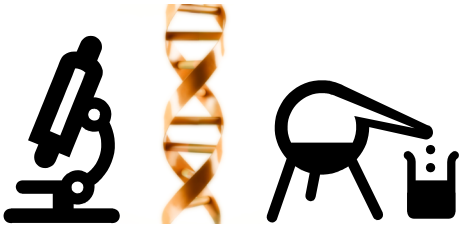
Fresno Unified School District

AP BIOLOGY
COURSE OUTLINE



Adapted from The College Board Course Description for AP Biology, 2006

Introduction

The AP Biology course is designed to be the equivalent of a two-semester college introductory biology course usually taken by biology majors during their first year. After showing themselves to be qualified on the AP Exam, some students, in their freshman year, are permitted to undertake upper-level courses in biology or to register for courses for which biology is a prerequisite. Other students may have fulfilled a basic requirement for a laboratory-science course and will be able to undertake other courses to pursue their majors.

AP Biology should include those topics regularly covered in a college biology course for majors. The college course in biology differs significantly from the usual first high school course in biology with respect to the kind of textbook used, the range and depth of topics covered, the type of laboratory work done by students, and the time and effort required of students. The textbooks used for AP Biology should be those used by college biology majors. The kinds of labs done by AP students must be the equivalent of those done by college students.

Prerequisites

The AP Biology course is an excellent option for any interested student who has completed two years of high school laboratory science: one year of Biology and one year of Chemistry. Due to the quantitative analysis that is required in the course, students should also have completed successfully at least one year of algebra. Because of the prerequisites, AP Biology will usually be taken in either the junior or senior year. Students are required to take the AP Biology exam at the end of the year. It aims to provide students with the conceptual framework, factual knowledge, and analytical skills necessary to deal critically with the rapidly changing science of biology.

Course Description

To provide students with the content equivalent to a college level introductory biology courses for biology majors as determined by the College Board, goals have been set for percentage coverage of the following three general areas:

- Molecules and Cells, 25%
- Heredity and Evolution 25%
- Organisms and Populations, 50%

These three areas have been subdivided into major categories with percentage goals specified for each. The percentage goals should serve as a guide for the AP Biology course and should be used to apportion the time devoted to each category. The exam is constructed using the percent-age goals as guidelines for question distribution.

The two main goals of AP Biology are to help students develop a conceptual framework for modern biology and an appreciation of science as a process. The ongoing knowledge explosion in biology makes these goals even more challenging. Primary emphasis in this AP Biology course is on developing an understanding of concepts rather than on memorizing terms and technical details. Essential to this conceptual understanding are a grasp of science as process rather than as an accumulation of facts; personal experience in scientific inquiry; recognition of unifying themes that integrate the major topics of biology; and application of biological knowledge and critical thinking to environmental and social concerns. The following guidelines are offered to help teachers and their students focus on unifying themes and key concepts.

Themes, Topics, and Concepts

Themes, topics, and concepts all give structure to an AP Biology course. *Themes* as overarching features of biology that applies throughout the curriculum. *Topics* are the subject areas in biology, and *concepts* are the most important ideas that form our current understanding of a particular topic.

An example of a topic is "cellular respiration." In a conceptual approach to this topic, for example, it is important to understand how membranes couple ATP synthesis to the energy released by electron transport. This key concept stands above discrete "facts" such as the role of a particular cytochrome in electron transport.

Emphasizing concepts over facts make the content of a biology course more meaningful and less overwhelming. A biology course has more structure and meaning when the key concepts for each topic are placed in the broader context of unifying themes. As an example, the theme of "energy transfer" helps students connect topics as diverse as cellular respiration and ecosystem dynamics. Concepts are the key ideas, restricted in scope to a certain topic. Themes cut across the topics. Increasingly, the AP biology Exam will emphasize the themes and concepts of biology and place less weight on specific facts.

