 50 (1957): 550-55.

Perk, K. "Osmotic Hemolysis of the Camel's Erythrocytes: I. A. Microcinematographic Study." *Journal of Experimental Zoology* 163 (1966): 241-46.

Pickett-Heaps, J. "Mitotic Mechanisms: An Alternative View." *Trends in Biochemical Sciences* 11 (December 1986): 504-7.

Pruitt, W. O. "Aging in the Masked Shrew, *Sorex cinereus cinereus* Kerr." *Journal of Mammalogy* 35 (February 1954): 35–39.

Razin, S., and S. Rottem. "Cholesterol in Membranes: Studies with Mycoplasmas." *Trends in Biochemical Sciences* 3 (March 1978): 51–55.

Reijngoud, D. "The pH and Transport of Protons in Lysosomes." *Trends in Biochemical Sciences* 3 (August 1978): 178-80.

Simanton, W. A. "Determination of the Surface Area of Insects." *Annals of the Entomological Society of America* 26 (1933): 247-54.

Student Activities

Research Paper

Students write and present a paper on a current topic in biology. For this paper they generally analyze the methods of a scientific investigation in a primary research report. I give them six weeks to work on it, and it is due near the end of the third report period.

Research Project

Each year the American Academy of Neurology sponsors the Neuroscience Research Prize competition. The competition began in 1992 to encourage high school students to explore, through investigative laboratory research, topics related to the brain and the nervous system. I require my students to complete a nonbehavioral research project that can be entered in this competition, following the Academy's guidelines. All of my students use living earthworms, *Lumbricus terrestris*, as the experimental organism. When presenting their projects, students use the same format that scientists use to present their research in a primary research report. I introduce this project during the first week of school and it is generally due during the second week of October. While the project is research driven, not unit driven, I try to tie it in with the Communication unit (Unit 3). For more information about this competition, go to the American Academy of Neurology's Web site at www.aan.com/professionals, click on *Awards & Fellowships*, and scroll down and click on *Neuroscience Research Prize*.

Free-Response Questions

Learning how to answer free-response questions is an important part of my course, and I give students a great deal of practice with this. During every report period they do 20-minute in-class, graded assignments that are designed to help them become comfortable with this kind of evaluation. Students answer any one of the following four types of free-response questions, and I explain to them how each type is to be answered.

1. **Discuss/Explain.** Present the facts and support them with examples and evidence.
2. **Compare/Contrast.** Present similarities and differences between two or more objects.
3. **Describe.** Present the physical and chemical properties of an object, working from the most general to the most specific.
4. **State.** Present all of the information known about the subject.

Then I give my students the following instructions.

1. Read the question carefully before writing anything.
2. Identify the question's major components.
3. Make a list of facts that relate to each of the components.
4. Present the facts accurately and sequentially.
5. Answer the question that has been asked, not the question you would have preferred to answer.

The level of difficulty of the free-response questions increases as the school year progresses. Students do at least two of these assignments every report period, though this varies; my goal is for them to do four.

- **First Report Period Question.** I announce the question in class several days before students are to answer it. They are allowed to use a fact sheet they have written to help them answer the question.
- **Second Report Period Question.** I announce the question in class several days before students are to answer it, but this time they are not allowed to use a fact sheet.
- **Third Report Period Question.** Students read and discuss in class a scientific article (a primary research report) that generally spans multiple units. They know that part of the upcoming free-response question will relate to the data in the article and part will relate to the units we have covered thus far in class. For example, if I give students a report on the reduction of telomeric DNA during replication, they know they may need to use the data in that report to answer part one of the free-response question while discussing in part two the general properties of enzymes. Students answer at least two of these types of two-part questions in the third report period.

Sample Lecture Outline

Lecture Unit 6: Chapter 14, "Mendel and the Gene Idea"

A. Mendel's laws

1. Law (Principle) of dominance—when two contrasting traits of the parent generation (P) are crossed, the dominant trait appears in the first generation (F_1, or filial one)

   a) Dominant trait—symbolized with a capital letter (*A*)

   b) Recessive trait—symbolized with a lowercase letter (*a*)

2. Law of segregation—for each character an organism inherits two factors, one from each parent, that separates during gamete formation

   a) Homozygous—having a pair of identical alleles (alternative version of a gene)

   b) Heterozygous—having two different alleles for a trait

3. Law of independent assortment—genes located on different chromosomes assort independently of one another

   a) Genotype—actual genetic information

   b) Phenotype—expression of the genes

B. Probability (the likelihood that a specific event will occur)

1. P = M/N; M = the number of one kind of event, N = the total number of events

   a) Probability ranges from 0 to 1, where 1 is certain to occur

   b) Expressed as a decimal, percent, or fraction

   c) Expected ratios are most likely to occur when the population size in the study is very large

2. Rule of multiplication—the chance that two or more independent events will occur simultaneously is equal to the product of their chances occurring separately (law of probability)

    a) Punnett Square—a mathematical tool used to determine the probability of inheriting traits

3. Rule of addition—to determine the probability of an event occurring in two or more different ways, add the separate probabilities of each way that the event can occur

C. Mendelian inheritance patterns (complete dominance)

1. Monohybrid cross

    a) Albinism—lack of pigmentation in skin and eyes; recessive and nonlethal

    b) Cystic fibrosis—defective chlorine pump; chlorine accumulates in cells, causing mucus that surrounds the cells to become thick; recessive and lethal

    c) Polydactyly—extra digits on hands and feet; dominant and nonlethal

    d) Huntington disease—production of quinolinic acid, a stimulant

    e) Achondroplasia (a type of dwarfism)—heterozygous, disproportionate limbs

    f) Tay-Sachs disease—absence of hexosaminidase A; gangliosides are stored in the brain, which progressively kills brain cells until there is a loss of function and death; recessive disorder

2. Special crosses—used to determine genetic background

    a) Testcross—used to determine the genotype of a dominant phenotype; cross the unknown dominant phenotype with the recessive phenotype or with a dominant phenotype of known lineage

    b) Backcross—used to uncover hidden or carried genes (mate offspring with parent)

3. Multiple hybrid crosses—mating that involves at least two traits

Rules for performing a dihybrid or multiple hybrids cross:

    a) Determine the frequency of the genotypes in each cross using the Punnett square

    b) Let one set of genotypes form the base of a branching diagram

    c) Distribute the genotypic frequencies of the second cross on the genotypic frequencies of the first cross (if you are working with multiple hybrid crosses, distribute the genotypic frequencies of the third cross on the genotypic frequencies of the second cross, and so on)

    d) Find the product of the genotypic frequencies for each branch of your branching diagram

D. Non-Mendelian inheritance patterns (no complete dominance)

1. Incomplete dominance—blending of traits; partial expression of two alleles in the offspring

    a) RR = red snapdragons, RW = pink, WW = white

    b) Phenotype equals the genotype, pink is an intermediate phenotype

2. Codominance—expressions of two alternative forms of an allele in the phenotype of the offspring

    a) *RR* = reddish brown cow, *RW* = roan (spotted-white and reddish brown), *WW* = white

3. Pleiotropy—the ability of a *single* gene to have multiple effects on an organism (e.g., sickle cell anemia)

4. Epistasis—a gene at one locus alters the phenotypic expression of a gene at a second loci (multiple hybrid cross)

5. Polygenic inheritance—requires the additive effects of two or more genes for the expression of a phenotype (e.g., height, skin color in humans, etc.)

6. Multifactorial characters—both genes and environment collectively influence a phenotype.

E. Pedigree analysis

1. Pedigree—a family tree describing the interrelationships of parents and children across several generations

    a) Symbols commonly used in pedigree charts:

        (1) Male = square

        (2) Female = circle

        (3) Affected = shaded square or circle

        (4) Unaffected = unshaded square or circle

        (5) Mating = horizontal line

        (6) Descendents = vertical line

F. Technology used in genetic counseling and testing

1. Amniocentesis—between the fourteenth and sixteenth weeks of gestation, a physician inserts a needle into the uterus and extracts about 10 mL of amniotic fluid (the fluid that bathes the fetus). Tests are performed on the then-cultured cells. Complications include maternal bleeding and fetal death.

2. Karyotype—a picture of the metaphase chromosomes

3. Chorionic villus sampling (CVS)—a physician suctions off a small amount of fetal tissue from the placenta, usually getting enough mitotic cells to perform a karyotype immediately

4. Ultrasound—a noninvasive procedure that uses sound waves to produce an image of the fetus

Genetic Problems

1. If a certain character were always inherited through the egg, never through the sperm, what part of the gamete would probably be responsible for the transmission of the genetic basis for the character? Explain.

2. Each somatic cell of *Drosophila melanogaster* (a fruit fly) contains four pairs of chromosomes. In any individual *Drosophila* what relation do these four pairs of chromosomes bear to the chromosomes of the two parents of the fly?

3. A spotted rabbit, when crossed with a solid-colored rabbit, produced all spotted offspring. When these F_1 rabbits were crossed among themselves, they produced 32 spotted rabbits and 10 solid-colored rabbits. Which of the traits is expressed by a dominant allele? How many of the spotted rabbits in the F_2 generation would be expected to be homozygous? How many of the solid-colored rabbits would be homozygous?

4. An albino man marries a naturally pigmented woman. They have nine children, all naturally pigmented. What are the genotypes of the parents and of the children?

5. In poultry, a rose comb is dependent on a dominant allele (*R*), single comb on its recessive allele (*r*). Birds of the Wyandotte breed are required to have rose combs. In certain strains of Wyandottes, however, single-combed birds occasionally appear. Why is this? When a single-combed bird appears in a flock it is immediately discarded. Will this practice be sufficient to eliminate the allele for single comb from the flock? A rose-combed male is mated with two rose-combed females. Female A produces 14 chicks, all rose-combed. Female B produces nine chicks, seven of which are rose-combed and two single-combed. What are the genotypes of the three parent birds?

6. In radishes, the shape may be long or round or oval. Crosses between round and oval gave 159 long and 156 oval. Crosses between oval and long gave 203 oval and 199 round. Crosses between long and round gave 576 oval. Crosses between oval and oval gave 121 long, 243 oval, and 119 round. What type of inheritance is involved?

7. What proportion of the offspring of the following crosses, involving independent segregation, will be completely homozygous? How many offspring in each cross will have the genotype aabbdd?

   (a) *AaBbDd* *AaBbDd*

   (b) *aaBbdd* *aabbdd*

   (c) *AABBdd* *AABBdd*

   (d) *aaBBdd* *AaBbDd*

8. In snapdragons, red flowers (*R*) are incompletely dominant to white (*W*), the hybrid being pink; narrow leaves (*N*) are incompletely dominant to broad leaves (*B*), the hybrid being intermediate in width. Assuming that the gene pairs recombine independently, give the genotypic and phenotypic ratios expected among the progeny of a cross between the following:

   (a) a red medium and a pink medium-sized plant

   (b) a pink medium-sized and white narrow plant

   (c) two identical hybrids

9. In man, aniridia (a type of blindness) is due to a dominant allele. Migraine (a type of sick headache) is the result of a different dominant allele. A man with aniridia, whose mother was not blind, marries a woman who suffers from migraine but whose father did not. In what proportion of their children would both aniridia and migraine be expected to occur?

10. In summer squash, white fruit color is dependent on a dominant allele (*W*) and colored fruit on its recessive allele (*w*). In the presence of *ww*, the color may be yellow, due to a dominant allele (*G*), or green, due to its recessive allele (*g*). How many different genotypes may be involved in the production of white fruits?

11. In human beings, two right-handed parents sometimes produce left-handed children. Also, two left-handed parents sometimes produce right-handed children. If left-handedness is hereditary, could the above facts be explained on the basis of a single pair of genes? Discuss the reasons for your answer.

12. In wheat, red kernel color is dependent upon the presence of two dominant alleles (*R* and *B*) and white kernel color upon the presence of both recessives in the homozygous state. Other combinations result in brown. Two brown varieties (*rrBB* and *Rrbb*) are crossed. What is the phenotype of the offspring in the F_1 generation?

13. In foxes, a silver-black coat is governed by a recessive allele (*b*) and red color by its dominant allele (*B*). Determine the genotypic and phenotypic ratios expected from the following matings:

    (a) pure red × carrier red

    (b) carrier red × silver-black

    (c) pure red × silver-black

14. In *Drosophila*, sepia-colored eyes are due to a recessive allele (*s*) and wild type (red eye color) to its dominant allele (s^+). If sepia-eyed females are crossed to pure wild-type males, what phenotypic and genotypic ratios are expected if the F_2 males are backcrossed to the sepia-eyed parental females?

15. The genetics of the ABO human blood group is presented here. A woman of blood type A is suing a man of blood type B for paternity. The woman's child is blood type O.

    (a) Could this man be the father of her child? Explain.

    (b) If this man is the father of this child, specify the genotypes of both parents.

    (c) If it is impossible for this type B man to be the father of a type O child, regardless of the mother's genotype, specify his genotype.

    (d) If a man was of blood type AB, could he be the father of a type O child?

Genotypes	**Reactions With:**		**Phenotype**
	Anti -A	Anti -B	(Blood Groups)
I^AI^A, I^Ai	+	–	A
I^BI^B, I^Bi	–	+	B
I^AI^B	+	+	AB
ii	–	–	O

Syllabus 3

Susan Offner
Lexington High School
Lexington, Massachusetts

School Profile

School Location and Environment: Lexington High School is a large, comprehensive, suburban high school in the Boston area. The town is affluent and a number of the students come from highly educated families. Many of the parents are professionals; many are professors at the numerous colleges in the Boston area. Lexington participates in the state-funded METCO (Metropolitan Council for Education Opportunity) Program, which brings students from Boston to the Lexington public schools.

Grades:	9–12
Type:	Public high school
Total Enrollment:	Approximately 2,000 students
Ethnic Diversity:	Asian/Pacific Islander Americans comprise 18 percent of the total student population; African Americans, 4 percent; and Hispanics, 1.5 percent.
College Record:	Approximately 95 percent of the graduating seniors enroll in four-year colleges or universities.

Personal Philosophy

To me, twentieth- and twenty-first-century biology is the Greatest Show on Earth. Teaching AP Biology gives me the chance to share incredible discoveries with a whole generation of students. I estimate that about 80 percent of what I teach was not known in 1972 when I became a biology teacher. Therefore, I am continually keeping myself up to date by reading as much as possible. In addition to the science sections of newspapers and popular science magazines, I read *Science* and *Nature*. These are two premier international journals of science that contain many articles that are accessible to a scientifically knowledgeable reader who is not an expert in any one field. This reading, plus attending as many conferences and lecture series as possible, plus sharing with other biology teachers both locally and nationally, has enabled me to stay up to date and excited about biology so that I am able to teach it effectively.

Class Profile

Lexington High School offers between four and five sections of AP Biology each year. I am one of four teachers who teach the course. There is a great deal of informal collaboration among the AP Biology teachers. We give our students the same summer and independent research assignments and the same final exam. We also use the same textbook and cover the same curriculum. However, we each have the latitude to design and teach the course in our own way and develop our own lab programs.

An average class size is 24 students. Lexington is unusual in that its AP Biology course is a first-year course for sophomores only. This works well at Lexington, where students are high achieving, well supported (none of the students need to hold after-school jobs), and beautifully prepared by a rigorous curriculum that begins in kindergarten. We do not have a problem getting students to do homework; on the contrary, frequently my job is to calm them down and get them to be less perfectionistic and more productive (e.g., "No, you do not need to memorize every word in the chapter, but it would be a good idea to understand the main themes it is trying to convey"). Most students who try the course succeed in it. Occasionally someone feels overwhelmed and switches to a regular biology course.

We are also fortunate with our schedule. Classes meet every day for 50 to 55 minutes. Once a week we have a double lab period that runs between 105 and 115 minutes, depending on the vagaries of a complicated schedule. This makes it possible to not only do all of the 12 labs in the *AP Lab Manual for Students* but many additional labs as well, resulting in a very rich laboratory program.

