AP Biology Syllabus

AP Biology is a course with a large curriculum and high expectations. At the beginning of the year, I tell students that this course will ask much more of them than a regular honors course. They will have to work more and become more independent learners. I am here to help, but they must also learn to help themselves when I am not around. Students who put in the time and effort throughout the year will gain a lot of knowledge about biology, but they will also grow tremendously as students. I ask them to consider what is motivating them to take the course, and what they expect to get out of it. I suggest that students whose only goal is to get a 4 or 5 on the AP exam so they can supposedly get into the college of their dreams should re-evaluate if they have the commitment and love of learning necessary to maintain their effort throughout the year.

I expect my students to learn a lot of material from the textbook. I cannot cover everything in class. To help, I provide a reading guide for each chapter. The reading guide points out concepts that are particularly important, as well as letting students know what concepts they will not be required to learn. The reading guide is not intended to be a study guide that gives a list of each thing they need to know, but it does help organize their approaches to each reading assignment. In addition, students are required to make study guides for each chapter, which I look at, grade for completion, and return to the students. The study guides they produce are used again at the end of the year during review for the AP exam.

Students are also encouraged to search out other sources of information. Many students like to use the CD-ROM that comes with their textbook. I suggest that they use their Cliffs guide throughout the year, not just when studying for the AP exam at the end of the year. Many students also purchase other AP exam prep books. I have a list of useful web sites on my web page, and I sometimes mention other web sites in class. I illustrate points in class using relevant DVD's, especially "Visualizing Cell Processes" and snippets from the Howard Hughes Medical Institute Holiday Lecture DVD's.

Class time is mostly used to answer questions from the reading and go over difficult points, or to do labs. We have 70 minute periods, so it is possible to do most labs during class time. However, Lab 2 (enzyme catalysis) is done on a Sunday afternoon so that it does not need to be divided up into more than one lab period. Some additional class time is used to work on crafting good answers to a free response questions. There are also optional Sunday sessions where students hone skill in preparation for the AP exam.

My course is not organized the way that my textbook is organized. In order to help students see the connections between units, I move around. The order of topics is logical, however. We start with the basics, reviewing the main ideas in biology and the necessary simple chemistry. The book introduces "eleven themes that unify biology" in the first chapter, which are quite similar to the eight themes of the official AP bio course description (science as process; evolution; energy transfer; continuity and change; relationship of structure to function; regulation; interdependence in nature; science, technology, and society). We refer to the themes throughout the year.

We then move on to cells and membranes. Once we have membranes under our belts, we study processes in which membranes and membrane proteins play a crucial role. These are cellular communication, excretory systems, and nervous systems. We then return to the small scale and cover metabolism and cellular respiration. We then learn about how the glucose for cellular respiration enters a body (digestive systems), how it and oxygen (among other substances) travels through a body (circulatory systems), and then one important way in which ATP generated by cellular respiration is used (muscular systems).

We then return to cellular energetics by studying photosynthesis, which leads to a study of plant structure and function, transport, and nutrition. After the foray into plants, we return to basic cellular processes to study cell division. The study of cell division leads directly into genetics, followed by a study of what genes really are and how they function in cells (including replication, transcription, and translation).

The study of the function of DNA leads directly into a study of control of gene expression in both prokaryotes and eukaryotes, as well as learning about modern nucleic acid technology and methodologies.

With this strong foundation in classical and modern genetics, we move on to evolution and speciation. Students have studied evolution in their first-year biology class, so they have some understanding of it, and we have been referring to it throughout the year. Nonetheless, it's important to do an in-depth study of the topic.

Evolution leads well into a study of the immune system, since B cell maturation and antibody production is also a selective process. We then complete our organismal studies by focusing on regulation in both animals and plants (endocrine systems and plant responses to environmental signals). Following hormones with reproductive systems and animal development is a natural next step. Finally, we finish with the big picture: ecology.

Because of our schedule, I ask students to do some work over school breaks. The taxonomy unit is covered on their own over winter break. Students must search out answers to specific questions and fill out a packet. In addition, some of the ecology unit is covered during spring break. Again, students must turn in work indicating that they have covered the material adequately.