Major Themes in AP Biology

I. Science as a Process
II. Evolution
III. Energy Transfer
IV. Continuity and Change
V. Relationship of Structure to Function
VI. Regulation
VII. Interdependence in Nature
VIII. Science, Technology, and Society

Topic Outline	*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	

Topic Outline	*Percentage of Course*
(Heredity and Evolution continued)	
C. Evolutionary Biology …….	8%
Early evolution of life	
Evidence for evolution	
Mechanisms of evolution	
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 issue	

Explanation of the Major Themes

The AP Biology Development Committee has identified eight major themes that recur throughout the course. AP Biology teachers should emphasize the pervasiveness of the themes to assist students in organizing concepts and topics into a coherent conceptual framework.

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.*

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.*

Textbooks

A number of recently published textbooks are appropriate for college students enrolled in AP Biology. Many such textbooks can be found by clicking on the Teachers' Resources tab on the AP Central home page (apcentral.collegeboard.com). AP Biology teachers in Fresno Unified are required to choose from this approved list.

The Teachers' Resources section of AP Central (apcentral.collegeboard.com) also offers reviews of textbooks, articles, Web sites, and other teaching resources.

The Laboratory

Laboratory experience must be included in all AP Biology courses. Since one-fourth to one-third of the credit in most college introductory biology courses is derived from laboratory work, it follows that approximately the same degree of emphasis should be placed on laboratory experience in an AP course. Descriptive and experimental laboratory exercises should be assigned that will provide the maximum opportunity for students to learn a variety of skills and those facts, principles, and concepts of general

biology covered in lectures, reading, and discussion. In addition, good laboratory exercises can present novel material not covered in other parts of the course. Laboratory work should encourage the development of important skills such as detailed observation, accurate recording, experimental design, manual manipulation, data interpretation, statistical analysis, and operation of technical equipment. Laboratory assignments offer the opportunity for students to learn about problem solving, the scientific method, the techniques of research, and the use of scientific literature. Laboratory investigations also encourage higher-order thinking, which may include evaluating and monitoring progress through an investigation, generating ideas, and formulating hypotheses.

Surveys confirmed that most colleges and universities have a laboratory component in their general biology courses that are taken by majors or by a combination of majors and non-majors. In teaching AP Biology, teachers are challenged to teach a course that is equivalent to a college level course in both quality and sophistication. In order to reflect these aspects, every AP Biology course should therefore have a substantial laboratory component. The AP Biology Development Committee has produced a set of 12 laboratories to provide a standard with which teachers can begin integrating laboratories more efficiently into the AP Biology curriculum.

School administrators should be aware that an AP college-level laboratory is significantly more expensive to operate than a typical high school biology laboratory and requires more time than non-laboratory courses. The first-level college course consists of approximately 40 to 50 hours of lecture and 30 to 40 hours of laboratory work per quarter or semester. Proportional allocations of time for laboratory work should be accorded an AP Biology course. School administrators should provide the equivalent of two double periods a week for laboratory work.

Some of the laboratories will require equipment schools may not have; alternative ways of conducting the laboratories are therefore offered. Schools should try to purchase college-level laboratory equipment eventually. Many teachers have indicated that their administrations do not fully realize the implications, in both cost and time, of incorporating serious laboratories into their programs. *An AP course is a college course, and the equipment and time allotted to laboratories should be similar to that in a college course.*

Many laboratories that teachers are already conducting are worthwhile and important. The laboratory section in this book describes the objectives of 12 laboratories that have been developed by the AP Biology Development Committee. The laboratories are not "perfect" or "ultimate" but exemplify experimental and quantitative, rather than descriptive, laboratory exercises. They are intended to challenge students' abilities to understand problems, develop and implement appropriate experimental designs, manipulate data, draw conclusions, think analytically, and develop hypotheses. In these laboratories, students are challenged to perform experiments drawn from some of the more important areas within modern biology, including biological chemistry, cell structure and function, energy transformation, molecular genetics, heredity, plant structure and physiology, animal structure and physiology, behavior, and ecology.

The laboratories should be considered basic introductions to, or springboards into, further experiments, studies, or independent projects. They are not intended to be ends in themselves.

