AP® Biology
Syllabus 2

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. In addition to the science sections of newspapers and popular science magazines, I employ such journals as *Science* and *Nature* as resources throughout the course, thus making modern environmental and social concerns associated with biology a continuing theme. **[C7]**

C7 -- applications of biological knowledge and critical thinking to environmental and social concerns

Course Overview

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. **[C8]** I organize my course around the eight themes from the AP Biology Curricular requirements. **[C6]** 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*.

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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 our 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. **[C4]**

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Regulation
Interdependence in nature
Science, Technology and society

C4 -- an understanding of science as a process rather than an accumulation of facts

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.

Every unit includes an exercise designed to integrate the topic of that unit into the eight major themes of the AP Biology Course Description. Throughout the time spent on each unit, we discuss as a class how the topic at hand relates to and fits within each theme, and how these themes transcend all of the unit topics. For example, in Unit 1 (Ecology and Behavior),

Theme 1 – Science as Process – Students engage in a project (Radish Seed Experiment) demonstrating the use of scientific reasoning to solve a problem.

Theme 2 – Evolution – Students compare ecological time with evolutionary time and examine how they correspond.

Theme 3 – Energy transfer – Students are asked to describe the movement, conversion, and storage of energy within an ecosystem, usually originating with the sun, then stored and converted to chemical energy by autotrophs, then passed on to heterotrophs and/or dissipated as heat.

Theme 4 – Continuity and change – Students are asked to consider how specific changes to an ecosystem (geological, climatic, introduction of new organisms, etc.) can affect the organisms that live within it.

Theme 5 – Relationship of Structure to Function – Students consider how organisms are physically adapted to survive and reproduce in their environment.

Theme 6 – Regulation – Students are to understand how an organism's regulatory mechanisms (such as those that control body temperature) serve to aid or hinder its survival in particular environments.

Theme 7 – Interdependence in Nature – The very key to ecology – how organisms interact within their environment, and how they cannot survive without such interactions.

Theme 8 – Science, Technology and Society – Students are asked to consider how the population growth of human beings has influenced local ecosystems throughout history, and how it continues to do so, even to the extent of affecting the entire biosphere. **[C6]**

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AP Biology Syllabus

Dates	Unit	Topics	Chapter Readings
First Semester, First Term			
Sept. 12–30	1	Ecology and Behavior **[C3]** *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 **[C1]**	2, 3, 4, 5, 6
Oct. 24–Nov. 10	3	Cells, Cell Membranes, Transport, Cell Communications **[C1]**	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 **[C2]**	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 **[C2]** Construction (completed and graded during the third term)	12, 13, 14, 15, 19 (pp. 354-56)
Second Semester, Third Term			
Jan. 30–	7	Evolution **[C2]**	22, 23, 24, 25,

C3 -- Organisms and Populations

C1 -- Molecules and Cells

C2 -- Heredity and Evolution

Feb. 17			26
Feb. 27–Mar. 17	8	Three Domains, Phylogenetic Trees, Prokaryote and Eukaryote Diversity, Animal Phylogeny and Diversity, Animal Development **[C3]**	21, 27, 28, 32, 33, 34, 47
Mar. 20–Apr. 7	9	Plants **[C3]**	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

C3 -- Organisms and Populations

Lab Schedule **[C8]**

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.

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- *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. 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.

In order to weed out endless terms, I teach around the eight themes presented in the AP Biology curriculum requirements. **[C6]**
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. **[C5]**

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 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. I continually use this theme of unity and interdependence in nature to illustrate to students the important environmental, medical, and social concerns associated with biology. **[C7]**

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C5 -- recognition of evolution as the foundation of modern biological models and thought

C7 -- applications of biological knowledge and critical thinking to environmental and social concerns

Lab Component

Working in pairs, students usually do 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. **[C8]**

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

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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. Independent research projects require a full lab report. 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

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.

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).

Term Projects

Each term students complete a project that requires them to do independent work and turn in a report. **[C4]**

C4 -- an understanding of science as a process rather than an accumulation of facts

- 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 Karyote 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.