Finally, we are probably unique in that we teach just three classes, a total of 18 hours per week of teaching, plus 3 hours of duty time and 2 homeroom periods per week. This is what enables us to teach at the intense level required to get the entire AP curriculum into a first-year course, as well as to have the time to supervise students' independent research projects. We used to have a technician who would cook our agar and prepare our solutions, but we lost her to budget cuts a few years ago and have been trying mightily to get her back ever since.

Course Overview

The AP Program is rigorous, requiring its teachers to teach seriously, yet it is flexible enough that teachers can tailor the course to reflect their own expertise and teach the material in the way that makes the most sense to them. I organize my course around three themes: the cell theory, DNA, and evolution. Approximately two-thirds of my course is lecture and one-third is labs and class activities. We do a wet lab just about every week. Students are required to read the textbook chapters listed on the syllabus, and they take a test at the end of each unit. The course textbook is the sixth edition of Neil A. Campbell and Jane B. Reese's *Biology*.

Students in all sections of AP Biology work on unit 1 (ecology and behavior) as a summer assignment. In June we issue each student a textbook and a packet of work to be completed over the summer. The packet consists of the six ecology and behavior chapters from the textbook's student study guide, instructions to complete the questions at the end of each chapter in the textbook, several questions we have written for each chapter, and directions to write out definitions for all of the bold-faced terms in the chapters. We collect this packet on the first day of school; during either the second or third week of school students take a test on the ecology unit. We then proceed to the second unit.

All students who take the AP Biology course are required to do an independent research project outside of class time. I assign this in September and it is due at the beginning of March. Students do most of the work on it independently and at home. Every year Lexington High School holds a large science fair, and most of the AP Biology students compete with their projects and win prizes at both the regional and state levels. We also have semifinalists every year in the Intel Science Talent Search competition; although these students are seniors, they sometimes win awards for the projects they did during their sophomore year in AP Biology. In the past, students have isolated new phages and annotated their genomes, constructed phylogenetic trees from genome databases using MacClade 4 and PAUP* software, and tested the effects of spices and antibiotics on different kinds of bacteria.

I spend very little in-class time on preparation for the AP Exam other than to discuss some test-taking strategies. I give my students all of the AP Biology Released Exams since 1986, one at a time, over the course of the year. They take each exam at home and I grade them using the scoring guidelines, returning the exams with the correct answers marked. I tell my students to look at the questions they missed and figure out why they missed them. When they have finished one Released Exam, I give them another to work on at home.

Course Planner

I organize my course into 11 units and distribute the following syllabus to my students on the first day of class, telling them it is their homework for the year. We spend about two to three weeks on each unit.

AP Biology Syllabus

Dates	Unit	Topics	Chapter Readings
First Semester, First Term			
Sept. 12–30	1	Ecology and Behavior *First-Term Project:* Radish Seed Experiment	50, 51, 52, 53, 54, 55
Oct. 3–21	2	Atoms and Molecules, Bonds, Water, Carbohydrates, Lipids, Proteins, Nucleic Acids, Enzymes	2, 3, 4, 5, 6
Oct. 24–Nov. 10	3	Cells, Cell Membranes, Transport, Cell Communications	7, 8, 11
Second Term			
Nov. 14–Dec. 2	4	DNA Structure and Replication, DNA → RNA → Protein, Protein Synthesis, Viruses, Bacterial Genetics, Biotechnology *Second-Term Project:* Original DNA/Genetic Code Papers Presentation	16, 17, 18, 19 (pp. 356-68), 20
Dec. 5–23	5	Cell Respiration and Photosynthesis	9, 10
Jan. 3–27	6	Mitosis, Meiosis, Classical Genetics *Third-Term Project:* Human Karyotype Construction (completed and graded during the third term)	12, 13, 14, 15, 19 (pp. 354-56)
Second Semester, Third Term			
Jan. 30–Feb. 17	7	Evolution	22, 23, 24, 25, 26
Feb. 27–Mar. 17	8	Three Domains, Phylogenetic Trees, Prokaryote and Eukaryote Diversity, Animal Phylogeny and Diversity, Animal Development	21, 27, 28, 32, 33, 34, 47
Mar. 20–Apr. 7	9	Plants	29, 30, 35, 36, 37, 38, 39
Fourth Term			
Apr. 24–May 19	10	Digestion, Circulation, Gas Exchange, Homeostasis (excretory systems), Immune System	40, 41, 42, 43, 44
May 22–June 22	11	Hormones and Reproduction, Nerves, Muscles, Sense Organs *Fourth-Term Project:* Owl Pellet Investigation	45, 46, 48, 49

Lab Schedule

I have accumulated labs from innumerable sources during what I describe as my wanderings. I attend as many conventions, meetings, AP Readings, conferences, and other professional development events as possible. From each one I gather a variety of labs and handouts that I modify for my course; this has added up to a wealth of specially tailored resources over my 34 years of teaching. I share with other teachers and am always on the lookout for new and interesting things to do with my students. I encourage all new AP Biology teachers to do the same: go to as many meetings as possible, participate in the AP Biology Electronic Discussion Group, and meet other AP Biology teachers.

Since my AP Biology course is a first-year course, I also include souped-up versions of labs that would normally be done in a first-year non-AP course, such as basic microscope work or testing for carbohydrates, sugars, lipids, and proteins using the iodine, Benedict's, brown paper bag, and Biuret Test respectively. Company contact information for most of the supplies and kits used in the following lab schedule can be found in the resources section of chapter 5.

Unit 1

- *Dissolved O_2*

  Students complete AP Lab 12, Exercise 12A, "Dissolved Oxygen and Temperature."

- *Choice Chambers*

  Students complete AP Lab 11, Exercise 11A, "General Observation of Behaviors."

- *Biological Magnification*

  Students magnify the amount of poison per gram of tissue in this lab I developed.

- *Biomes*

  Students examine biomes in this lab I modified from an old Heath lab manual.

- *Winogradsky Column*

  I use the Winogradsky Column Set (70-3490) from Carolina Biological Supply Company to illustrate the variety of microbes present in the pond mud samples students bring in.

Unit 2

- *Acids, Bases, and Buffers*

  In this lab, which I modified from a similar one in *BSCS Biology: An Ecological Approach* (Green Version), students test various substances to determine how resistant they are to changes in pH.

- *Molecular Models*

  Students use the "Design Your Own" Custom Molecular Model Kit 530A from Lab-Aids to build fatty acids, fats, amino acids, and simple proteins using molecular models.

- *Enzyme Catalysis Activity*

  Students complete AP Lab 2, "Enzyme Catalysis."

Unit 3

- *Use of the Microscope/Microscopic Measurement*

  Letter e, starch grains, cork, onion, cheek, Elodea. This is a lab that can be found in virtually all lab manuals.

- *Prokaryotic versus Eukaryotic Cells*

  A comparison of Elodea (a plant) and *Anabaena* (a cyanobacterium, a prokaryote). I wrote this lab because I wanted a lab reinforcement for the difference between prokaryotic and eukaryotic cells. *Anabaena* with heterocysts and akinetes are available from Carolina Biological Supply Company, Cyanobacteria Cultures (15-1710).

- *Examining Protists*

  Amoeba, *Euglena*, *Paramecium*, *Stentor*, *Blepharisma*. For this teacher-generated lab I use single demoslide tubes containing *Amoeba*, *Paramecium caudatum*, *Chilomonas*, *Euglena gracilis*, *Stentor*, and *Volvox* from Connecticut Valley Biological Supply Company (LD 12–Mixed Protozoa).

- *Diffusion and Osmosis*

  Students complete AP Lab 1, "Diffusion and Osmosis."

- *Cell Membrane Model Building*

  Working in pairs, students build a model of a cell membrane, a phospholipid bilayer. They bring their finished phospholipids to a table and we arrange a bilayer representing a cell membrane. I wrote this lab and use the "Design Your Own" Custom Molecular Model Kit 530A.

- *Cell Size and Diffusion*

  Students cut potato cubes 1, 2, and 4 cm on one side and soak them in purple grape juice overnight. The next day they cut the cubes open and observe that in 24 hours the purple has only penetrated by diffusion about 1 mm. This explains why cells are small, because diffusion is very efficient over small distances but very inefficient over long distances. This is a lab I extensively modified from an old lab manual.

- *Properties of Water*

  How many drops of water can fit on a penny? We also do simple demonstrations of capillary action in this teacher-generated lab.

Unit 4

- *Transformation*

  This lab uses the pGLO Bacterial Transformation Kit from Bio-Rad Laboratories (catalog number 166-0003EDU). All of the information for doing it is in the kit.

- *Gel Electrophoresis*

  Students complete AP Lab 6, "Molecular Biology."

- *DNA Extraction from Onion Cells*

  Students extract DNA from onion cells in this lab, which comes from an old in-house write-up.

- *Genome Databases*

  I have developed a series of bioinformatics tutorials designed to introduce students to the genome databases, MacClade 4 (a program for aligning genome sequences in different organisms), and PAUP* (a program for finding phylogenetic trees from sequences aligned in MacClade).

- *Phagehunting Project*

  My class was involved in the Phagehunting Project sponsored by the Bacteriophage Institute at the University of Pittsburgh during the 2004–2005 and 2005–2006 school years. Students brought in soil samples and isolated 19 new phages. One of these was purified at the University of Pittsburgh and its genome was sequenced there. This gave us the opportunity to annotate part of the genome. About 12 students from two classes worked on this phage as part of their science fair research project. Two of these students are continuing to work on two of the other phages at the Franklin W. Olin College of Engineering in Needham, Massachusetts, for a summer internship with Dr. Helen Donis-Keller. We hope to continue this project in the future.

Unit 5

- *Photosynthesis*

  Students complete AP Lab 4, Exercise 4B, "Photosynthesis/The Light Reaction."

- *Cell Respiration*

  I do a modification of AP Lab 3 ("Mitosis and Meiosis") that also involves enzyme specificity. Lactose and melibiose are both disaccharides consisting of galactose + glucose. In lactose, there is a beta linkage between the monosaccharides, in melibiose there is an alpha linkage. Therefore, lactose can be digested by Lactaid® (beta-galactosidase) and melibiose can be digested by Beano® (alpha-galactosidase). Since yeast can grow on glucose, but not on lactose or melibiose, yeast will only grow in test tubes that have had lactose + Lactaid or melibiose + Beano added to them. The sole disadvantage of this lab is that melibiose (available from Sigma-Aldrich) is very expensive.

- *Plant Pigment Chromatography*

  Students complete AP Lab 4, Exercise 4A, "Plant Pigment Chromatography."

- *Examining Stomates in Zebrina Leaves*

  I keep a Zebrina plant in my room all year. This lab, which I modified from a handout another teacher gave me, is very effective since stomates appear a brilliant green against a purple background.

- *Examining Xylem*

  Students put celery (about one-inch lengths of stalk) in red food coloring and watch the food coloring move up the xylem in this lab I developed.

Unit 6

- *Fruit Fly Lab*

  Students complete AP Lab 7, "Genetics of Organisms."

- *Mitosis and Meiosis*

  Students complete AP Lab 3, "Mitosis and Meiosis."

- *Probability I*

  Students flip a coin 100 times in groups of 10 to show that in probability, as numbers become larger, you more closely approximate your predicted ratio. This is a homework assignment. I adapted this lab from one I found in Albert Kaskel's *Laboratory Biology: Investigating Living Systems*, now out of print.

- *Probability II*

  Students do an M&M's® and chi-square lab that I modified from a lab some teachers on the AP Biology Electronic Discussion Group gave me.

Unit 7

- *Hardy-Weinberg Law of Genetic Equilibrium*

  Students complete AP Lab 8, "Population Genetics and Evolution."

- *Timeline*

  Students create a timeline—1,000 mm of time. This is a lab I found in an old lab manual and extensively modified.

- *Living Sands: Mapping Time and Space with Forams*

  Designed by Lynn Margulis and Lois Brynes, this packaged lab is an excellent introduction to how foraminiferans are used to date fossils in areas where there are no volcanic tuffs. It is available as a kit (E2-20-2213) from Neo/SCI. If you are careful with it, the kit can be used year after year by putting the sands in small petri dishes that can be reused indefinitely.

- *Green River Formation Fossils*

  The Green River Formation in Kemmerer, Wyoming, contains billions of fossil fish from the Middle Eocene epoch, 55 million years ago. I obtain unprepared fish from Antares Fossils and Minerals in Evanston, Wyoming, and have my students prepare these fish in class. I also show them *Fossil Lake*, a short video that describes the Green River Formation and has excellent footage of the area and some of the most spectacular fossils that have been found there.

Unit 8

- *Earthworm Dissection*

  Earthworm dissection labs can be found in most lab manuals.

- *Crayfish Dissection*

  Students follow this lab I wrote for dissecting crayfish.

- *Examining Choanoflagellates*

  I am in the processing of developing activities involving Choanoflagellates, the organisms most closely related to animals. This is an excellent opportunity to discuss animal origins and the genes that evolved to make the animal body plans possible. Because Choanoflagellates are too small to be seen with regular student microscopes, I use still pictures from the Web site that is maintained by Dr. Nicole King, an assistant professor of genetics and development at the University of California, Berkeley's Department of Molecular and Cell Biology.

Unit 9

- *Transpiration*

  Students complete AP Lab 9, "Transpiration." For simplicity, I buy tomato flats and use them rather than growing plants from seeds.

- *Flower Dissection*

  Flower dissection labs can be found in most lab manuals. I use one from an old edition of the *Modern Biology* textbook. I make sure students see pollen grains and ovules.

- *Fruits*

  Most lab manuals include a fruit seed lab. I emphasize that each seed came from a fertilized ovule.

Units 10 and 11

- *Pulse Rates*

  Students complete AP Lab 10, Exercise 10A, "Measuring Blood Pressure," and Exercise 10B, "A Test of Fitness."

- *Daphnia*

  I use a cricket chirp lab (available from Cricket Science) for the *Daphnia* part of Lab 10 in the AP Lab Manual (Exercise 10C, "Heart Rate and Temperature"). This is a cassette tape with real cricket chirps at different temperatures. Students count the number of chirps per minute at different temperatures, graph their results, and then calculate the temperature of three unknown cricket chirps. There is a nice correlation between temperature and chirps per minute (more chirps at a higher temperature).

- *Fetal Pig Dissection*

  Students do a thorough fetal pig dissection after the AP Exam. I developed this lab many years ago from a book I borrowed from MIT University's library. Fetal pig dissection labs can be found in most lab manuals, however.

Teaching Strategies

In general, when I am not doing the labs and activities described in this syllabus, I am lecturing. My goal is to explain things really clearly so that my students can read their textbook productively. Without clear lectures, this textbook, or any college textbook, is overwhelming to a high school student. The fact that Campbell is both accurate and relevant is an enormous advantage to me.

I expect students to spend an hour a night (or five hours on the weekend) reading and taking notes on the textbook according to their syllabus. It is not unusual for a student to begin the course shakily and mature academically as the year goes on. Many students tell me that my course was the one that taught them how to read a textbook and study successfully at the college level.

Because I have to cover two years of biology in one, I find it is necessary to type out my notes, distribute them to the students, and then read from them (interactively, of course) in class. In this way, we basically cover two days of work every day. These notes were an enormous amount of work to put together, but now they are a treasure. I simply update the ones that need updating, and teach. I find that the clarity of the notes is helpful for my students. When I taught AP Biology as a second-year biology course, I did not have to do this and could simply lecture and have students take notes from the overhead projector as I went along.

In order to weed out endless terms, I teach around three themes: the cell theory, DNA, and evolution. I try to bring up evolution in every unit by using the phylogenetic trees I have developed over the last few years (see the student activities section of this syllabus for an example). When we do cell respiration, for instance, I point out that the fact that glycolysis is found across all three domains (Bacteria, Archaea, Eukarya) means it was present in the universal ancestor who lived 3.3 to 3.5 billion years ago. The fact that the genetic code is universal (the same genetic code in all three domains) is also powerful evidence for evolution.