To allow students to show their mastery of laboratory science skills and knowledge, each year some questions on the objective portion of the AP biology Exam and/or one or more of the four mandatory essay questions may reflect the topics and objectives associated with the 12 AP Biology laboratories. *This should not preclude AP Biology teachers from using their own existing laboratory exercises as long as they encompass the same topics and objectives.*

12 Recommended Biology Laboratories for AP Biology

1. Diffusion and Osmosis
2. Enzyme Catalysis
3. Mitosis and Meiosis
4. Plant Pigments and Photosynthesis
5. Cell Respiration
6. Molecular Biology
7. Genetics of Organisms
8. Population Genetics and Evolution
9. Transpiration
10. Physiology of the Circulatory System
11. Animal Behavior
12. Dissolved Oxygen and Aquatic Primary Productivity

An overview and objectives are presented for each laboratory on the pages that follow. Teachers can use this information in conjunction with their own laboratories that address these topics and objectives, or in conjunction with the *AP Biology Laboratory Manual for Students* and the *AP Biology Laboratory Manual for Teachers* (go to AP Central for ordering information).

Laboratory 1. Diffusion and Osmosis

Overview
In this laboratory, students will investigate the processes of diffusion and osmosis in a model of a membrane system. They will also investigate the effect of solute concentration on water potential as it relates to living plant tissues.

Objectives: Before doing this laboratory, students should understand:
- The mechanisms of diffusion and osmosis and their importance to cells;
- The effects of solute size and concentration gradients on diffusion across selectively permeable membranes;
- The effects of selectively permeable membrane on diffusion and osmosis between two solutions separated by the membrane
- The concept of water potential;
- The relationship between solute concentration and pressure potential and the water potential of a solution; and
- The concept of molarity and its relationship to osmotic concentration

After doing this laboratory, students should be able to:

- Measure the water potential of a solution in a controlled experiment;
- Determine the osmotic concentration of living tissue or an unknown solution from experimental data;
- Describe the effects of water gain or loss in animal and plant cells; and
- Relate osmotic potential to solute concentration and water potential.

Laboratory 2. Enzyme Catalysis

Overview

In this laboratory, students will observe the conversion of hydrogen peroxide (H_2O_2) to water and oxygen gas by the enzyme catalase. They will then measure the amount of oxygen generated and calculate the rate of the enzyme-catalyzed reaction.

Objectives: Before doing this laboratory, students should understand:

- The general functions and activities of enzymes;
- The relationship between the structure and function of enzymes;
- The concept of initial reaction rates of enzymes;
- How the concept of free energy relates to enzyme activity; and
- That changes in temperature, pH, enzyme concentration, and substrate concentration can affect the initial reaction rates of enzyme-catalyzed reactions.

After doing this laboratory, students should be able to:

- Measure the effects of changes of temperature, pH, enzyme concentration, and substrate concentration on reaction rates of an enzyme-catalyzed reaction in a controlled experiment; and
- Explain how environments factors affect the rate of enzyme-catalyzed reactions.

Laboratory 3. Mitosis and Meiosis

Overview

In this laboratory, students will investigate the process of mitosis and meiosis. The first part is a study of mitosis. They will use prepared slides of onion root tips to study plant mitosis and to calculate the relative duration of the phases of mitosis in the meristem of root tissue. Prepared slides of the whitefish blastula will be used to study mitosis in animal cells and to compare animal mitosis with plant mitosis. The second part is a study of meiosis. Students will simulate the stages of meiosis by using chromosome models. They will study the crossing over and recombination that occurs during meiosis. They will observe the arrangements of ascospores in the asci from a cross between wild type *Sordaria fimicola* and mutants for tan spore coat color in the fungus. These arrangements will be used to estimate the percentage of crossing over that occurs between the centromere and the gene that controls the tan spore color.

Objectives: Before doing this laboratory, students should understand:

- The events of mitosis in animal and plant cells;
- The events of meiosis (gametogenesis) in animal and plant cells; and

- The key mechanical and genetic differences between meiosis and mitosis.

After doing this laboratory, students should be able to:
- Recognize the stages of mitosis in a plant or animal cell;
- Calculate the relative duration of the cell cycle stages;
- Describe how independent assortment and crossing over can generate genetic variation among the products of meiosis;
- Use chromosome models to demonstrate the activity of chromosomes during meiosis I and meiosis II;
- Relate chromosome activity to Mendelian segregation and independent assortment;
- Demonstrate the role of meiosis in the formation of gametes in a controlled experiment, using a model organism;
- Calculate the map distance of a particular gene from a chromosome's center or between two genes, using a model organism;
- Compare and contrast the results of meiosis and mitosis in plant cells; and
- Compare and contrast the results of meiosis and mitosis in animal cells.