Course Textbook

Biology, 7th ed. by Neil A. Campbell and Jane B. Reece, Pearson Education, Inc., 2005

Additional Materials

CliffsAP Biology, 2nd ed., by Phillip E. Pack. Wiley Publishing, 2001

Laboratory notebook (carbonless duplicate life sciences notebook from Hayden-McNeil)

Course Outline

Unit	Topics	Lab exercises	Assigned readings
Introduction to the process of scientific inquiry	• Experimental design, including controls and sample size consideration • Hypotheses • Data collection and analysis	Lab 11: Animal Behavior (one full class period)	Students will have read chapter 1, which pertains to this material, over the summer
1: Principles of biology and basic chemistry	<u>Principles of biology</u> • Levels of biological organization • Emergent properties • Feedback regulation • The three domains of life • Biology as an experimental science (referring back to above) • Science as a human endeavor in a social context • 11 themes <u>Basic chemistry</u> (should be a review) • Elements and matter • Electrons Energy levels Role in bond formation • Chemical bonds Ionic Non-polar covalent Polar covalent Hydrogen • Van der Waals interactions <u>Water</u> (should largely be a review) • Effects of polarity and hydrogen bonding Cohesion High specific heat High heat of evaporation Structure and density of ice • Strong solvent • pH <u>Carbon</u> (should largely be a review) • Carbon's bonding pattern (4 covalent bonds) • Functional groups (names and structures) • Structure of ATP		Chapters 1-4 (summer reading assignmen t)
2: Cells: Their components and communication	<u>Biological macromolecules</u> • Concept of polymers Hydrolysis and dehydration synthesis • Carbohydrates- simple sugars and their polymers Structure and uses of important examples • Lipids Structure and uses of many lipids, focusing on fatty acids, triacylglycerols, phospholipids, and steroids • Proteins Structure of amino acids Nature of the peptide bond Four levels of protein structure Diversity of proteins Relationship of structure to function	Lab 1: Diffusion and Osmosis (one full class period, plus return for data collection next day)	Chapters 5, 6, 7, and 11

	Denaturation • Nucleic acids Structure of a nucleotide Watson-Crick model of DNA structure Comparison of RNA to DNA (structure and function) <u>Cells</u> • Microscopy techniques • Comparison of structure of prokaryotic cells to eukaryotic cells • Evolutionary origins of organelles • Surface area : volume problem faced by cells • Structure and function of nucleus, organelles, and other cell parts • Comparison of plant and animal cells • Extracellular materials, incl. cell walls and glycocalyx • Intercellular junctions <u>Membranes</u> • Fluid-mosaic model, with lots of detail • Process of science: how membrane models have changed over the years • Roles of membrane proteins • Role of extracellular carbohydrates in cell-cell recognition • Selective permeability • Osmosis and cell membranes • Forms of active and passive transport • Endocytosis, exocytosis, phagocytosis, and pinocytosis <u>Cellular communication</u> (not as detailed as the textbook) • Concept of second messenger systems • Cascades that amplify signal within cell • Importance of phosphorylation for regulating many proteins • Why one signal molecule may have different effects on different cells		
3: Introduction to animal body systems that focus on membrane activities	<u>Introduction to animal body systems</u> • Common challenges, various solutions • Correlation between form and function • Energy budgets and metabolic rates • Homeostasis! • Feedback loops to regulate and maintain homeostasis • Thermoregulatory mechanisms <u>Osmoregulation and excretory systems</u> • The challenge of maintaining a constant internal environment • Nitrogenous wastes—why one and not another? • Excretory systems, with special emphasis on mammalian urinary system <u>Nervous systems</u> • Structure of nervous systems • Reflex arcs • Neuron structure • Events of an action potential • What happens at a synapse • Adaptations that help signal conduction (myelinization) • Organization of the vertebrate nervous system, with emphasis on human CNS (not in as much detail as the book)		Chapters 40, 44, and 48