Meiosis evolved about 1.4 billion years ago in the common ancestor of animals, plants, and fungi, as well as slime molds, ciliates, and other organisms. Oxygen-producing photosynthesis evolved once in the common ancestor of cyanobacteria, and chloroplasts are the product of an endosymbiotic event in which an early plant ancestor engulfed a cyanobacteria about 1 to 1.2 billion years ago. This kind of teaching helps students understand that life has a history and there is an underlying unity to life that is best explained by evolution.

Occasionally, parents of students or a junior scientist from the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts, will come to give a guest lecture. These are mainly for enrichment, though; I cover the basic curriculum.

Lab Component

I share a self-contained classroom with one other teacher. We have sinks and gas jets in the room as well as basic lab equipment like microscopes, glassware, dissection materials, a few dissecting microscopes, an incubator, and two illuminated plant stands. We also have access to four carts of Apple iBook™ laptop computers; there are 10 iBooks with wireless Internet connection on each cart.

Working in pairs, students do almost every lab exercise in the *AP Biology Lab Manual for Students*. They also do a variety of labs I have written myself or modified over the years from sources too numerous to be named. Field labs are not a part of this course.

Students do a lab every week, and they are required to turn in some kind of write-up for each one. These write-ups vary depending on the lab. For many labs, like model building, I simply check off that the students have completed the lab. Some labs require only a well-organized data summary and brief conclusions. Others, such as dissections and microscope labs, merely consist of a well-drawn diagram of what students saw. For labs that come from the AP Lab Manual, students must complete the graphs and answer the questions in the manual. The independent research project includes a full lab report. I give students very specific directions for making graphs and data tables and drawing scientific diagrams, and I ensure they do these tasks properly.

Students have two days from the completion of a lab to turn in their reports. I emphasize excellent presentation of data and discussion of results over length. I also try to minimize busy work by not requiring students to write out detailed methods for a lab for which I have provided a detailed procedure.

Student Evaluation

I strongly believe that students should be encouraged to take AP Biology. To make this a reality, I have configured my grading so that any student with reasonable reading and concentration skills and who is willing to work hard will be successful in the course. To this end, my unit tests consist of two equally weighted parts: multiple-choice questions and free-response questions.

- **Multiple-Choice Questions.** The first part of each test consists of approximately 50 multiple-choice questions from the test bank that accompanies the textbook. This forces students to read their textbook and it rewards the truly outstanding students, a few of whom consistently score over 80 percent or even over 90 percent on these tests.
- **Essay Questions.** I have all of the free-response questions from the last 20 years of AP Biology Exams arranged by unit (I did this many years ago and just add to it every year). At the beginning of each unit, I give students all of the old AP Exam questions that are relevant to that unit. For the second part of the unit test I choose one of these questions and require students to answer it, closed book, in class. I use the AP Exam scoring guidelines to grade it. As a result, any student who takes the time and effort to prepare answers to all of the essay questions will be assured of an A on half of the test.

Quizzes in my course are really glorified homework assignments. For example, students draw a dipeptide if I draw a typical amino acid on the board. I announce quizzes in advance. Students take a final exam at the end of the year, but I do not give semester exams.

Unit tests count for approximately 65 percent of students' final grade for the year. The independent research project counts for approximately 10 percent. The four term projects count for approximately 10 to 25 percent. Lab reports, homework, and quizzes together count for approximately 10 to 15 percent.

Teacher Resources

Textbook

Campbell, Neil A., and Jane B. Reese. *Biology*. 6th ed. San Francisco: Benjamin Cummings, 2002.

Taylor, Martha R. *Student Study Guide*. 6th ed. San Francisco: Benjamin Cummings, 2002.
This student resource accompanies the Campbell text.

Selected Sources for Labs

BSCS Biology: An Ecological Approach. Green Version. 6th ed. Dubuque, Iowa: Kendall/Hunt, n.d.

The College Board. *AP Biology Lab Manual for Students*. New York: College Entrance Examination Board, 2001.

Kaskel, Albert. *Laboratory Biology: Investigating Living Systems*. Columbus, Ohio: Charles E. Merrill, 1983.
This book is out of print but may be available through online used book sources or from the professional collections of longtime AP Biology teachers.

Multimedia

Anderson, Robert C. *Myths and Science of Cricket Chirps*. Audiocassette. N.p.: Cricket Science, 1993.

Fossil Lake: Paleontology and Preparation at Fossil Butte National Monument. VHS. N.p.: Dinosaur Nature Association, 1991.
This 17-minute video is available from the Intermountain Natural History Association, www.inhaweb.com/videos.html or 800 845-3466 (product number W1443).

Software

Maddison, David R., and Wayne P. Maddison. *MacClade 4: Analysis of Phylogeny and Character Evolution*. CD-ROM. Sunderland, Mass.: Sinauer, 2000.

Swofford, David L. *PAUP*: Phylogenetic Analysis Using Parsimony (and Other Methods), 4.0 Beta*. CD-ROM. Sunderland, Mass.: Sinauer, 2002.
For more information about PAUP* and MacClade 4, visit the Sinauer Web site, www.sinauer.com.

Web Sites

Intel Science Talent Search
www.sciserv.org/sts/
Visit this Web site for information about the contest and how to enter it, as well as to get entry forms, instructions, and the names of recent winners.

King Lab
http://mcb.berkeley.edu/labs/king
Dr. Nicole King's Choanoflagellates Web site has good still pictures.

Massachusetts Science Fair
www.scifair.com
This is a good source for ideas for independent research projects.

National Center for Biotechnology Information
www.ncbi.nlm.nih.gov/
I use this Web site for the genome database lab in Unit 4.

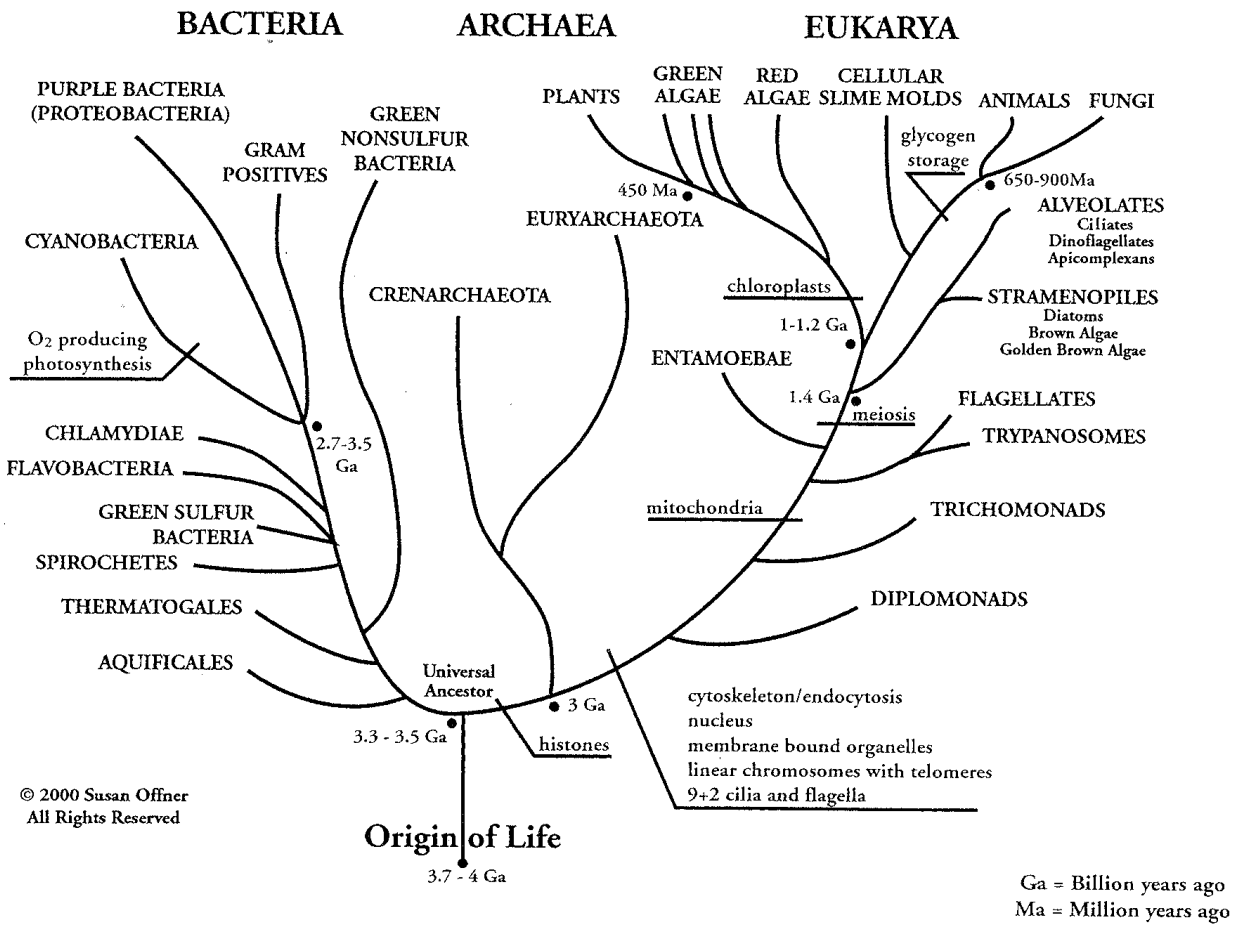
Student Activities

First-Day Activity

I have developed and published plain English maps of the human and fruit fly chromosomes, as well as a universal phylogenetic tree, that I use with my class. A good first-day activity is to give students the human and fruit fly maps and ask them to find 10 genes that are on both maps. After my students have done this, I point out that, in fact, humans and fruit flies share thousands of genes and, since humans and fruit flies have not had a common ancestor in at least 543 million years, these genes have to be at least that old. We also discuss the functions of some of these genes. I can then show students how these genes have to go back before the Cambrian explosion, 543 million years ago. By this time, Arthropod and Chordate lineages had already separated. This brings up evolution on the very first day of class.

I use both the maps and the tree extensively throughout the year, after having introduced them during the first day of school. Science Kit® and Boreal® Laboratories carries all three posters along with related student resources: the Human Chromosome Map and Study Kit (WW4517601), Plain English Map of *Drosophila* Chromosomes (WW4563501), and Three Domains of Classification: A Phylogenetic Tree Study Kit (WW4785301).

Universal Phylogenetic Tree



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Term Projects

Each term students complete a project that requires them to do independent work and turn in a report.

- **First Term: Radish Seed Experiment (Unit 1).** Students design and carry out an experiment at home that tests whether radishes grow better in the light or the dark. This project gives students a chance to learn the elements of experimental design, as well as how to make graphs and tables for data presentation. Students submit a written lab report, and I grade them on their experimental design and their presentation and discussion of data.
- **Second Term: Original DNA/Genetic Code Papers (Unit 4).** Students read one of the original papers on the discovery of DNA or the genetic code and give an oral presentation to the class. This is the only project that students do in groups, and they hand in their written reports after their presentations.
- **Third Term: Human Karyotype Construction (Unit 6).** Students prepare a human karyotype on paper at home, which is much more effective than just manipulating chromosomes on a Web site. There are several sources for chromosomes; I use an old set I obtained from Parco, which has since gone out of business.
- **Fourth Term: Owl Pellet Investigation (Unit 11).** Students spend several weeks working on an owl pellet in the lab after the AP Exam. They are required to reconstruct the skeletons of all the animals the owl ate that are present in its pellet. This is an excellent opportunity for me to teach students about the skeleton, comparative anatomy, and homology among mammals, as well as scientific reasoning (e.g., how do you know how many animals the owl ate?). This project serves as an interesting and relaxing ending to a very hectic year. I use the instructions and charts that come with the pellets, plus handouts I have collected from various colleagues over the years. We get our pellets from Pellets, Inc., though most supply companies sell them.

Syllabus 4

Marguerite A. Graham
Gulliver Preparatory School
Pinecrest, Florida

School Profile

School Location and Environment: Gulliver Preparatory School is one of the five Gulliver Schools in Miami, Florida. The school enjoys the quiet beauty of a prestigious residential community while having access to the cultural amenities of greater Miami. It is in close proximity to the University of Miami, Miami-Dade Community College, and Florida International University. All three participate in the school's dual enrollment program, which allows Gulliver students to earn college credits. Its enviable location enables the school to draw students from all sections of Miami's metropolitan area and enroll international youngsters whose parents are involved in the community's rich economic and cultural life. Gulliver is proud that its student body, which includes students from over 40 countries, reflects the multiethnic and multiracial character of South Florida. In this school, English is often a second language for students.

Grades:	9–12
Type:	Private high school
Total Enrollment:	Approximately 650 students
Ethnic Diversity:	Hispanics comprise 31 percent of the student population; African Americans, 3 percent; Asian Americans, 2 percent; and others, 7 percent.
College Record:	One hundred percent of the graduating seniors go on to attend four-year colleges or universities.

Personal Philosophy

I enjoy teaching biology because I see it as an opportunity to encourage students to make a difference in this world. I see everything as connected to biology in some way, so I orient my teaching to help students make correct decisions about the environment and their health, and to see that their decisions can and will affect others. I also like to highlight the cultural differences in the naming of plants and animals, as well as in customs, because it includes everyone in my ethnically diverse class. I always say to them that I expect to see their names up there in lights making a difference when I am old and gray and sitting in my rocking chair.

Class Profile

Gulliver's science sequence is biology in the ninth grade, chemistry in the tenth grade, and in the eleventh grade, honors students may take either honors physics, AP Biology, or AP Chemistry. Taking physics as a junior allows the strong math students the option of taking AP Physics as seniors. Many juniors choose AP Biology because they prefer not to take such a demanding and rigorous course when they are seniors. The majority of the students are seniors, however, because they have taken the mandated biology and chemistry courses, as well as physics. As an advanced placement course at Gulliver, AP Biology generates two bonus points to a student's grade-point average.

Gulliver usually offers two sections of AP Biology, with 16 being the maximum number of students per section. Only one section is offered if fewer students enroll. The typical class size is between 12 and 14 students.

The school day is long, running from 7:50 a.m. to 4:00 p.m. In this time we teach five 45-minute periods and have three periods for planning. The AP Biology course is scheduled for a double period every day. I have the flexibility of using my classroom for both labs and lectures because it has lab tables. The room is a bit on the small size, but the school is generous in providing equipment and supplies, and I have most of the things I need to do the labs. I share the room with other teachers, so my labs must be set up after school, early in the morning, or on weekends.

Course Overview

My AP Biology course has been influenced by the *PAK: Individualized Biology* workbooks by Dr. Marvin Druger. Although I no longer use these workbooks, I have adapted my program to follow a similar sequence to that of the workbooks. My main goals are for my students to have a good understanding of the concepts in biology and a grasp of its relevance to themselves and society. I also aim to promote self-learning among my students.

I usually begin the year with taxonomy/phylogeny followed by evolution and ecology, concepts that establish the big picture of this wonderful biosphere. Students already know a little about these concepts, and at this point in the school year they are relaxed and it is easy to hook them into the course. By the time I get into difficult biochemistry, it is too late to drop the course so they stick with it and continue to enjoy it.

In order to cover so much information, I must be very organized and stick to the deadlines I have set. I provide my students with several planning tools.

- **Course Schedule.** At the beginning of the school year I give students a course schedule for the whole year. It indicates the time allocated for each topic and the dates of the unit tests. The course schedule, annotated for this Teacher's Guide, can be found in the course planner section of this syllabus.
- **Monthly Calendars.** These give students a time frame for the readings, indicate the chapters I plan to cover in lectures, and give the dates for the unit tests. A sample calendar for September immediately follows the course schedule.
- **Reading and Lecture Guidelines.** There is a lot of material to cover during the lectures and class discussions, so I give my students handouts throughout the year. These can be detailed notes or a mixture of notes and spaces for students to fill in during class. I provide them with reading guidelines for most of the textbook chapters. I also give them lecture guidelines so they can follow along as I lecture and make notes directly on the guidelines. I have found that such handouts help students participate more in class discussions; instead of concentrating on writing detailed notes, they are more focused on trying to understand the topics and concepts (sample reading and lecture guidelines can be found in the sample guidelines section of this syllabus).

The textbook for the course is the seventh edition of Neil A. Campbell and Jane B. Reece's *Biology*. Students also use the *AP Biology Lab Manual for Students*.