Laboratory 4. Plant Pigments and Photosynthesis

Overview
In this laboratory, students will separate plant pigments using chromatography. They will also measure the rate of photosynthesis in isolated chloroplasts. The measurement technique involves the reduction of the dye, DPIP. The transfer of electrons during the light-dependent reactions of photosynthesis reduces DPIP, and it changes from blue to colorless.

Objectives: Before doing this laboratory, students should understand:
- How chromatography separates two or more compounds that are initially present in a mixture;
- The process of photosynthesis;
- The function of plant pigments;
- The relationship between light wavelength and photosynthetic rate; and
- The relationship between light intensity and photosynthetic rate.

After doing this laboratory, students should be able to:
- Separate pigments and calculate their Rf values;
- Describe a technique to determine photosynthetic rates;
- Compare photosynthetic rates at different temperatures, or different light intensities, or different wavelengths of light using controlled experiments; and
- Explain why the rate of photosynthesis varies under different environmental conditions.

Laboratory 5. Cell Respiration

Overview

In this experiment, students will work with seeds that are living but dormant. A seed contains an embryo plant and a food supply surrounded by a seed coat. When the necessary conditions are met, germination occurs, and the rate of cellular respiration greatly increases. In this laboratory, students will measure oxygen consumption during germination. They will measure the change in gas volume in respirometers containing either germinating or nongerminating peas. In addition, they will measure the respiration of these peas at two different temperatures.

Objectives: Before doing this laboratory, students should understand:

- How a respirometer works in terms of the gas laws; and
- The general processes of metabolism in living organisms.

After doing this laboratory, students should be able to:

- Calculate the rate of cell respiration from experimental data;
- Relate gas production to respiration rate; and
- Test the effects of temperature on the rate of cell respiration in ungerminated versus germinated seeds in a controlled experiment.

Laboratory 6. Molecular Biology

Overview

In this laboratory, students will investigate some basic principles of genetic engineering. Plasmids containing specific fragments of foreign DNA will be used to transform *Escherichia coli* cells, conferring antibiotic (ampicillin) resistance. Restriction enzyme digests of phage lambda DNA will also be used to demonstrate techniques for separating and identifying DNA fragments using gel electrophoresis.

Objectives: Before doing this laboratory, students should understand:

- How gel electrophoresis separates DNA molecules present in a mixture;
- The principles of bacterial transformation;
- The conditions under which cells can be transformed;
- The process of competent cell preparation;
- How a plasmid can be engineered to include a piece of foreign DNA;
- How plasmid vectors are used to transfer genes;
- How antibiotic resistance is transferred between cells;
- How restriction endonucleases function; and
- The importance of restriction enzymes to genetic engineering experiments.

After doing this laboratory, students should be able to:

- Use plasmids as vectors to transform bacteria with a gene for antibiotic resistance in a controlled experiment;
- Demonstrate how restriction enzymes are used in genetic engineering;
- Use electrophoresis to separate DNA fragments;
- Describe the biological process of transformation in bacteria**;**
- Calculate transformation efficiency;
- Be able to use multiple experimental controls;

- Design a procedure to select positively for antibiotic resistant transformed cells; and
- Determine unknown DNA fragment sizes when given DNA fragments of known size.

Laboratory 7. Genetics of Organisms

Overview
In this laboratory, students will use living organisms to do genetic crosses. They will learn how to collect and manipulate the organisms, collect data from F1 and F2 generations, and analyze the results from a monohybrid, dihybrid, or sex-linked cross. The procedures that follow apply to fruit flies; teachers may substitute other procedures using different organisms.

Objectives: Before doing this laboratory, students should understand:
- Chi-square analysis of data; and
- The life cycle of diploid organisms useful in genetics studies.

After doing this laboratory, students should be able to:
- Investigate the independent assortment of two genes and determine whether the two genes are autosomal or sex-linked using a multi-generation experiment; and
- Analyze the data from their genetic crosses using chi-square analysis techniques.