4: Principles of metabolism and cellular respiration	Metabolism • Concept of metabolic pathways • Different forms of energy • First and second laws of thermodynamics • Free energy and chemical reactions • Enzymes as biological catalysts • Conditions that affect enzyme activity • Regulation of enzyme activity by inhibition and allosteric interactions Cellular respiration • Stages of aerobic cellular respiration • Concept of chemiosmosis • Stages of anaerobic cellular respiration (both alcohol fermentation and lactic acid fermentation) • Comparison of efficiency of aerobic vs. anaerobic • How other food molecules feed into respiration pathways • Regulation of respiration pathways	Lab 2: Enzyme Catalysis (done on a Sunday, 3-4 hrs.) Lab 5: Cellular Respiration (1 full class period, plus set-up the class before)	Chapters 8 and 9
5: How animals obtain, distribute, and utilize energy-containing molecules	Animal digestive systems • Feeding strategies • Essential nutrients and why they are essential • Stages of food processing • Brief overview of digestive systems of hydra, earthworm, insects, birds, and ruminants (evolutionary considerations taken) • Focus on human digestive system—structure and function of each part • Distinction between alimentary canal and accessory organs • Pay special attention to correlation of form and function • Role of the cecum in some herbivores Circulatory systems • Why most animals need circulatory systems • Open vs. closed circulatory systems • Different types of blood vessels • Composition of blood • Circulatory patterns in fish, amphibians, reptiles, birds • Human heart anatomy • Natural pacemaker • Blood pressure hill • Lymphatic system • Clotting cascade Respiratory systems • Characteristics of respiratory surfaces • Connection between respiratory systems and circulatory systems (except in insects) • Gills, including countercurrent exchange in fish gills • Tracheal systems in insects • Structure of human respiratory system • Ventilation of lungs (role of diaphragm, etc.) • Diffusion of gases into and out of blood • Role of hemoglobin and other respiratory pigments	Lab 10A: learn how to take blood pressure (one half of a class period) Labs 10B and 10C: Physiology of the Circulatory System (one full class period)	Chapters 41, 42, and 49
6: Photosynthesis and basic plant anatomy and physiology	Photosynthesis • Importance of photosynthesis to life on earth • Light-dependent reactions of photosynthesis • How it was determined that the oxygen plants release comes from water (^{18}O experiments) • Role of photosynthetic pigments • Cyclic photophosphorylation • Calvin cycle	Lab 4A: Plant Pigment Paper Chromatography (1 full class period) Lab 4B: Rate of	Chapters 10, 35, 36, and 37 Article: “How Trees Get High” by

	• C4 metabolism • CAM metabolism Plant structure and growth • Basic plant anatomy • Three types of tissues (ground, vascular, dermal) • Parenchyma, collenchyma, sclerenchyma • Xylem and phloem • Role of meristems • Differentiation of cells in growing plant Transport in plants • Review of water potential (used in Lab 1) • Transpiration, including cohesion-tension model • Mycorrhizae • Control of stomata by guard cells • Flow from source to sink in phloem Plant Nutrition • Need for minerals through soil • Nitrogen cycle and role of bacteria in the cycle • Nitrogen fixation by symbiotic bacteria in root nodules in certain plants	Photosynthesis (one full class period) Lab 9: Transpiration (covers four days of data collection)	Adam Summers, from Natural History Magazine (March 1, 2005)
7: Basics of taxonomy	March Through the Kingdoms assignment (parts of chapters 25-34) modified from: http://www.bio.kimunity.com/documents/FebVacationAssignment2004.pdf To be done independently over winter break and turned in the first class in January Students study taxonomy and consider how it reflects evolutionary relationships		Students locate necessary information in the textbook and the Cliffs guide
8: Cell division	The cell cycle and mitosis • Chromosome duplication (without going into details of DNA replication) • Binary fission in prokaryotes • Phases of the cell cycle • Control of cell cycle by cyclin-dependent kinases • Events of mitosis (in detail) • Role of mitotic spindle • Comparison of cytokinesis in plant and animal cells • Loss of cell cycle control: cancer Meiosis • Comparison of asexual and sexual reproduction • Diploid vs. haploid • Alternation of meiosis and fertilization • Events of meiosis (in detail) • Comparison of mitosis and meiosis • Role of independent assortment and crossing over in generating variety • Importance of variation in a population	Lab 3: Mitosis and Meiosis (1.5-2 full class periods) Activity that demonstrates the variation possible due to independent assortment	Chapters 12 and 13
9: Classical genetics and molecular genetics	Mendelian genetics • Story of Mendel's work • Dominant vs. recessive alleles (including common misunderstandings of what dominant means in terms of what goes on in the cell and/or frequency in the population) • Law of segregation • How to make predictions using Punnett squares • Testcrosses • Law of independent assortment • Basic rules of probability	Lab 7: Fast Plants genetics lab (covers 4 days) Lab 7: Drosophila lab demo (half of one class period)	Chapters 14, 15, 16, and 17 Article: "DNA is Not Destiny" by Ethan Watters, from