Course Planner

The school year begins in mid-August and ends in late May. The first semester begins with orientation and a discussion on how to use the Campbell textbook before we move to themes of biology.

Unit 1. Survey of Animals/Protists and Classification Concepts (2 weeks)

Readings

- Themes of biology, chapter 1
- Animal survey and classification, selected readings from chapters 25.2–25.3, 24, 26.6, 28, 31, 32, 33, 34

Class Activities

- Review terms like *prokaryotic/eukaryotic* and *autotroph/heterotroph*, and terms used in classification and the formation of phylogenetic trees, like *symmetry*, and types of coelom
- Receive outline notes and guidance on the textbook readings and the major phyla
- Observe specimens and practice placing the organisms on the phylogenetic trees

Labs

- Hydra/Planaria behavior lab (this is described in the student activities section of this syllabus)
- *Daphnia* (AP Lab 10, Exercise 10C)
- Microscope use and measurement (this lab can be found in most lab manuals)
- Itty-bitty city lab (this is described in the student activities section of this syllabus)

Unit 1 test on survey of animals/protists and classification concepts

Unit 2. Evolution and Past Diversity of Life (2 weeks)

Readings

- Evolution, chapters 22–25
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Historical background behind Darwin's theory; voyage of the *Beagle*
- Evidences for evolution
- Evolution in action today
- Modern synthesis, population genetics, Hardy-Weinberg law of genetic equilibrium, problems
- Natural selection, microevolution events, types of selection, preservation of variation
- Speciation, prezygotic and postzygotic isolating mechanisms, allopatric and sympatric speciation
- Gradualism/punctuated equilibrium
- Fossil record, extinctions, dating of fossils

Lab

- Population genetics and evolution (AP Lab 8)

Class Activity

- At the end of the unit watch the video *The Odyssey of Life: The Ultimate Journey*, which supports the concepts in the lecture and notes

Unit 2 test on evolution

Unit 3. Ecology (2 weeks)

Readings

- Ecology, Chapters 50, 52–55
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Biomes: aquatic and terrestrial biomes and the factors that influence them
- Community ecology, ecological succession, soil and its role in succession
- Ecosystem ecology, trophic structure, and productivity
- Population ecology

Independent Work

- Students use the Internet and chapter 50 in their textbooks to find the latitude, temperature range, rainfall, flora, fauna, and anything that is unique about their assigned biome. They provide their classmates with a one-half- to one-page handout and give a presentation that lasts for five minutes or less. In order to speed things along, and because I know students covered biomes in their first-year biology course, I make this a two-day assignment.

Lab

- Dissolved oxygen and aquatic primary productivity (AP Lab 12). Students have the weekend to complete a lab write-up (to be counted as a test grade) for this lab.

Unit 3 test on ecology

Unit 4. Animal Behavior (1 week)

Topics and Readings

- Students read chapter 51 and watch videos on behavior like *Konrad Lorenz: Science of Animal Behavior* or National Geographic's *Search for the Great Apes*.

Lecture Topics

- Instead of a formal lecture, this week we discuss concepts of behavior.

Independent Work

- Students use their textbook and the Internet to answer assigned questions about famous animal behaviorists and concepts. This activity provides the background for the pill bug lab (AP Lab 11, Exercise 11A). (See the student activities section of this syllabus for a description of the famous animal behaviorist assignment.)

Labs

- Animal behavior (AP Lab 11). Because this lab has all the components of the scientific method, I give it a higher weighting than a test grade.
- "Be a Behaviorist for a Day" field trip to Monkey Jungle in Miami. Monkey Jungle is a 30-acre preserve with about 400 primates (go to www.monkeyjungle.com for information about this facility). Students have the weekend to complete a lab write-up (to be counted as a test grade) for this lab.

Unit 5. Cell and Cell Functions (3 weeks)

Readings

- Architecture of cells (includes bacteria and viruses), chapters 7, 27, 18
- How substances get into cells, chapter 8
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Architecture of prokaryotic cells and eukaryotic cells: comparing structures
- Cell wall of bacteria and plants
- Organelles; emphasis on mitochondria and chloroplasts
- Membrane structure and function, transport across the membrane
- Bacteria reproduction and nutritional modes
- Bacteria: classification and their roles, both harmful and beneficial
- Viruses: basic virus structure, reproduction
- AIDS and other important viruses
- Viroids, prions, emerging viruses

Labs

- Diffusion and osmosis (AP Lab 1)
- Examination of different cell types (this lab can be found in most lab manuals)
- Gram-staining techniques and the effect of antibiotics on bacteria (this lab can be found in most lab manuals)

Class Activity

- Close with a video on bacteria/viruses (I choose something that can show the uses of this diverse group)

Unit 5 test on cells and cell function, bacteria, and viruses

Unit 6. Biochemistry (2 weeks)

Readings

- Chemical basis of life, protein and enzymes, chapters 2–5
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Elementary principles of inorganic chemistry (e.g., atoms, molecules, etc.)
- Role of water and carbon and the functional groups
- Macromolecules: carbohydrates, lipids, proteins, nucleic acids
- Proteins and enzymes
- The closing lecture is a demonstration of the food tests used to identify the different organic compounds (they have all done this in their previous biology course)

Independent Work

- The origin of life (chapter 26). I spend about a day tracing the historical development of ideas concerning the origin of life and current views of the origin of life and the experimental evidence that supports these views. Students learn more about the origin of life by reading the chapter in their textbook and answering the guided questions I provide. This independent class work appears 10 weeks into the first semester because it is at this point that students have an understanding of organic molecules and can appreciate the molecular evolution concepts that are used to explain the origin of life.

Lab

- Enzyme catalysis (AP Lab 2)

Unit 6 test on biochemistry and the origin of life

Unit 7. Biotechnology (2 weeks)

Readings

- Biotechnology, chapters 19 and 20
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- DNA historical background, experimental evidence
- DNA structure
- DNA replication in detail, experimental evidence
- Protein synthesis, transcription, and translation
- Mutations
- Biotechnology techniques: cloning, PCR, principles of electrophoresis, RFLP analysis

Lab

- DNA extraction, transformation, and electrophoresis (AP Lab 6)

Unit 7 test on biotechnology

Unit 8. Reproduction (1 week)

Note: Reproduction is divided into two parts. Unit 8 covers mitosis and meiosis, because these processes set the stage for understanding embryology and development. Mitosis and meiosis are tested on the first semester exam. Unit 9 covers human reproduction and embryology.

Readings

- Reproduction: mitosis and meiosis, chapters 12 and 13
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Significance of mitosis and meiosis
- Cell cycle
- Mitosis in plants and animals
- Meiosis in plants and animals
- Chromosomal abnormalities due to non-disjunction
- Cancer

Lab

- Mitosis and meiosis (AP Lab 3)

First semester exam

Winter Break (the second semester begins after the break)

Unit 9. Reproduction and Embryology (2 weeks)

Note: The human system is included here because it fits into this sequence of teaching and makes a nice closure by bringing in the significance of mitosis and meiosis to reproduction.

Readings

- Reproduction: human reproduction and embryology, chapters 45 and 46.
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Basic embryological terms
- Comparison of development stages in echinoderm, frog, chicken, and human
- Extra embryonic membranes in chicken and human, and their importance

- Human anatomy, male and female
- Menstrual cycle
- Human development to birth

Lab

- Chick embryology lab. This lab gives me a chance to discuss amniotic eggs and their significance to evolution. I incubate about two-dozen eggs, opening them for the first four days to show students the stages of development and leaving the rest to hatch so students can enjoy the baby chicks. This lab continues into genetics.

Class Activity

- Students watch the video *Chick Embryology*.

Unit 9 test on reproduction and embryology

Unit 10. Genetics (2 weeks)

Readings

- Genetics, chapters 14 and 15
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Mendelian genetics, probability, segregation, independent assortment
- Non-Mendelian patterns, codominance, pleiotropy, epitasis, polygeny
- Human genetics, pedigree analysis
- Sex linkage, autosomal linkage, linkage maps
- *Drosophila* genetics, setting up a cross
- Chi-square
- Eukaryotic chromosome
- Control of gene expression, *lac* Operon

Class Activity and Assignment

- Students solve several problems from the ends of chapters 14 and 15 for homework. We go over the problems in class, with students writing the hardest ones on the board. Students teaching students is a very effective teaching strategy; my role is to help only when difficulty arises. These problems give them good practice.
- The unit closes with a research assignment on different inherited diseases (a description of this assignment can be found in the student activities section of this syllabus).

Lab

- *Drosophila* (AP Lab 7). Students have the weekend to complete a lab write-up (to be counted as a test grade) for this lab.

Unit 10 test on genetics

Unit 11. Photosynthesis and Respiration (2 weeks)

Readings

- Photosynthesis and respiration, chapters 10 and 9
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Angiosperm leaf anatomy
- Chloroplast structure and function
- Light reactions/light-dependent reactions
- Light-independent reactions/Calvin cycle
- C3 and C4 cycles
- Overview of aerobic and anaerobic respiration
- Mitochondrion structure
- Glycolysis/Krebs cycle
- Chemiosmosis in respiration and photosynthesis

Labs

- Plant pigments and photosynthesis (AP Lab 4). Students have the weekend to complete a lab write-up (to be counted as a test grade) for this lab. Sometimes I have them write a lab report for the cell respiration lab instead.
- Cell respiration (AP Lab 5)

Unit 11 test on photosynthesis and respiration

Unit 12. The Plants (2 weeks)

Readings

- The plants, chapters 29, 30, 35, 36, 27, 38, 39
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Alternation of generations
- Angiosperm structure and growth

- Angiosperm reproduction and development
- Plant control systems

Lab

- Transpiration (AP Lab 9)

Class Activity

- This topic has a "look, see, feel format," and I bring in specimens of flowers and do a simple lab to show the floral anatomy when I am teaching plant reproduction.
- Students usually do some basic planting activities like stem cuttings and planting a seed. They generally enjoy this because they are city kids and know very little about how things grow.
- Videos like *Sexual Encounters of the Floral Kind* close the unit.

Unit 12 test on the plants

Spring Break

Unit 13. Animal Structure and Function (3–4 weeks)

Note: At this point in the course I am very short of time, so I provide notes and questions on each section to guide students on the depth of study and spend class time discussing what they have learned. I focus on teaching the heart and circulation, respiratory, and immune systems because I find doing so links everything together. I usually spend about a week on these concepts.

Readings

- All systems (human and animal), chapters 40–49
- Receive outline notes and guidance on the textbook readings

Lecture Topics

- Basic principles of anatomy, with an emphasis on mammalian systems
- Digestive system structure and function
- Heart and circulatory system
- Respiratory system
- Immune system
- Osmoregulation and the excretory system
- Endocrine system: homeostasis, sugar and calcium control, review of sex hormones
- Nervous system: plan of the nervous system, neuron structure, reflex arc, transmission of nerve impulse
- Muscular system: voluntary and involuntary muscles, muscular contraction
- Review of human reproduction and embryology

Labs

- Measuring blood pressure (AP Lab 10, Exercise 10A)
- Fitness test (AP Lab 10, Exercise 10B)

Unit 13 test on human systems

Unit 14. Review (1 week)

- Review for AP Exam

Closure Activities (1–2 weeks)

After the AP Exam I usually have a week or two for a fetal pig dissection lab. If I have just a week, students do just the dissection; if I have more than a week, I invite a forensic scientist to give a lecture or a doctor to talk about sexually transmitted diseases. I also show movies of interesting topics I did not get a chance to show earlier in the year. In the past my students have watched such films as *The Double Helix*, *Lorenzo's Oil*, and *Gattacca*; there are many good ones to fill the remaining time. These movies usually lead to some very lively discussions, which my students enjoy.

Sample Calendar

The following is a sample calendar detailing expectations and homework that I give to my students each month.

September

Sunday	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*
			1 (Unit 1 cont'd.) Microscope Lab: Itty-Bitty City	**2** Lab: Examine Hydra/Planaria	**3** Lab: Complete labs	**4**
5	**6** *Labor Day*	**7** Lecture: Animal Survey	**8** Lecture: Animal Survey	**9** **Unit 1 Test:** Animal Survey Begin Unit 2 tomorrow	**10** Read ch. 22; Evolutionary History, Evidence	**11**
12	**13** Read chs. 24 & 25; Speciation	**14** Lecture: Geological Time Scale, Extinctions	**15** Lecture: Punctuated Equilibrium/ Gradualism	**16** *No School*	**17** Lecture: To Be Announced	**18**
19	**20** **Quiz:** chs. 22–24 Video: *The Ultimate Journey*	**21** Hardy-Weinberg Problems	**22** AP Lab 8	**23** Review Unit 2	**24** **Test:** Evolution Begin Unit 3 on Monday, read ch. 50	**25**
26	**27** Lecture: Biomes	**28** Lecture: Community Ecology	**29** Lecture: Population Ecology	**30** AP Lab 12, Exercise 12A	Independent Biome Project	

AP BIO

Teaching Strategies

Most of my class time is spent in either lecture and class discussion or in lab activities. The lectures are supported by excellent visuals for most of the topics in the textbook. This is possible because I have an InFocus® projector, which allows me to connect to and present video and Internet sources, in my room. When it is unavailable, I use overhead transparencies. The main rule, I feel, is to diversify my presentation style so that lectures incorporate a "touch, see, and feel" format to keep them interesting.

At the beginning of the year I provide students with guidance on the reading by picking specific sections from each chapter for them to take notes on, because I have found that they waste time on unnecessary information otherwise. I also check their answers on the reading guidelines questions for a homework grade. This is my way of getting them to read and focus on important information. Although such guidance can be cut back in the second semester when students have learned how to cope with the reading, it is especially important if the teacher starts the year with taxonomy/phylogeny and a survey of the animals and protists as I do. There is so much information for these topics that students often get lost. Most of my lectures here are on the factors used in making phylogenetic trees (e.g., the basics of embryology, symmetry, origin of the eukaryotic cell, etc.). I support this with practice multiple-choice questions from AP Central, the Released Exams, and test preparation books to help students focus on what is important in the chapter sections I assign.

I rarely seem to have enough time for an in-depth review before the AP Exam. I use the topic outline in the *AP Biology Course Description* as a guide for review. I make sure that I also go over the objectives of the 12 labs in the *AP Biology Lab Manual for Students;* doing so gives students an opportunity to review the labs and the requirements of good lab design (e.g., variables, controls, etc.). I also prepare a packet of materials that includes multiple-choice and free-response questions from the Released Exams, and I advise my students use a test preparation book like *CliffsAP Biology* to help them in their review process. I discuss the format and how the exam is scored. I try to give at least one timed multiple-choice test so they can see that they remember more than they think; this is a good confidence booster.

Lab Component

I cover all of the labs in the *AP Biology Lab Manual for Students*, either exactly or modified to fulfill my course objectives. I also add several labs to support such concepts as microscopy and measurement, observations of cells, and selected microorganisms and plant-growth labs. I use the fifth edition of Judith Giles Morgan and M. Eloise Brown Carter's *Investigating Biology Lab Manual* for those labs that are not in the AP Lab Manual. Planting labs vary from year to year; sometimes we plant herb seeds and sometimes we plant stem cuttings. Sometimes I use Fast Plants® from Carolina Biological Supply Company to get students excited about plants.

I really like behavior so I introduce many of the concepts by doing lab activities like Hydra and Planaria labs. These are excellent subjects for teaching orientation behavior. They also give me an opportunity to lead a discussion on how these simple responses play a part in their survival and selection of habitat.

I manage to squeeze in one field trip each year. "Be a Behaviorist for a Day" is a lab that I designed that shows that behavior studies can be done even with limited time in the curriculum. After reading the textbook's behavior chapter and watching some videos for background, we go to Monkey Jungle, a local primate preserve, where students observe primate behavior using an ethogram. Afterwards they write a full lab report. This is a highly successful unit because the learning is different. It teaches students a lot about behavior and the way behavioral scientists work.