Laboratory 8. Population Genetics and Evolution

Overview
In this activity, students will learn about the Hardy-Weinberg law of genetic equilibrium and study the relationship between evolution and changes in allele frequency by using their class to represent a sample population.

Objectives
Before doing this laboratory, students should understand:
- How natural selection can alter allelic frequencies in a population;
- The Hardy-Weinberg equation and its use in determining the frequency al alleles in a population; and
- The effects of allelic frequencies of selection against the homozygous recessive or other genotypes.

After doing this laboratory, students should be able to:
- Calculate the frequencies of alleles and genotypes in the gene pool of a population using the Hardy-Weinberg formula; and
- Discuss natural selection and other causes of microevolution as deviations from the conditions required to maintain Hardy-Weinberg equilibrium.
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Laboratory 9. Transpiration

Overview

In this laboratory, students will apply what they learned about water potential from Laboratory 1 (Diffusion and Osmosis) to the movement of water within the plant. They will measure transpiration under different laboratory conditions. They will also study the organization of the plant stem and leaf as it relates to these processes by observing sections of tissue.

Objectives: Before doing this laboratory, students should understand:

- How water moves from roots to leaves in terms of the physical/chemical properties of water and the forces provided by differences in water potential;
- The role of transpiration in the transport of water within a plant; and
- The structures used by plants to transport water and regulate water movement.

After doing this laboratory, students should be able to:

- Test the effects of environmental variables on rates of transpiration using a controlled experiment; and
- Make thin sections of stem, identify xylem and phloem cells, and relate the function of these vascular tissues to the structures of their cells.

Laboratory 10. Physiology of the Circulatory System

Overview

In Exercise 10A, students will learn how to measure blood pressure. In Exercise 10B, they will measure pulse rate under different conditions: standing, reclining, after the baroreceptor reflex, and during and immediately after exercise. The blood pressure and pulse rate will be analyzed and related to an index of relative fitness. In Exercise 10C, they will measure the effect of temperature on the heart rate of the water flea, Daphnia magna.

Objectives: Before doing this laboratory, students should understand:

- The relationship between temperature and the rates of physiological processes; and
- Basic anatomy of various circulatory systems.

After doing this laboratory, students should be able to:

- Measure heart rate and blood pressure in a human volunteer;
- Describe the effect of changing body position on heart rate and blood pressure;
- Explain how exercise changes heart rate;
- Determine a human's fitness index;
- Analyze cardiovascular data collected by the entire class; and
- Discuss and explain the relationship between heart rate and temperature.

Laboratory 11. Animal Behavior

Overview

In this laboratory, students will observe some aspects of animal behavior. In Exercise 11A, they will observe pillbugs and design an experiment to investigate their responses

to environmental variables. In Exercise 11B, they will also observe and investigate mating behavior in fruit flies. You may suggest other organisms or other types of animal behavior to study.

Objectives: Before doing this laboratory, students should understand:

- The concept of distribution of organisms in a resource gradient; and
- The difference between kinesis and taxis.

After doing this laboratory, students should be able to:

- Describe some aspects of animal behavior, such as orientation behavior, agonistic behavior, dominance display, or mating behavior; and
- Understand the adaptiveness of the behaviors they studied.

Laboratory 12. Dissolved Oxygen and Aquatic Primary Productivity

Overview

In Exercise 12A, students will measure and analyze the dissolved oxygen (DO) concentration in water samples at varying temperatures. In Exercise 12B, they will measure and analyze the primary productivity of natural waters or laboratory cultures using screens to simulate the attenuation of light with increasing depth.

Objectives: Before doing this laboratory, students should understand:

- The biological importance of carbon and oxygen cycling in ecosystems;
- How primary productivity relates to the metabolism of organisms in an ecosystem;
- The physical and biological factors that affect the solubility of gasses in aquatic ecosystems; and
- The relationship between dissolved oxygen and the process of photosynthesis and respiration and how these processes affect primary productivity.

After doing this laboratory, students should be able to:

- Measure primary productivity based on changes in dissolved oxygen in a controlled experiment; and
- Investigate the effects of changing light intensity and/or inorganic nutrient concentrations on primary productivity in a controlled experiment.