	• Codominance, esp. in human blood types • Incomplete dominance • Pleiotropy • Epistasis • Many phenotypes are due to the actions of several genes • Effect of environment on phenotype • How to analyze pedigrees • Carriers of recessive disease alleles <u>Chromosomal basis of genetics</u> • Patterns of gene inheritance are due to patterns of chromosome inheritance • Thomas Hunt Morgan and fruit fly genetics • Importance of model systems such as Drosophila • Linkage and recombination maps • Inheritance of sex-linked traits • X inactivation (Barr body formation) • Chromosomal abnormalities (structural and numbers) • Imprinting <u>DNA and inheritance</u> • The discoveries that led to the determination that DNA is the genetic material • The discovery of the structure of DNA • Details about DNA structure • DNA replication and repair in detail • How semiconservative replication was demonstrated • Proofreading and DNA repair mechanisms • Replication of telomeres <u>Transcription and translation</u> • Evidence that genes specify proteins, esp. Beadle and Tatum's work • Genetic code and how it was elucidated • Near universality of the genetic code • Events of transcription • Post-transcriptional modifications of mRNA's • Splicing of mRNA's to remove introns • Events of translation • Components of a ribosome • Post-translational modifications of proteins • Coupling of transcription and translation in prokaryotes • Mutations and their effect on the protein product	Lab activity: M&M χ^2 activity (half of one class period)	<u>Discover Magazine</u>, Nov. 2006
10: Prokaryotic gene expression and modern DNA technology	<u>Viral and Bacterial Genetics</u> • Viral structures • Viral life cycles • Requirement for host cell • Lytic vs. lysogenic cycles of phage • Animal virus reproduction Budding and the incorporation of cell membranes Retroviruses • Some viruses can cause cancer; discussion of who should be given the new HPV vaccine • Other infectious particles Viroids Prions • Recombination in bacteria Transformation Transduction Conjugation • Plasmids Antibiotic resistance and how it is growing due to	Lab 6A: bacterial transformation (one full class period, plus return for results next day). For this lab I use the BioRad pGLO kit. Lab 6B: agarose gel electrophoresis of DNA fragments (1 full class period, plus return for	Chapters 18 and 20

	widespread antibiotic overuse • Transposons • Operons (focus on lac and trp operons) - details of how the operon is regulated DNA Technology and Genomics • Cloning a piece of DNA into a plasmid or phage vector Use of restriction endonucleases Use of ligase How to find cells containing the vector • DNA libraries cDNA vs. genomic DNA • Expression vectors, both prokaryotic and eukaryotic • Amplification by PCR • Agarose gel electrophoresis and Southern blotting • RFLPs and SNPs as genetic markers • Mapping of DNA Review of genetic mapping Physical mapping • Sequencing DNA • What to do with sequenced genomes Locating genes Comparing species Studying expression of many genes at a time (chips) Proteomics • Applications Gene therapy (mixed successes) RNAi Diagnostics Production of pharmaceutical products Transgenic plants and animals Discussion of ethical issues Forensic applications	results next day, after staining)	
11: Eukaryotic gene expression and development	Eukaryotic Genomes • Chromatin structure and DNA packing, including regulation • Ways to control eukaryotic gene expression Transcriptional regulation Control of mRNA half-life Translational regulation Protein degradation • Genes involved in cancer • Roles of non-coding DNA in the genome Repetitive DNA • Transposable elements (and their role in evolution) • Gene families (including their role in evolution) • Exon shuffling and evolution Genetics of Development • The idea of model organisms and several examples • Concepts of cell division, differentiation, and morphogenesis • Differences in cells within one organism are due to differences in gene expression • Potency and cloning of plants and animals Discussion of the ethics of animal cloning • Animal stem cells Discussion of the ethics of embryonic stem cells • Roles of transcriptional regulation and cytoplasmic determinants • Pattern formation in *Drosophila*, focusing on *Hox* genes		Chapters 19 and 21 Article: "How Does a Single Cell Become a Whole Body?" by Mark Caldwell from Discover Magazine Nov. 1992 (old, but still good)