The double periods allow me to complete the course's lab activities. However, even with a double period it can be difficult to accomplish all the labs because the school has many unscheduled events that disrupt plans. When a lab cannot be done due to a scheduling conflict, I provide data and students work through the protocol from the Lab Bench section of their textbook's Web site.

On the day of the lab, if a lot of equipment is involved, I organize students into lab groups of no more than four and discuss the setup so they understand the equipment they will be using. I find this preliminary step is important because many of my students come to the AP Biology course with limited lab experience. Microscope labs are done individually.

Most of the time I have students end their labs by answering the questions in the lab manual or writing a brief evaluation (i.e., writing an analysis, conclusion, limitations, and recommendations) of the lab. When a full lab report is required, I instruct students to include the following elements: title, introduction/background information, purpose (the specific topic being investigated), procedure, data/results, analysis, conclusion, limitation, and recommendations. I give them the weekend to complete their lab reports, and I stress quality over length.

Setting up labs is the most difficult and time-consuming aspect of the course's laboratory component. In order to speed up the process, I prepare everything before a lab so no time is wasted. I buy kits whenever possible and keep the supplies in separate storage containers so that I can find everything easily. I usually have students read the lab the day before an experiment.

Student Evaluation

I use quizzes, homework, unit tests, major projects, lab reports, and research papers to evaluate my students' learning.

- **Quizzes and Homework (20%).** I give regular quizzes (one or two per unit) in the middle of a concept I am teaching. It is my way of keeping students on task. It also alerts them to what they should study for the upcoming unit test, which is more heavily weighted. I feel these quizzes have improved test performance. Students answer the questions on the reading guidelines for homework.
- **Unit Tests and Major Projects (50%).** Unit tests are composed of 50 to 60 multiple-choice questions and one essay question. The multiple-choice questions are a mixture of questions from the Released Exams and test preparation books; the essay questions are usually from the Released Exams. I typically give students the essay question first and time that for 20 minutes. I also generally give them an additional five minutes before they begin writing so they can outline their responses. Having the additional planning time has improved their answers tremendously. After I collect the finished essay part of a unit test, I pass out the multiple-choice part. My purpose for giving students the essay question first is to encourage them to be concise, to not overwrite, and to keep within their time limit. I use the AP scoring guidelines to grade the essay responses. My students are usually very well prepared for the AP Exam in May. I do not give a final exam because my students have just taken the AP Exam.
- **Lab Reports (30%).** Students complete and turn in at least four typewritten formal lab reports that carry the same weight as a unit test: dissolved oxygen and temperature (unit 3), primate behavior (unit 4), enzyme catalysis (unit 6), and photosynthesis (unit 11). The dissolved oxygen and temperature lab report and the animal behavior lab report both require introductions. The other lab reports often have different requirements, such as writing only an evaluation or answering the questions for a lab in the AP Lab Manual.

- **Research Papers.** Students write at least two research papers, which are weighted as a test grade. Topics are usually in genetics, biotechnology, or ecology. Sometimes I add another like I did recently when I had students read the September 2005 special issue of *Scientific American*, "Crossroads for Planet Earth." I asked them to evaluate the articles on the problems facing this planet and write their opinions of the current situation.

Teacher Resources

Books

Campbell, Neil A., and Jane B. Reece. *Biology*. 7th ed. San Francisco: Pearson, Benjamin Cummings, 2005.

The College Board. *AP Biology Lab Manual for Students*. New York: College Entrance Examination Board, 2001.

Druger, Marvin. *PAK: Individualized Biology Units 1–13*. 4th ed. Dubuque, Iowa: Kendall/Hunt, 1997.

Druger, Marvin. *PAK: Individualized Biology Units 14–18*. 3rd ed. Dubuque, Iowa: Kendall/Hunt, 1999.
Both of the PAK workbooks give teachers guidance on how to set up an AP course. The workbooks are available from Kendall/Hunt, www.kendallhunt.com (search for *Marvin Druger* on the publisher's Web site).

Morgan, Judith Giles, and M. Eloise Brown Carter. *Investigating Biology Lab Manual*. 5th ed. San Francisco: Benjamin Cummings, 2005.

Pack, Phillip E. *CliffsAP Biology*. 2nd ed. New York: Hungry Minds, 2001.

Paterson, J. D. *Primate Behavior: An Exercise Workbook*. 2nd ed. Long Grove, Ill.: Waveland Press, 1992.
This book is helpful for primate observations. It can be found on the publisher's Web site, www.waveland.com, or call 847 634-0081.

Senior Biology 1: Student Resource and Activity Manual. Hamilton, New Zealand: Biozone International, 2005.

Senior Biology 2: Student Resource and Activity Manual. Hamilton, New Zealand: Biozone International, 2005.
I use the 2004 editions, which are no longer available. The worksheets in these two publications are useful, especially for reviewing a concept. This resource can be found on the publisher's Web site, www.thebiozone.com.

Periodicals

These periodicals keep me in touch with new information I can incorporate into my teaching.

The American Biology Teacher
www.nabt.org
Available to members of the National Association of Biology Teachers.

Science News Online: The Weekly Newsmagazine of Science
www.sciencenews.org
A 16-page online weekly subscription newsmagazine.

The Science Teacher
www.nsta.org
Available to members of the National Science Teachers Association.

Scientific American
www.sciam.com

Videos

Chick Embryology. Bioscience Series. VHS. N.p.: National Geographic School Publishing, n.d.

Konrad Lorenz: Science of Animal Behavior. VHS. Washington, D.C.: National Geographic Society, 1985.

National Geographic Video: Search for the Great Apes. VHS. N.p.: Sony Pictures, 1975.

NOVA: The Miracle of Life. VHS. Written and produced by Bebe Nixon. Directed and produced by Bob Erikson and Carl O. Lofman. Boston: WGBH Educational Video, 1983.

The Odyssey of Life: The Ultimate Journey. VHS. Directed by Mikael Agaton. Boston: WGBH Educational Video, 1996.

Sexual Encounters of the Floral Kind: Intriguing Methods of Pollination. PBS Nature series. VHS. N.p.: PBS, 1983.
This is available from Ward's Natural Science (item number 193 V 0201).

The Trials of Life. VHS. With David Attenborough. N.p.: Turner Home Video, 1996.

Web Sites

Access Excellence @ The National Health Museum
www.accessexcellence.org
Click on the *Activities Exchange* button for excellent teacher-designed labs.

HHMI: Howard Hughes Medical Institute
www.hhmi.org
Good, general information on genetics and biotechnology is on this Web site.

Itty Bitty City: The Microscopic World in a Drop of Pond Water
www.accessexcellence.org/MTC/96PT/Share/graham.html
This is the step-by-step procedure of the lab exercise, including follow-up questions, that is described in the student activities section of this syllabus.

National Institutes of Health
www.nih.org
I find this Web site useful for genetics and biotechnology help.

PBS.org
www.pbs.org/teachersource/science_tech/high-evolution.html
Lesson plans and activities for teachers to use when teaching evolution can be found by going to *Teacher Resources* and clicking on *Science* and then on *Evolution*.

Woodrow Wilson National Fellowship Foundation's Leadership Program for Teachers
www.woodrow.org/teachers/
Click on *Teacher Resources* and then on *Biology* for good activities. "Hunting for the Elusive Amoeba," the soil activity I wrote, can be found by clicking on *1999 Biology* and then looking on the right-side menu bar for the activity title.

Student Activities

Hydra/Planaria Behavior Lab (Unit 1)

This is a lab I developed by combining a lab in Marvin Druger's *Individualized Biology* and the lab that accompanies the Ward's Planaria kit. It introduces students to behavior concepts and lab design. The lab is popular with students and can be used as a segue to other activities. The first time you try this lab it is easiest if you buy the kit, which comes with literature to use for inquiry discussions. I prefer the method used by Wards's Planaria Regeneration Lab Activity (item number 87 V 2502), but other companies have good kits, too. All of the purchased kits can be reused the next year. I recommend timing the lab so that the Planaria arrive three days before the lab starts, which gives them a chance to get a little hungry.

You will need to provide your students with the following equipment:

- At least two Planaria kits per student
- Lots of small petri dishes
- Bottled water (chlorinated tap water kills Planaria)
- Dissection microscopes
- Watch glasses
- Flashlights
- Fresh liver or egg yolk
- Dissecting needle droppers
- Rules
- Diagrams of Planaria
- Log books

This is a two-part lab. In the first part students do background research on Planaria, learn how to write a hypothesis, observe the structure of Planaria under a microscope and how it reacts to different stimuli (e.g., light, food, being turned over, etc.), analyze their observations by answering questions, and determine whether their observations support the hypothesis they developed before the lab. In the second part students cut Planaria into thirds and observe their regeneration process over a two-week period. They record their observations in a log and answer questions about what they saw. The first part of the lab takes two 45-minute periods or one double period to complete. The second part requires only five minutes of observation every other day for two weeks; this can be done in class or before the school day starts.

Itty-Bitty City Lab (Unit 1)

I developed this lab, based on a lab in an early edition of the *Modern Biology* textbook (Holt, Rinehart and Winston, 1991), to teach students how to use a microscope and to learn about the organisms that inhabit the itty-bitty city of a drop of pond water. It works best when each student has a microscope and works independently. They also need to have slides, cover slips, the slowing gel methylcellulose, and pond water. If the pond water in your area does not have a good variety of organisms, you can make your own sample with purchased protists. Have students observe a drop of pond water on a slide, make drawings of and notes about what they see, and then answer questions about the organisms' behavior and characteristics. This lab takes one to two class periods.

Behavioral Biology/Ethology Assignment (Unit 4)

This assignment is also known as the "famous animal behaviorist" report. It involves reading chapter 51 and other sources for information on the listed behaviorists and concepts. We use this as the background for the pill bug lab (AP Lab 11, Exercise 11A).

Directions to Students: Write short paragraphs on the following concepts. In your description, make sure you define each concept and clearly indicate the work of the famous behaviorists highlighted on this list. You will use this paper as a study sheet later.

- Fixed action pattern
- Sign stimulus
- **Niko Tinbergen**'s work on the digger wasps
- Learning defined: habituation, imprinting—classical experiment of **Konrad Lorenz**
- Associative learning: classical experiment of **Ivan Pavlov,** operant conditioning work of **Frederick Skinner**
- Kinesis/taxis
- Migration: piloting, orientation, navigation
- Social behavior: define the concept, support with an explained example, and explain why agnostic behavior, dominance hierarchies, territoriality, and courtship exist for the animal
- Diverse modes of communication (e.g., displays, pheromones, foraging in bees), the work of **Karl von Frisch** (e.g., round dance, wiggle dance)
- Altruism
- Kin selection

Head your paper "Introduction/Behavioral Concepts." Identify the other sources you have used. Type and double-space your paper, indicating each section clearly. You have two days to complete this assignment.

Genetic Diseases Research Assignment (Unit 10)

I give my students the following assignment to help them learn about the role genetics plays in some diseases.

Directions to Students:

1. Use the information you find in your textbook and on the Internet to describe the characteristics and symptoms of the following diseases:

   - Achondroplasia
   - Cystic fibrosis
   - Fragile-X syndrome
   - Hemophilia
   - Huntington's disease
   - Phenylketonuria (PKU)
   - Sickle-cell anemia
   - Tay-Sachs disease

2. Write a report on these diseases using the headings *Cause*, *Symptoms*, and *Treatment* to organize it. When writing about cause, make sure you determine the chromosome location. Is it a recessive or dominant trait? When writing about treatment, try to find out if there is a prenatal diagnosis and if support groups are available for the condition (supply the name, address, phone number, and Web site URL for the support groups).

3. Explain in your report the different fetal testing techniques.

Sample Guidelines

This section contains examples of the reading and lecture guidelines I give my students. The reading guidelines help them read their textbook effectively and come to class prepared with some background knowledge on the topics. They answer the questions on the reading guidelines for a homework assignment. The lecture guidelines help them follow the lectures and see the relationships between the topics and the concepts. Both the reading and the lecture guidelines are valuable for speeding up students' note taking during class, freeing their attention for class discussion.

Reading Guidelines for Taxonomy and Phylogeny (Unit 1)

Read concept 25.5 and 25.3 (pages 495-99).

Review concept 25.2 and make notes on concept 25.3, defining all of the bold words.

Read concept 26.4 (pages 523-25). Carefully explain the origin of eukaryotes by endosymbiosis and answer the concept checks questions.

Read chapter 28 (beginning on page 549, "The Protists") and do the following:

1. Explain what has happened to the kingdom Protista.

2. Read concept 28.1 and list the features of protists (e.g., cell types, types of nutrition, habitats, reproduction, etc.).

3. Write something about the following protists, such as their economic importance as disease carriers, or anything that is unusual about them (e.g., their location, role in the food chain, etc.). Type this information and attach your report to this reading guideline.

   - Diplomonad–*Giardia*
   - Parabaslid–*Trichomonas*
   - Euglenozoans–Trypanosomes, Euglenas
   - Dinoflagellates (three important roles)
   - Apicomplexans–*Plasmodium* malarial parasite
   - Ciliates–*Paramecium* (study the *Paramecium*, draw it, and describe its feeding, waste removal, and water balance)
   - Diatoms
   - Brown algae (describe its unusual uses)
   - Foraminiferans
   - Amoebozoans–*Entamoeba* and slime molds
   - Red algae
   - Green algae

Reading Guidelines for Chapter 23 (Unit 2)

Chapter 23 points out the role of genetics in evolution. Its major focus is on populations, genes, and frequencies of genes. This new study is population genetics, a synthesis of Darwinian theory of evolution with Mendelian genetics.

Refer to modern synthesis (page 455).

Define: gene pool, population, allele, species.

Skip pages 456-58 (the Hardy-Weinberg law of genetic equilibrium will be taught separately).

Microevolution is a change in the genetic makeup of a population from generation to generation. Explain how the following factors cause genetic change:

1. Mutation
2. Sexual recombination
3. Gene flow
4. Genetic drift
   a. Founder effect
   b. Bottleneck effect

Answer the following questions about natural selection:

1. How does natural selection lead to polymorphism, geographic variation, and a cline?
2. How does natural selection alter the frequency of traits by directional selection, disruptive selection, and stabilizing selection?
3. How does diploidy maintain diversity?
4. How does heterozygote advantage maintain genes in an environment?
5. What is the importance of neutral variation?
6. What is the importance of sexual selection?

Lecture Guidelines for Animal Survey Opening Lecture (Unit 1)

This lecture focuses on the five kingdoms, the three-domain system, and phylogenetic trees.

Review of Basic Terms

Prokaryote, eukaryote, autotrophic, heterotrophic, symbiosis

Five-Kingdom Classification Review

The characteristics of the five kingdoms: this is based on similar cell structure and organization, reproduction, and nutrition.

- **Kingdom Monera.** Contains all prokaryotic cells, bacteria, and cyanobacteria. Reproduction is mainly sexual. Absorption and photosynthesis are the main nutritional modes.
- **Kingdom Protista.** Mainly unicellular eukaryotic cells. Most are microscopic. Reproduce asexually by fission. Some have sexual cycles. Nutritional methods are absorption, photosynthesis, and ingestion, or a combination of these methods.
- **Kingdom Plantae.** Eukaryotic cells ranging from microscopic to large, complex, green plants with complex tissue differentiation. Reproduction is mainly sexual. Photosynthesis is the main form of nutrition.
- **Kingdom Fungi.** Includes eukaryotic multicellular and multinuclear organisms. Microscopic and familiar macroscopic forms like mushrooms. Both sexual and asexual reproduction. All have absorptive nutrition.
- **Kingdom Animalia.** Consists of multicellular eukaryotic cells. Complex tissue differentiation. Reproduction is primarily sexual. Nutrition is by ingestion, though absorption is also found.

Three-Domain System

DNA analysis has led to the development of the three-domain system, grouping the five kingdoms into higher levels of classification: Archaea, Bacteria, and Eukarya. Archaea and Bacteria have prokaryotic cells. All eukaryotic cells are in the Eukarya domain, which has at least four kingdoms: Animalia, Plantae, Fungi, and Protista. You will learn that DNA analysis is resulting in the Kingdom Protista being divided into more kingdoms (see pages 540-41 and 529-31 in your textbook).

Phylogenetic Trees

These are diagrams that show evolutionary relationships. The 35 major groups of animals have been arranged by 4 major points:

1. Basic body plan and arrangement of parts, symmetry
2. Presence and absence of body cavities
3. Number of layers in which the cells are arranged (e.g., germ layers, ectoderm, etc.)
4. Pattern of development from fertilized egg to adult embryology

Background Review

Basic embryology plays an important role in this classification (see page 628 in your textbook).

Define the following terms (see page 632 in your textbook):

1. Fertilization
2. Zygote
3. Cleavage (cell division without growth 2 types)
   a. *Spiral/determinate cleavage*. Early divisions spiral occurring in a plane oblique to the long axis of the cell. Determinate cleavage (i.e., fixed fate of cells).
   b. *Radial/indeterminate cleavage*. Early divisions are radial, parallel to and at right angles to the axis of the cell. The fate of cells is not determined (see page 632 in your textbook).
4. Blastula (a hollow ball of cells)
5. Gastrulation (infolding and formation of blastopore and the germ layers)
6. Ectoderm
7. Endoderm
8. Mesoderm (mesoderm can be formed in two ways: schizocoelus and enterocoelus)

These embryological differences split the coelomate animals into two groups: deutersomes and protosomes.

Protosomes	Deutersomes
Blastopore becomes a mouth	Blastopore becomes an anus
Spiral cleavage in embryo	Radial cleavage in embryo
Determinate cleavage (fixed fate)	Indeterminate cleavage (fate can be altered)
Coelom formed by mesoderm splitting schizocoelus	Coelom formed by mesoderm pouches enterocoelus
Examples: • Annelids • Arthropods • Molluscs	Examples: • Echinoderms • Chordates

Chapter 4
The AP Exam in Biology

AP Exam Basics

The AP Biology Exam is administered every May and, for many AP Biology courses, it is the culminating event of the school year. Both teachers and students find it helpful to understand how the exam is created, administered, and scored. They also need to be familiar with the different types of questions they will see on it. Space constraints limit this section to a brief summary of the AP Exam. Visit AP Central for a more in-depth and detailed description (from the main page at apcentral.collegeboard.com, click on *Exams* and then on *All About the Exam*).

Creating the Exam

The construction of an AP Biology Exam can take two to three years from the initial writing of the questions to the administration of the exam. All of the multiple-choice and free-response questions that appear on an AP Biology Exam are created by the AP Biology Development Committee. The Development Committee writes, reviews, revises, and approves all potential questions. ETS content experts also review the questions to ensure they have been worded clearly and concisely and contain no biases. Once questions have been through this preliminary review process, the multiple-choice questions are field tested in college and university classrooms, and student performance on them is statistically evaluated. The Development Committee reviews the results and decides which questions to use on an AP Exam.

Exam Format

The AP Biology Exam is three hours in length and consists of two parts: a multiple-choice section and a free-response section.

- **Section I. Multiple-Choice.** Students have 80 minutes to answer 100 multiple-choice questions that are designed to measure their comprehension across all of the three general areas in the topic outline. Approximately 25 percent of the questions cover *molecules and cells*, 25 percent cover *heredity and evolution*, and 50 percent cover *organisms and populations.* The multiple-choice section counts for 60 percent of the exam.
- **Section II. Free-Response.** The second part of the exam consists of four mandatory free-response, or essay, questions: one covers *molecules and cells*, one covers *heredity and evolution*, and two cover *organisms and populations*. One of the four questions is based on the objectives of a specific lab and may include experimental design or student analysis and interpretation of experimental results. All free-response questions address at least one major theme. Students have a 10-minute planning period and 90 minutes to respond to the questions. Each question is weighted equally. The free-response section counts for 40 percent of the exam.

Scoring the Exam

The multiple-choice questions are scored by computer, and a correction factor is used to compensate for random guessing (one-fourth of a point is subtracted for each incorrect answer). The free-response questions are scored at the annual AP Reading in June. The Reading brings together a team of high school AP Biology teachers and college and university biology professors who spend one week reading the answers to the free-response questions.

The Readers are a diverse group with a good balance of gender, ethnicity, experience, geography, and institution size and type. Each Reader is assigned to score one question, though all Readers are familiar with all of the questions. Table Leaders oversee the scoring of their group of Readers, while the Question Leader works with all of the Table Leaders for that question. This hierarchy is part of the check-and-balance system that strives to maintain consistent scoring among the groups of Readers for each question.

The Development Committee and the Chief Reader work together during the development of an AP Exam to determine how the points are to be distributed within each question. Before the AP Reading begins, the Chief Reader, Question Leaders, and Table Leaders meet to read some of the exams and get a feel for how students performed and to identify any problem areas. They finalize the scoring guidelines based on the sample essay responses they have read. The Table Leaders select sample responses that fall within the limits that have been set for each score to use as examples for the Readers.

On the first day of the Reading, the Table Leaders train the Readers how to apply the scoring guidelines consistently. They practice on sample student responses before they begin scoring actual responses. The training also includes advice on how to avoid certain types of biases, such as poor penmanship and the halo effect (i.e., carrying over one's opinion of the previously-read response to the one being read now).

Table Leaders and Question Leaders take steps throughout the Reading to ensure that scoring remains consistent and fair. Such measures include assigning several Readers the same student response to score, Table Leaders "backreading" (reading) their Readers' work, and working with individual Readers as needed. Daily printouts that track the Readers' scoring also help the Table Leaders ensure their Readers are scoring consistently as a group. Furthermore, Readers never have access to the names, genders, schools, and geographic regions of the students whose responses they are scoring. They also are never able to see the scores of students' responses to the other questions on the exam.

Grade Setting

Students receive points for correct answers; Readers do not subtract points for incorrect answers. Once Readers' scores for the free-response section are in, ETS statisticians weigh, convert, and combine them with the score for the multiple-choice section and then derive a composite score for each student. Next, the Chief Reader meets with College Board representatives and ETS statisticians and assessment developers to determine the cut points, and the Chief Reader converts the composite scores to the five-point scale on which the AP grades are reported.

5 Extremely well qualified

4 Well qualified

3 Qualified

2 Possibly qualified

1 No recommendation

The Chief Reader compares the grades to comparability studies done with college students who have taken an introductory-level biology course. Comparing high school performance against college performance helps maintain the validity of the grade as an assessment of college-level mastery of biology. The Chief Reader also compares the current year's grades with statistical information from previous years, which helps keep the level of mastery represented by reported grades constant from one year to the next.

On the last day of the Reading, all of the participants gather to debrief and discuss the exam, comparing it to exams from previous years. Their observations, along with the Chief Reader's statistical analysis of student performance for that year, are in the Chief Reader's annual report, "Student Performance Q&A" (from apcentral.collegeboard.com, click on *The Exams*, then on *Exam Questions*, then on *Biology*, and look in the *Scoring* column for each year). You can find more detailed information about how the AP Exam is scored and how the Readers' scores are converted to AP grades in the Released Exams.

AP Grade Reports

AP grades are reported to students, their schools, and their designated colleges in July. Each school automatically receives an AP Grade Report for each student, a cumulative roster of all students, rosters of all students by exam, an AP Scholar roster for any qualifying students, and an *AP Instructional Planning Report.* (Note: Data for students testing late with an alternate form of the exam are not included in this report.) For a fee, schools may also request their students' free-response booklets.

Using the AP Instructional Planning Report

Schools receive the *AP Instructional Planning Report* for each of their AP classes in September. The report compares your students' performance on specific topics in the AP Exam to the performance of students worldwide on those same topics, helping you target areas for increased attention and focus in the curriculum. To get the most out of the report, please read the interpretive information on the document. It explains how the data, when used correctly, can provide valuable information for instructional and curricular assessment as well as for planning and development. Contact your school's AP Coordinator for this report.

Preparing Students for the AP Exam

All students who take the AP Biology course should be encouraged to take the AP Biology Exam. The exam offers students the opportunity to demonstrate the concepts, skills, and content they have worked hard all year to learn. It also gives them a sense of what college-level exam requirements are like, as well as the opportunity to receive feedback on their grades. Moreover, students may receive college credit if they earn a grade of 4 or 5 on the exam; some colleges and universities give credit for a grade of 3.

The more exposure your students have to the format, wording, pacing, and scoring of AP Biology Exam questions, the more comfortable they will be with them by the time they take the exam in May. Prepare your students for the AP Biology Exam from the very beginning of the school year by using multiple-choice and free-response questions on your unit tests and semester exams. Free-response questions also make good in-class activities. Have pairs of students respond to them and then use the scoring guidelines to see how well they did. This introduces students to a critical review of their work.

Experienced AP teachers frequently use questions from the Released Exams to test their students, selecting only those questions that pertain to the unit being tested. They also use the free-response questions and scoring guidelines on AP Central (go to apcentral.collegeboard.com and click on *The Exams* and then on *Exam Questions*). These date from 1999 to the most recently administered exam and may be

downloaded free of charge. The testing materials in the Released Exams and on AP Central are copyrighted by the College Board, but you have permission as an AP teacher to make copies to use in your classroom. Although you can use the test bank that accompanies your textbook, screen the questions carefully because not all of them require the analytical skills that students are asked to demonstrate on the AP Exam.

A test consisting of 25 to 30 multiple-choice questions and 1 free-response question is generally enough for a 45- or 50-minute class period. Include a five-minute reading period as part of the testing process so that students can get in the habit of organizing their thoughts before they begin to write their response. Always use a scoring guideline to grade the free-response questions; this helps students learn what AP Readers look for in an essay response.

Time management is usually one of the challenges students encounter on the AP Exam. Timing them during tests helps them develop the time-management skills that are critical to doing well on the AP Exam. In the spring you may want to give your students a full AP Exam as a dress rehearsal for the real one. The College Board's AP Biology Exam, Packet of 10, which consists of 10 copies of a formerly administered exam and corresponding answer sheet, greatly enhance any simulated AP Exam. You can purchase this resource from the College Board Store (store.collegeboard.com).

Types of AP Biology Exam Questions

The tests you develop for your course should expose your students to the following question formats, all of which have been used on past AP Exams.

Multiple-Choice Questions

- Classification Set
- Lab Set
- Except
- Least
- Tiered-Stem

Free-Response Questions

- Laboratory Based
- Content Based

Multiple-Choice Questions

The following examples have been reprinted from *AP Biology Released Exams*, which can be purchased from the College Board Store (store.collegeboard.com).

Classification Set Questions

Classification questions consist of a set of answers to be used for a set of questions. The major difference between this type of question set and a matching question set is that students can use an answer once, more than once, or not at all. It is important that students are aware of this difference. The following example has been reprinted from the 1999 *AP Biology Released Exam*.

Questions 87–91

(A) Annelida

(B) Mollusca

(C) Arthropoda

(D) Echinodermata

(E) Chordata

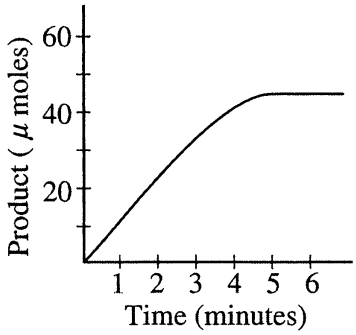
87. Bilaterally symmetrical; deuterostome; dorsal hollow nerve cord
88. Coelomate; exoskeleton; jointed appendages
89. Pharyngeal slits; endoskeleton derived from mesoderm; ventral heart
90. Internal calcareous skeleton; deuterostome; water-vascular system
91. Closed circulatory system; protostome; many body segments

Lab Set Questions

Lab set questions are based on a laboratory experiment; the data and results from the experiment are presented in the question. The intent of this type of question is to assess students' analytical skills and knowledge of laboratory protocol. You can create your own lab set questions from the laboratory experiments your students have done, or you can give them laboratory scenarios with the data included. The following example has been reprinted from the 2002 *AP Biology Released Exam*.

Questions 93–96 refer to the following:

A scientist determined the rate of an enzyme-catalyzed reaction by measuring the amount of product formed over time. The following curve was generated from the data collected.



93. Based solely on the curve, what can be said concerning the calculated reaction rates at 1 minute and at 2 minutes?

    (A) The rate after 2 minutes is greater than the rate after 1 minute.
    (B) The rates are the same at 1 minute and at 2 minutes.
    (C) The rates are affected by high concentrations of inhibitors.
    (D) The rates are both zero.
    (E) The greater the rate, the faster the enzyme is denatured.

94. The rate of the reaction could also be determined by

    (A) measuring the change in the amount of enzyme
    (B) measuring the change in the amount of substrate
    (C) measuring the change in salt concentration
    (D) adding more substrate
    (E) adding more enzyme

95. What is the most likely explanation for the change in the slope of the line between 3 and 5 minutes?

    (A) The enzyme had denatured.
    (B) The enzyme had achieved its maximum velocity.
    (C) A large amount of the substrate had been consumed.
    (D) An allosteric inhibitor appeared.
    (E) There was a dramatic change in the pH.

96. During which time interval is the reaction rate lowest?

    (A) 0–1 minute
    (B) 1–2 minutes
    (C) 2–3 minutes
    (D) 3–4 minutes
    (E) 4–5 minutes

Except Questions

These multiple-choice questions contain the word EXCEPT in the stem of the question. Students who are unfamiliar with this format experience difficulty because they are used to searching for the correct answer, not eliminating the wrong one. Except questions force students to differentiate between a number of correct answers and one that is wrong, and this type of question requires more reasoning than the standard multiple-choice question. The following example has been reprinted from the 2002 *AP Biology Released Exam*.

8. All of the following statements concerning characteristics of predator-prey relationships are correct EXCEPT:

    (A) A rise in the population of prey is often followed by a rise in the population of predators.
    (B) A rise in the population of predators is followed by a decrease in the population of prey.
    (C) Camouflage is an adaptation that protects prey.
    (D) The production of large numbers of offspring within very short periods of time ensures the survival of some prey populations.
    (E) The population of predators most often eliminates the population of prey.

Least Questions

These multiple-choice questions contain the word LEAST in the question stem. This format requires students to be able to categorize the answers from the most likely answer to the least likely answer, a task they find difficult. Like except questions, least questions demand the use of higher reasoning skills. The following example has been reprinted from the 2002 *AP Biology Released Exam*.

6. The LEAST effective means of controlling pest species such as rats or roaches over a long period of time is generally to

   (A) limit food supplies

   (B) reduce the number of potential habitats

   (C) distribute pesticides throughout the habitat

   (D) introduce predators of the pest

   (E) introduce a disease, which affects only the pest

Tiered-Stem Questions

Tiered-stem questions are probably the most difficult of all multiple-choice questions because they require students to use a number of cognitive processes when answering them. Try to include at least one on every test in order to give your students ample practice with them. The following example has been reprinted from the 1999 *AP Biology Released Exam*.

18. In a mesophyll cell of a leaf, the synthesis of ATP occurs in which of the following?

    I. Ribosomes

    II. Mitochondria

    III. Chloroplasts

    A. I only

    B. II only

    C. III only

    D. II and III only

    E. I, II, and III

Free-Response Questions

Laboratory-Based Questions

Laboratory-based questions either ask students to design a laboratory experiment or provide them with the results of an experiment to analyze. In the first scenario, as indicated by the example reprinted from the 1999 *AP Biology Released Exam* below, students are given an incredible amount of latitude in designing their own experiment. They should keep in mind the scientific method and protocol when answering this type of question. In the second scenario students may have to graph the results of the experiment they have been given to analyze and then explain the relationship that is indicated by the graph.

1. The rate of photosynthesis may vary with changes that occur in environmental temperature, wavelength of light, and light intensity. Using a photosynthetic organism of your choice, choose only ONE of the three variables (temperature, wavelength of light, or light intensity) and for this variable

   - **design** a scientific experiment to determine the effect of the variable on the rate of photosynthesis for the organism;
   - **explain** how you would measure the rate of photosynthesis in your experiment;
   - **describe** the results you would expect. **Explain** why you would expect these results.