	(and noting the evolutionary conservation of *Hox* genes) • Cell fate maps in *C. elegans*, focusing on induction and apoptosis • Comparative embryology and what we can learn		
12: Evolution	<u>Darwinism</u> • The scientific and cultural environment in which Darwin lived and worked • Darwin's theory of descent with modification due to natural selection • Concept of "fitness" • Specific examples that show natural selection at work in short time frames Evolution of drug-resistant HIV and bacterial strains Recent work on anoles in the Caribbean • Supporting evidence Homologous structures Comparative embryology (with caveats) Molecular data Biogeography Fossil record <u>Evolution of Populations</u> • The modern synthesis of evolution and genetics • Gene pools and allele frequencies • Hardy-Weinberg • Sources of variation that make evolution possible • Genetic drift compared to natural selection • Modes of selection (directional, stabilizing, disruptive) • Sexual selection and sexual dimorphism <u>Speciation</u> • Cladogenesis vs. anagenesis • Biological species concept (and its limitations) • Barriers that keep species separated (prezygotic and postzygotic) • Allopatric speciation • Sympatric speciation • Speciation by polyploidy • Adaptive radiations, with a focus on islands • Concept of punctuated equilibrium • The effects that heterochrony can have • The effects that changes in spatial patterns can have	Lab 8: Population Genetics and Evolution (1 full class period)	Chapters 22, 23, and 24 A handout that I created called "Evolution Myths"
13: Immunity and hormonal regulation	<u>The Human Immune System</u> • Components of innate immune system • Structure of an antibody • Variable regions result from gene rearrangement • Proliferation of selected B cells (clonal selection) • Primary response vs. secondary response to antigen • Immunization (both active and passive) • Blood groups and transfusions (relate it to genetics) • Disorders of the immune system Allergies Autoimmune disorders Immunodeficiencies <u>Endocrine Systems</u> • Basic characteristics of hormones (relate it to chap. 11) • Review of negative feedback loops • Major human endocrine glands • Actions of major human hormones		Chapters 43, 45, and 39

	• Invertebrates also have hormones—ex: role of ecdysone in insects Plant Responses • Major plant hormones • Classic coleoptile experiments on phototropism and auxin • Role of ethylene in fruit ripening • Phytochrome and its effects on plants • Photoperiodism, including classical experiments of effects of flashes of light during night • Gravitropism • Thigmotropism • Responses to environmental stresses • Defenses against disease and herbivores		
14: Reproduction and development	Angiosperm Reproduction • Flower anatomy • Pollination • Double fertilization • Development of seeds and fruits • Asexual reproduction in plants, including vegetative propagation • Transgenic plants and concerns about their release to the larger environment Animal Reproduction • Types of asexual reproduction in animals • Sexual reproduction, with a focus on humans Reproductive system anatomy Production of sperm and eggs (details of spermatogenesis and oogenesis) Hormonal regulation, especially of menstrual cycle Animal Development • Review of ideas presented in Unit 11 • Acrosomal reaction and blocks against polyspermy • Cleavage • Axis determination • Gastrulation • Fates of the three embryonic germ layers • Neurulation and neural crest cells • Somites • Role of extraembryonic membranes in eggs • Grey crescent and Spemann's organizer • The idea of potency and that human cells remain totipotent up to the 8 cell stage, allowing for testing of IVF embryos for diseases (ethical issues discussed here) • Limb formation		Chapters 38, 46 and 47
15: Ecology	Read chapters 50, 51, 52, and 53 (independent assignment for spring break) Chapter 50 is an introduction to ecology. Little attention is paid to the earth science portions of the chapter. Biomes are covered. Chapter 51 is behavioral ecology. This brings back Lab 11, which we did at the beginning of the year. Important concepts include imprinting, pheromones, learning and communication. An evolutionary context is provided. Chapter 52 is population ecology. Important concepts include survivorship curves, exponential vs. logistic growth, age structure pyramids, and global carrying capacity. Questions are raised about the ethics of trying to control human population growth.	Lab 12: Dissolved Oxygen and Aquatic Primary Productivity (normally 1.5-2 full class periods, but only 1 if there are 2 sections and 1 can set up the gross productivity bottles and the	Chapter 54 is covered in class