Content-Based Questions

Some essay questions are based on content, within the context of the eight major themes in the Course Description, and ask students to make connections between different areas in biology. The prompts for this type of question include *explain*, *discuss*, *identify*, and *describe*. Students must know the course content to answer these questions successfully. The following example appeared on the 2003 AP Biology Exam.

2. Regulatory (control) mechanisms in organisms are necessary for survival. Choose THREE of the following examples and **explain** how each is regulated.

   (i) Flowering in plants

   (ii) Water balance in plants

   (iii) Water balance in terrestrial vertebrates

   (iv) Body temperature in terrestrial vertebrates

Review Themes

One of my best ways to prepare students for the exam is to make a grid with the AP Biology themes along the top of a page and the various topics (protists, plants, respiration, etc.) along the side. I print out and distribute the grids to my class. Students work in groups and fill in the grid with two examples for each. For instance, where the structure/function theme intersects with cells, they could write: "1. Membrane proteins allow control of cell access. 2. Endomembrane systems allow the synthesis, processing and packaging of proteins." This exercise prompts students to think about the themes for each topic, and they will have two examples for each before taking the exam. This review method is a great help for the essay questions.

—David M. Title, Niwot High School, Niwot, Colorado

Review Sessions

Covering all of the material on the Course Description's topic outline is extremely important when preparing students for the exam. As spring approaches, you should begin holding review sessions. These can take several forms, including review packets, before- and after-school review sessions, and Super Saturdays. Offering a variety of options keeps students interested, and some methods are more effective for some students than others.

- **Review Packets.** A review packet usually has a synopsis of a given topic with practice multiple-choice and free-response questions. Their purpose is to alert students to the most important topics they should study for the exam. Some of the study guides that accompany college textbooks can be

a resource for study packets. You may want to create your own study packets to meet your students' specific needs. You can have students complete these on their own and turn them in for evaluation, or encourage them to work on the questions in study groups. Distribute the packets four to six weeks before the exam.

- **Review Sessions.** These are very effective in helping students prepare for the exam. On Mondays, Wednesdays, and Fridays in April my students come in 90 minutes before school to review. Our sessions cover potential exam content as well as provide additional time to practice answering multiple-choice and free-response questions. When appropriate, I include a review of laboratory experiments as well. My students sign up for different days to bring breakfast for the group, which makes the sessions more enjoyable and a nice way to end the course. I do not devote any class time to review because my students are continuing to learn new material until the day of the exam.
- **Super Saturdays.** These extended review sessions generally run for five hours, and a school or district may hold three or four throughout the school year. Each Saturday consists of four one-hour review sessions for specific topics chosen by the teacher and based on the students' needs. If a district is doing this for several schools, different biology teachers frequently offer different sessions, and students can pick and choose which ones to attend. The school usually provides lunch and door prizes for the attending students. Super Saturdays are a great way for students to review for the exam and learn supplemental material that may not be covered during the course of the year. Moreover, Super Saturdays expose students to different teaching styles and approaches.

Test-Taking Strategies

Students benefit from a review of basic test-taking strategies for the AP Exam as well as a review of the course content. Some teachers like to outline the following tips in class. Others prefer to put them on a handout their students can refer to as needed.

General AP Exam Tips

- Get a good night's sleep the night before the exam. Being well rested is more useful than cramming.
- Remember to bring the set of stickers that has your ID barcode and number, and place one on each piece of testing material. Do not share these stickers with a friend.
- Do not assume you do not have to do well on the exam because you heard that your chosen college does not accept AP grades. Credit policies can change, especially over the summer.
- Be sure you understand the exam's instructions, including the time allowed for each section and breaks.

Multiple-Choice Question Tips

- Read the question completely before answering it. You are looking for the best answer, not an ideal answer.
- Do not look for trick questions. The AP Exam contains no trick questions.
- Answer immediately questions you know the answer to and skip the others; go back and answer them after you have answered all of the other questions.
- Guess the answer only if you can eliminate two or three choices.
- Change your answer only if you have discovered that you have misread either the question or an answer option. Usually your first choice is the best choice.

- Remember that for sets of questions, some answer choices may be used more than once and some not at all.
- Check your answer sheet regularly to ensure you are not filling in answer bubbles on the wrong line.
- Remember to bring several number two pencils with you to the exam.

Free-Response Question Tips

- Read the entire question through before answering and note its different parts.
- Use the planning period to organize your thoughts and the way you will present them. It is well worth your time to write out a brief outline of your answer on the question sheet.
- Keep track of your time; you have 22.5 minutes for each response.
- Answer the question that has been asked, not the question you wish had been asked.
- Do not begin your answer by writing the question, an introduction, or a thesis. You do not have the time to follow a research paper style of writing *and* write a complete answer to the question.
- Answer all parts of the question; a maximum score cannot be earned otherwise.
- Avoid the temptation to turn your answer into a "brain dump." Even though you will not be penalized for writing erroneous or irrelevant information, doing so uses up time you need to answer other questions.
- Use diagrams to help explain your answer. If you use diagrams, however, you must refer to them in your answer.
- Write clearly so the Readers can give you credit for what you know.
- Check your answer after you have finished writing it to see if you have missed anything.
- Remember to bring several blue or black ink pens with you to the exam.

What to Do After the AP Exam

While for some schools, the AP Biology Exam comes at the end of the academic year, many AP teachers find they have three to five weeks of class time left after the exam. Their students spend the time after the AP Exam and before the end of the school year doing activities like these.

- Creating *PowerPoint* presentations designed to be used by teachers in the lower grades
- Engaging in an in-depth dissection of a cat or other organism
- Researching local ecological problems and presenting a report to the class
- Working on a biotechnology unit that goes beyond the basics and deals with bioethics, incorporating related lab activities
- Studying science in the news
- Performing a thorough cleanup of the lab facility
- Working on a forensics unit
- Investigating further those previously-covered topics that students are most interested in

However you decide to use the additional time at the end of the year, teachers report best success when their students consider the activity to be a bonus or special treat.

Design Science Activities

I've had my students do something different every year—write research papers, do projects, read a science-related book, and so on. This year we designed science activities to share with a first-grade class at a local elementary school. Working in pairs, my students researched, planned, and developed science stations that included a 15- or 20-minute activity for groups of 4 to 5 first graders. The first-grade students rotated around to the different stations and fully participated in this science discovery day. My students earned a lab grade. We were all pretty excited about it!

—Nicole Harmer, Brainerd High School, Brainerd, Minnesota

Field Trips

Try multiple one-day field trips. I take my students on three a year and none of the trips costs more than $25 (including bus transportation). We have gone to an aquarium (where students performed the diffusion and osmosis lab on bay water samples), a wild animal park (where they learned about animal conservation and the importance of maintaining a large gene pool), a science museum with an exhibit on developmental biology, the Body Worlds Exhibit when it came through our area, a local university to tour the campus and see two different science research labs, and a human dissection lab from a chiropractic college. I am always looking for local ideas and opportunities. The trips are a great way to bond with students and show them the world of science outside of the classroom.

—Pamela J. Porter, Edison High School, Huntington Beach, California

Chapter 5
Resources for Teachers

How to Address Limited Resources

Students titrate the products of the enzyme catalysis lab (AP Lab 2). The plastic cups and syringes, labeled with a permanent marker, can be reused every year. The burettes, borrowed from the chemistry department, can be easily rinsed out with a 50:50 vinegar/hydrogen peroxide mix. This cleaning solution also works on hands and desktops. (Photograph courtesy of Carol Leibl.)

Beginning an AP Biology course does not necessarily mean that your school must incur a great expense. The materials you need include a college-level textbook, a lab manual, and adequate laboratory equipment (see the lab facilities section in chapter 2 for a description of what constitutes adequate laboratory equipment). It is easy for new AP Biology teachers to feel discouraged by the cost of the materials and equipment they may need to buy for their laboratory program. But do not despair if your facilities fall somewhat short and budget constraints prevent you from immediately acquiring everything on your shopping list for the ideal lab. There are a number of creative ways to stretch what you have on hand.

- **Share resources.** You may find that you can share resources with other teachers. Perhaps the AP Chemistry teacher in your school has the burettes you need for the enzyme catalysis lab. Or maybe an AP Biology teacher at a nearby school can loan you some spectrophotometers after that teacher's students have finished the plant pigments and photosynthesis lab. If you are lucky, you may even be able to borrow probeware, which is often beyond a normal science budget, from another institution.
- **Order together.** If your school district has more than one high school, you may find it is feasible to jointly purchase and share expensive equipment with the other schools.

- **Send orders out to bid.** Experienced teachers never buy retail. Instead, they compile a list of materials they plan to use during the year and send them out for bids, even if they are only sending the bid request to one vendor. Many times, asking for a bid price on kits for the 12 AP Labs turns out to be less expensive than purchasing kits for only some of the labs. At the very least, companies that do not offer discounts usually offer to provide free shipping. Sometimes savings of up to 50 percent on more expensive items is possible when you bid them out. Be very specific about what you need and look carefully at the descriptions given in the bids to make sure you are comparing oranges with oranges.

- **Inventory your lab.** A disorganized supply area results in unnecessary purchases and wasted materials. Keep an up-to-date inventory of the materials you have on hand. This will allow you to see at a glance what you need to purchase to get your students through the labs for that year.

- **Use dry labs.** Lack of resources may require you to use dry labs for some activities (e.g., biotechnology, genetics, etc.). Dry labs should be used judiciously, however, because students learn more when they must roll up their sleeves and do a lab themselves.

- **Make a wish list.** You never know when funding will suddenly become available, so keep on hand a wish list of the lab kits and equipment you would like to be able to buy.

- **Keep it simple.** Never underestimate the value of simple experiments done with inexpensive equipment and materials. The teachers on the AP Biology Electronic Discussion Group are generous with their ideas for simple and economical experiments.

- **Use the Internet.** You can find countless free labs and class activities on the Internet, reducing your need to purchase many resource books in your first year or create experiments from scratch.

The Molecular Biology Lab: Practical Substitutions

If you don't have an autoclave or pressure cooker you can disinfect the plates you use for the molecular biology lab in the AP Lab Manual with a 10 percent Clorox® solution. Cover and let them sit for 10 minutes.

—Bruce Faitsch, Guilford High School, Guilford, Connecticut

Having appropriate laboratory materials for your students is an enormous issue for AP Biology teachers. It is essential that your school administrators understand that lab expenses for AP science courses are greater than those for regular high school lab experiences, and it is good practice to establish a separate operating and capital budget for AP science courses to manage their expenditures. Although most administrators are willing to fund the courses that are implemented in their schools, in this day of ever-tightening budgets you may find yourself having to cobble together some of your labs. Make sure your administrators know that such temporary measures cannot become permanent alternatives; they are stop-gap measures while funds are being pursued for providing students with college-level and safe lab experiences.

Recycle Lab Materials

I save the leftover agar from previous years to make practice gels for the molecular biology lab in the AP Lab Manual for the next year. I put two or three combs across a petri dish and pour practice gels. Pour some buffer across the top and you have a bunch of practice wells to use. You can make up some practice dye by mixing blue food coloring with a little bit of glycerin to simulate loading dye.

—Frank Bell, St. Mary's Hall, San Antonio, Texas

Resources

It is impossible to compile an exhaustive list of the thousands of resources that are available to AP Biology teachers. The best that can be offered here is an overview of some of the many different kinds of resources you will find helpful for teaching the AP Biology course. After perusing this section, visit the Teachers' Resources area on AP Central and the Advanced Placement Digital Library described in chapter 2. Both are good Web sites to explore when you are debating which textbook, lab manual, Web site, and more is the best to use with your students.

It is important to understand that no one resource in this bibliography is favored over another and 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 Biology Development Committee. All Web sites and contact information for publishers and organizations in this chapter and the rest of this Teacher's Guide were active and current as of its publication. All Web site URLs throughout this Teacher's Guide begin with *http://* .

Textbooks

All of the textbooks here have been used successfully for both AP and college instruction, and they enjoy good reputations. While some of the textbooks are more widely used than others, all do a thorough job of covering the AP Biology curriculum.

Campbell, Neil A., and Jane B. Reece. *Biology.* 7th ed. San Francisco: Pearson, Benjamin Cummings, 2005.

Freeman, Scott. *Biological Science.* 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 2004.

Mader, Sylvia S. *Biology.* 9th ed. Dubuque, Iowa: McGraw-Hill, 2007.

Purves, William K., Gordon H. Orians, Craig Heller, and David Sadava. *Life: The Science of Biology.* 7th ed. Gordonsville, Va.: W. H. Freeman, 2004.

Raven, Peter H., and George B. Johnson. *Biology.* 7th ed. Boston: McGraw-Hill Higher Education, 2005.

Solomon, Eldra P., Linda R. Berg, and Diana W. Martin. *Biology.* 7th ed. Belmont, Calif.: Brooks/Cole Thomson Learning, 2005.

Starr, Cecie, and Ralph Taggart. *Biology: The Unity and Diversity of Life.* 11th ed. Belmont, Calif.: Thomson Brooks/Cole, 2005.

General Books

American Chemical Society Task Force on Laboratory Waste Management. *Laboratory Waste Management: A Guidebook*. Washington, D.C.: American Chemical Society, 1994.

Bellamy, Mary Louise, and Kathy Frame. *Biology on a Shoestring*. Reston, Va.: National Association of Biology Teachers, 1995.
This book is out of print but it may be available from used book sources on the Internet or the professional collection of a long-time AP Biology teacher.

Finer, Kim R. *Internet Activities for General Biology*. N.p.: Wadsworth, 1998.
This is one of the first lab books with activity pages for integrating Internet source material.

Kirchmer, Erin. *A Lesson Manual for Teaching Science Laboratory Safety*. Natnick, Mass.: The Laboratory Safety Institute, 2005.

Luxon, S. G., ed. *Hazards in the Chemical Laboratory*. 5th ed. Cambridge: Royal Society of Chemistry, 1992.

Morhort, Evelyn, and Paul Brandwein. *A Sourcebook for the Biological Sciences*. 3rd ed. San Diego: Harcourt Brace Jovanovich, 1986.

Roy, Kenneth R. *Science Safe: Be Protected!: A Need-to-Know Primer on Critical Safety Issues for Science Educators*. Vol. 1. Natnick, Mass.: The Laboratory Safety Institute, 2002.

Uno, Gordon E. *Handbook on Teaching Undergraduate Science Courses: A Survival Training Manual*. Ft. Worth: Saunders College Publishing, 1999.

Laboratory Manuals

AP Biology Laboratory Manual for Students. New York: College Entrance Examination Board, 2001.

AP Biology Laboratory Manual for Teachers. New York: College Entrance Examination Board, 2001.

Dolphin, Warren D. *Biological Investigations: Form, Function, Diversity, and Process*. 7th ed. Boston: McGraw-Hill Higher Education, 2005.

Eberhard, Carolyn. *Saunders General Biology Laboratory Manual*. Updated ed. Ft. Worth: Saunders College Publishing, 1996.

Helms, Doris R., Carl W. Helms, Robert J. Kosinki, and John C. Cummings. *Biology in the Laboratory*. 3rd ed. Salt Lake City: W. H. Freeman, 1998.

Masterman, David, and Kelly Redding. *Biology with Computers*. Beaverton, Ore.: Vernier Software and Technology, n.d.

Moore, Randy, ed. *Biology Labs that Work: The Best of How-To-Do-Its*. 2 vols. Reston, Va.: National Association of Biology Teachers, n.d.

Morgan, Judith Giles, and M. Eloise Brown Carter. *Investigating Biology*. 4th ed. San Francisco: Benjamin Cummings, 2002.

Vodopich, Darrell S., and Randy Moore. *Biology Laboratory Manual*. 7th ed. Boston: McGraw-Hill, 2004.

Review Materials

Because test preparation guides tend to be updated annually, only the publishers are given here.

Anestis, Mark. *5 Steps to a 5: AP Biology*. Boston: McGraw-Hill.

Berthelsen, Barbara. *Multiple-Choice and Free-Response Questions in Preparation for the AP Biology Examination*. Brooklyn: D & S. Marketing Systems.

Callihan, L., J. Buckley, Joyce A. Blinn, Shira Rohde, and Jay M. Templin. *AP Biology: The Best Test Prep*. Advanced Placement (AP) Test series. Piscataway, N.J.: Research and Education Association.

Croston, Glenn E. *Kaplan AP Biology*. New York: Kaplan Publishing.

Goldberg, Deborah T. *Barron's How to Prepare for the AP Biology Advanced Placement Exam*. Hauppauge, N.Y.: Barron's Educational Series.

Heller, Richard F., and Rachael F. Heller. *Master the AP Biology Test*. New York: ARCO.

Pack, Phillip E. *Cliff'sAP Biology*. New York: Wiley Publishing.

Princeton, Review. *Cracking the AP Biology Exam*. New York: Random House.

Style Guides

Students can use the following general and science-specific style guides to ensure their lab reports and papers use correct style and format.

Harvey, Gordon. *Writing with Sources: A Guide for Students*. Indianapolis: Hackett, 1998.

Kirszner, Laurie G., and Stephen R. Mandell. *The Pocket Handbook for Biology*. 2nd ed. Boston: Heinle, 2004.

Lester, James D., and James D. Lester Jr. *The Essential Guide to Writing Research Papers*. New York: Longman, 1999.

McMillan, Victoria E. *Writing Papers in the Biological Sciences*. 3rd ed. Boston: Bedford/St. Martin's, 2001.

Veit, Richard. *Research: The Student's Guide to Writing Research Papers*. 4th ed. New York: Pearson/Longman, 2004.

Periodicals

General Subscriptions

Bioscience
Discover
National Geographic
Nature
Science
Science News
Scientific American

Membership Subscriptions

The American Biology Teacher
Members of the National Association of Biology Teachers receive this periodical nine times a year as part of their membership package.

Journal of College Science Teaching
Members of the National Science Teachers Association may choose to receive this periodical for college and university professors as a part of their membership package.

News and Views
Members of the National Association of Biology Teachers receive this monthly electronic newsletter as part of their membership package.

The Science Teacher
Members of the National Science Teachers Association may choose to receive this periodical for high school teachers as a part of their membership package.

Professional Organizations

National Association of Biology Teachers (NABT)
Address: 12030 Sunrise Valley Drive, Suite 110, Reston, VA 20191
Phone: 1-800-406-0775, 703 264-9696,
Web site: www.nabt.org

National Science Teachers Association (NSTA)
Address: 1840 Wilson Boulevard, Arlington, VA 22201-3000
Phone: 703 243-7100
Web site: www.nsta.org

Supply Companies

Antares Fossils and Minerals
Phone: 307 789-8737
E-mail: shop@antaresfossils.com
Web site: www.antaresfossils.com

Bio-Rad Laboratories, Life Science Research Group
Phone: 1-800-424-6723, 510 741-1000
Web site: www.bio-rad.com

Carolina Biological Supply Company
Phone: 1-800-334-5551
E-mail: carolina@carolina.com
Web site: www.carolina.com

Connecticut Valley Biological
Phone: 1-800-628-7748, 413 527-4030
E-mail: connval@ctvalleybio.com
Web site: www.ctvalleybio.com

Cricket Science
E-mail: robert@cricketscience.com
Web site: www.cricketscience.com

Edmund Scientific
Phone: 1-800-728-6999
Web site: www.scientificsonline.com

Edvotek, the Biotechnology Education Company
Phone: 1-800-338-6835
Web site: www.edvotek.com

Fisher Science Education
Phone: 1-800-955-1177
Web site: www.fisheredu.com

Flinn Scientific, Inc.
Phone: 1-800-452-1261
E-mail: flinn@flinnsci.com
Web site: www.flinnsci.com

Fotodyne, Inc.
Phone: 1-800-362-3686, 262 369-7000
Web site: www.fotodyne.com

Frey Scientific
Phone: 1-800-225-3739
Web site: www.freyscientific.com

Lab-Aids
Phone: 1-800-381-8003
Web site: www.lab-aids.com/home

LaMotte Chemical Products
Phone: 1-800-344-3100, 410 778-3100
Web site: www.lamotte.com

Modern Biology, Inc.
Phone: 1-800-733-6544
Web site: www.modernbio.com

Neo/SCI Corporation
Phone: 1-800-526-6689
Web site: www.neosci.com

Pellets, Inc.
Phone: 1-888-466-OWLS
Web site: http://pelletsinc.com

Science Kit & Boreal Laboratories
Phone: 1-800-828-7777
Web site: www.sciencekit.com

Sigma-Aldrich
Phone: 1-800-325-3010 (customer service in the United States)
Web site: www.sigmaaldrich.com

Ward's Natural Science
Phone: 1-800-962-2660
Web site: http://wardsci.com

Web Sites

Access Excellence @ the National Health Museum
www.accessexcellence.org
This site offers several options for student use, specifically, the What's New page and the DNA prime information. The site also contains a collection of illustrations and diagrams as well as an activity exchange with Web-based activities, classroom activities, and laboratory experiences, all of which are ready to be downloaded and printed free of charge.

The Biology Corner
www.biologycorner.com
Maintained by Shannon Muskopf, this site offers a series of Web quests based on different themes that guide students to a variety of Web sites where they answer questions on a given topic. The advantage of a Web quest over undirected research is the reliability of the sites students are directed to; the information they find will be reliable and current. You can also find information on lessons, quizzes, and images on this Web site. For more Web quests developed by other teachers, do an Internet search for *Web quest biology.* You can easily adapt the ones you find to suit your course and students.

The Biology Place
www.biology.com
Click on the *Biology Place* icon to enter this Pearson Education Web site. Teachers can use it free of charge and independently of the publisher's textbooks. The LabBench page features a tutorial and short quiz for each of the 12 AP Labs; you can use the quiz as a pre-lab requirement. The BioCoach page presents concepts in an interactive manner. You will also find a series of tutorials on selected topics to use with your students. The site's graphics are excellent.

Gene Almanac
www.dnalc.org/home.html
Maintained by Cold Spring Harbor Laboratory, this site presents a variety of animations and tutorials on DNA, genetics, and biotechnology, from both current and historical contexts.

The Laboratory Safety Institute
www.labsafety.org
Here you will find many publications, video rentals, safety gear, information on lab safety training workshops, and links to current news concerning lab safety and accidents. The site covers such topics as goggles, gloves, and wearing contact lenses in a lab. It is maintained by the Laboratory Safety Institute, a nonprofit organization.

Where to Find Material Data Safety Sheets on the Internet
www.ilpi.com/msds
Maintained by Interactive Learning Paradigms, this free site provides links to 350,000 MSDSs from 1,500 manufacturers, as well as frequently-asked questions about MSDSs, a glossary of MSDS terms, and links to other sites that have large MSDS collections.

Professional Development

In this section, the College Board outlines its professional development opportunities in support of educators.

The teachers, administrators, and AP Coordinators involved in the AP and Pre-AP Programs compose a dedicated, engaged, vibrant community of educational professionals. Welcome!

We invite you to become an active participant in the community. The College Board offers a variety of professional development opportunities designed to educate, support, and invigorate both new and experienced AP teachers and educational professionals. These year-round offerings range from half-day workshops to intensive weeklong Summer Institutes, from the AP Annual Conference to AP Central, and from participation in an AP Reading to Development Committee membership.

Workshops and Summer Institutes

At the heart of the College Board's professional development offerings are workshops and Summer Institutes. Participating in an AP workshop is generally one of the first steps to becoming a successful AP teacher. Workshops range in length from half-day to weeklong events and are focused on all 34 AP courses and a range of supplemental topics. Workshop consultants are innovative, successful, and experienced AP teachers; teachers trained in Pre-AP skills and strategies; college faculty members; and other educational professionals who have been trained and endorsed by the College Board. For new and experienced teachers, these course-specific training opportunities encompass all aspects of AP course content, organization, evaluation, and methodology. For administrators, counselors, and AP Coordinators, workshops address critical issues faced in introducing, developing, supporting, and expanding Pre-AP and AP programs in secondary schools. They also serve as a forum for exchanging ideas about AP.

While the AP Program does not have a set of formal requirements that teachers must satisfy prior to teaching an AP course, the College Board suggests that AP teachers have considerable experience, and an advanced degree in the discipline before undertaking an AP course.

AP Summer Institutes provide teachers with in-depth training in AP courses and teaching strategies. Participants engage in at least 30 hours of training led by College Board–endorsed consultants and receive printed materials, including excerpts from AP Course Descriptions, AP Exam information, and other course-specific teaching resources. Many locations offer guest speakers, field trips, and other hands-on activities. Each institute is managed individually by staff at the sponsoring institutions under the guidelines provided by the College Board.

Participants in College Board professional development workshops and summer institutes are eligible for continuing education units (CEUs). The College Board is authorized by the International Association for Continuing Education and Training (IACET) to offer CEUs. IACET is an internationally recognized organization that provides standards and authorization for continuing education and training.

Workshop and institute offerings for the AP Biology teacher (or potential teacher) range from introductory to topic-specific events and include offerings tailored to teachers in the pre-AP years. To learn more about scheduled workshops and summer institutes near you, visit the Institutes & Workshops area on AP Central: apcentral.collegeboard.com/events.

Online Events

The College Board offers a wide variety of online events, which are presented by College Board–endorsed consultants and recognized subject experts to participants via a Web-based, real-time interface. Online events range from one hour to several days and are interactive, allowing for exchanges between the presenter and participants and between participants. Like face-to-face workshops, online events range in focus from introductory themes to specific topics, and many offer CEUs for participants. For a complete list of upcoming and archived online events, visit apcentral.collegeboard.com/onlineevents/schedule.

Archives of many past online events are available for free or for a small fee. Archived events can be viewed on your computer at your convenience.

AP Central

AP Central is the College Board's online home for AP professionals and Pre-AP. The site offers a wealth of resources, including Course Descriptions, sample syllabi, exam questions, a vast database of teaching resource reviews, lesson plans, course-specific feature articles, and much more. Bookmark the AP Biology Course Home Page to gain quick access to the resources and information on AP Central about AP Biology: apcentral.collegeboard.com/biology.

AP Program information is also available on the site, including exam calendars, fee and fee-reduction policies, student performance data, participation forms, research reports, college and university AP grade acceptance policies, and more.

AP professionals are encouraged to contribute to the resources on AP Central by submitting articles, adding comments to Teachers' Resources reviews, and serving as an AP Central content adviser.

Electronic Discussion Groups

The AP electronic discussion groups (EDGs) were created to provide a moderated forum for the exchange of ideas, insights, and practices among AP teachers, AP Coordinators, consultants, AP Exam Readers, administrators, and college faculty. EDGs are Web-based threaded discussion groups focused on specific AP courses or roles, giving participants the ability to ask and answer questions online for viewing by other members of the EDG. To join an EDG, visit apcentral.collegeboard.com/edg.

AP Annual Conference

The AP Annual Conference (APAC) is a gathering of the AP and Pre-AP communities, including teachers, secondary school administrators, and college faculty. The APAC is the only national conference that focuses on providing complete strategies for middle and high school teachers and administrators involved in the AP Program. The 2007 conference will be held July 11 to 15 in Las Vegas, Nevada. Conference events include presentations by each course's Development Committee, course- and topic-specific sessions, guest speakers, and pre- and postconference workshops for new and experienced teachers. To learn more about this year's event, please visit www.collegeboard.com/apac.

AP professionals are encouraged to lead workshops and presentations at the conference. Proposals are due in the fall of each year prior to the event (visit AP Central for specific deadlines and requirements).

Professional Opportunities

College Board Consultants and Contributors

Experienced AP teachers and educational professionals share their techniques, best practices, materials, and expertise with other educators by serving as College Board consultants and contributors. They may lead workshops and summer institutes, sharing their proven techniques and best practices with new and experienced AP teachers, AP Coordinators, and administrators. They may also contribute to AP course and exam development (writing exam questions or serving on a Development Committee) or evaluate AP Exams at the annual Reading. Consultants and contributors may be teachers, postsecondary faculty, counselors, administrators, and retired educators. They receive an honorarium for their work and are reimbursed for expenses. To learn more about becoming a workshop consultant, visit apcentral.collegeboard.com/consultant.

AP Exam Readers

High school and college faculty members from around the world gather in the United States each June to evaluate and score the free-response sections of the AP Exams at the annual AP Reading. AP Exam Readers are led by a Chief Reader, a college professor who has the responsibility of ensuring that students receive grades that accurately reflect college-level achievement. Readers describe the experience as providing unparalleled insight and exposure to the exam evaluation process and as an opportunity for intensive collegial exchange between high school and college faculty. (More than 8,500 Readers participated in the 2006 Reading.) High school Readers receive certificates awarding professional development hours and CEUs for their participation in the AP Reading. To apply to become an AP Reader, go to apcentral.collegeboard.com/reader.

Development Committee Members

The dedicated members of each course's Development Committee play a critical role in the preparation of the Course Description and exam. They represent a diverse spectrum of knowledge and points of view in their fields and, as a group, are the authority when it comes to making subject-matter decisions in the exam-construction process. The AP Development Committees represent a unique collaboration between high school and college educators.

AP Grants

The College Board offers a suite of competitive grants that provide financial and technical assistance to schools and teachers interested in expanding access to AP. The suite consists of three grant programs: College Board AP Fellows, College Board Pre-AP Fellows, and the AP Start-Up Grant, totaling over

$600,000 in annual support for professional development and classroom resources. The programs provide stipends for teachers and schools that want to start an AP program or expand their current program. Schools and teachers that serve minority and/or low-income students who have been traditionally underrepresented in AP courses are given preference. To learn more, visit apcentral.collegeboard.com/apgrants.

Our Commitment to Professional Development

The College Board is committed to supporting and educating AP teachers, AP Coordinators, and administrators. We encourage you to attend professional development events and workshops to expand your knowledge of and familiarity with the AP course(s) you teach or that your school offers, and then to share that knowledge with other members of the AP community. In addition, we recommend that you join professional associations, attend meetings, and read journals to help support your involvement in the community of educational professionals in your discipline. By working with other educational professionals, you will strengthen that community and increase the variety of teaching resources you use. Your work in the classroom and contributions to professional development help the AP Program continue to grow, providing students worldwide with the opportunity to engage in college-level learning while still in high school.

Works Cited

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Adelman, Clifford. *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment.* Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement, 1999.

Advanced Placement Report to the Nation. New York: College Entrance Examination Board, 2005. http://www.collegeboard.com/prod_downloads/about/news_info/ap/2005/ap-report-nation.pdf.

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2004, 2005 *AP Biology Course Description.* New York: College Entrance Examination Board, 2003.

AP Biology Course Description. New York: College Entrance Examination Board, 2004.

AP Biology Lab Manual for Students. New York: College Entrance Examination Board, 2001.

AP Biology Lab Manual for Teachers. New York: College Entrance Examination Board, 2001.

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The College Board. "The History of the AP Program." http://apcentral.collegeboard.com/apc/public/program/history/8019.html.

The College Board. "FAQs: How Many Students Take the AP Biology Exam Worldwide?" http://apcentral.collegeboard.com/apc/Pageflows/FAQ/VwDetailFAQ.do?faqid=2102.

Committee on Programs for Advanced Study of Mathematics and Science in American High Schools. *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools.* Edited by Jerry P. Gollub, et al. Washington, D.C.: National Academy Press, 2002.

Levy, Frank, and Richard J. Murnane. "Education and the Changing Job Market." *Educational Leadership* 62, no. 2 (October 2004): 80–83.

Milewski, Glenn B., and Jacqueline M. Gillie. *What Are the Characteristics of AP Teachers? An Examination of Survey Results*, Research Report 2002-10. New York: College Entrance Examination Board, 2002.

Schofield, Carolyn. *AP Biology Teacher's Guide.* New York: College Entrance Examination Board, 2000.

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Venezia, Andrea, Michael W. Kirst, and Anthony L. Antonio. *Betraying the College Dream: How Disconnected K–12 and Postsecondary Education Systems Undermine Student Aspirations.* Palo Alto, Calif.: The Bridge Project, 2003.