	Chapter 53 is community ecology. Important concepts include interspecific interactions, trophic structures, and disturbance and ecological succession. <u>Ecosystems</u> • Energy flow and nutrient cycling (review from 1st year bio) • Productivity (gross and net) • Energy budgets • Food pyramids showing energy transfers between trophic levels • Human impact on ecosystems	other can do the assays)	
Review	<u>Review for final exam and AP Bio exam</u> • Review of all the required labs • Review of major topics (students are mostly using their own chapter study guides and the Cliffs book at this point) • Review of free response question writing skills and tactics • Practice tests (final exam for the class is a shortened old AP exam)		
16: Post-exam lab work	In this unit, I may also pilot test labs and activities that I want to incorporate into the class in coming years.	Lab 9B: sectioning and staining a stem (1 class period) Fetal pig dissection (3 full class periods), with option to dissect other specimens as well	

Each unit includes a test of the material in that unit, with the exception of the units covered during winter and spring breaks. Tests generally consist of multiple choice questions and short essay questions, along the lines of the AP exam. The winter break assignment requires the filling out of a packet, which will be graded. For the spring break assignment, students will prepare chapter summaries that will be graded.

Grading Policies

Grades will be determined according to the following scale:

Homework	10%
Labs, activities, and projects	35%
Tests and quizzes	40%
Work habits and attitude	5%
Midterm and final exams	10%

"Work habits and attitude" includes preparedness, attitude, engagement during class, involvement in class discussions, how directly and honestly you interact with me, and how well you met your responsibilities as a student, including turning work in on time and working with your assigned lab partners.

Labs

Most labs are based on the AP Biology Lab Manual for Students (2001), with some minimal modifications. Two of the labs differ significantly from the ones in the manual. The transpiration lab uses the "whole plant method" instead of potometers. The genetics lab uses Fast Plants seedlings instead of doing crosses with *Drosophila*, in a lab derived from Carolina Scientific material. In all cases, the objectives listed in the AP Biology Lab Manual for Students are met.

All labs are hands-on and performed by students with the exception of the *Drosophila* lab demo. Although I meet the objectives of Lab 7 with the Fast Plants lab, I think it is important for students to understand what it is like to do experiments with a classical genetics model system. Thus, we use Wards AP Biology Lab Companion CD-ROM Series Lab 7: Genetics of Drosophila v.2.1 to simulate F_1 and F_2 crosses with *Drosophila*. This is done as a demo for the entire class.

In almost all cases, students must do preparatory work before performing a lab. This work will include (but may not be limited to) reading the lab handout, writing out the procedure in the student's own words or pictures, and setting up data tables. Failure to prepare for lab will certainly affect a student's grade for that lab and may render the student unable to perform the lab on the assigned day.

Lab write-ups generally consist of data analysis and written questions found in the AP Biology Lab Manual for Students, although additional analysis questions are often added. Work is done in the lab notebook and the copy pages are turned in for evaluation. All lab work is graded. Lab write-ups take a considerable amount of time outside of class, and should be done carefully since they make up a large proportion of a student's overall grade.

Lab write-ups should be each student's own creation. When answering discussion questions, students may confer with one another and consult outside sources, but all answers should be in the student's own words. Failure to answer a question in your own words will result in no credit for the question, no matter how good the answer is. If two students submit the exact same answer, each of the students will get a score of zero for that question.

Lab groups will be assigned, usually randomly. Students are expected to work well with any classmate(s) at all times. I will ask for feedback about how well each member of the group contributed to the work of performing the lab. If partners report that a student did not participate adequately, that will affect his or her grade on the lab.

Students are assumed to have lab skills from their introductory chemistry and biology courses (both of which are required for admission to AP Biology). Thus, students do not do labs on how to use a microscope, pH and buffers, examination of microbes, cell size and diffusion, properties of water, etc.

Schedule

Classes meet for 70 min., every other day.