Syllabus

Advanced Biology – Semester A

Course Overview

Biology is presented as one form of scientific inquiry, the process of channeling human curiosity into purposeful exploration, discovery, and exploration of observable natural phenomena. Biology is the study of life, but it is most important as a shared method of asking questions all humans have about life and living things, and communicating responses to the questions in clear and understandable forms.

In this blended online course (employing both online and face-to-face learning), students will be taught and encouraged to continually pose questions about the subject matter. Through exploration and discovery of the phenomenon at the core of each lesson, students will be guided to answer their own questions and be able to discuss the phenomenon in ways that reflect sound scientific practices. Biology is presented as a living process, one that carries a body of current understandings and a method of building on those understandings to either deepen them or replace them with better explanations. In particular, we will explore these eight themes identified as the focus for AP-level Biology instruction:

- Science as a Process
- Evolution
- Energy Transfer
- Continuity and Change
- Relationship of Structure to Function
- Regulation
- Interdependence in Nature
- Science, Technology, and Society

Course Goals

- Foster a love of science, especially in terms of Biology.
- Provide learners with chances to inquire about natural phenomena, asking natural and well-formed questions.
- Expose learners to how the scientific method is applied in studying living things.
- Empower learners to explore natural phenomena in order to answer their own questions.
- Train learners to draw conclusions from observations in order to construct their own understanding of biological concepts.

- Build skills for learners to communicate their questions, observations, findings and conclusions to others interested in similar questions about living things.
- Expose learners to significant concepts and themes in Biology.
- Tie lessons together in terms of the eight themes which structure AP Biology.
- Assess learners' ability to ask and answer questions about nature.
- Reinforce an interest in nature and the living things that make up our common environment.
- Provide learners with a set of tools for solving problems that relate to nature and impact the daily lives of learners.

Teaching Strategies

Structure

This blended online course is organized into units and lessons. Each lesson incorporates multiple learning activities designed to develop, apply, and assess specific learning objectives. (See *Course Outline*, below.)

Concept Development Activities

In order to generate skills for lifelong learning and to employ the most appropriate learning approach for each topic, twenty-five percent of the lessons will use student-driven, constructivist approaches for concept development. For example, the lesson on Mendelian Genetics from Unit 4 of Semester A provides multiple opportunities for learners to take on-screen instruction about Mendel's discoveries and produce Punnett Squares that exemplify each of his discoveries. The experience of going from explanation of the concept to constructing an illustration of it themselves will move learners' understanding of those discoveries to a deeper level.

The remaining lessons will employ direct instruction approaches. Regardless of the approach, students will take full advantage of the online learning environment, linking to rich online, multimedia, and interactive resources. Developing critical of 21st century skills is an important secondary goal of this course.

Application and Inquiry Work Products

Application and inquiry will be an integrated part of the lessons, requiring higher-level cognitive work. Students will submit written work online for review, comment, and grading.

Discussions

Students will also have the opportunity to engage in online (asynchronous) discussions during this course. Discussion topics provide the chance to dig deeper into specific scientific and STEM concepts and applications.

Science Pedagogy

This course will be grounded in inquiry learning and will make special effort to integrate the study of biology in a broader STEM perspective.

- **Inquiry** – As often as possible, lessons will include inquiry-based approaches to new material. In particular, the 5 Es approach will be adapted for use in this course, asking learners to Engage, Explore, Explain, Elaborate, and Evaluate. The lesson "Water: An Essential for Life" in Unit 1 of Semester A provides a good example of this strategy. The lesson is structured around a series of short hands-on experiences with water in the form of short lab-like activities. This approach provides learners with a chance to experience the properties of water and form their own sense of the central ideas in the lesson.

- **STEM:** In today's global economy, employers are looking for skilled workers who are innovative problem solvers and critical thinkers. Such skills encompass what STEM education is. It fuses science, technology, engineering, and mathematics into one cohesive discipline. STEM education is designed to open students' minds to the exciting and fulfilling opportunities in STEM-related careers.

  Many guidelines have been integrated into the course design and lessons that embody the Goals of a STEM education. Lessons will use real-world scenarios that that will illustrate to students to how math, science, engineering, and technology are applied in professional and everyday lives. Students will leverage technologies such as graphing calculators, spreadsheets, and the Internet to help them solve difficult and complex problems. Students will also be given culminating activities that will require them to solve open-ended, complex problems.

  For example, the lesson on Gene Frequencies in Unit 6 of Semester A starts with a young high school student finding she has an interest in genetics. Through a school mentoring program, she finds a mentor who is a practicing scientist in this field. The high school student has some misconceptions about certain genetic principles and, through the lesson, has a chance to overcome them with the help of her mentor. This structure models the STEM career paths open to students, as

well as a method for students to explore and discover their own path to a STEM career.

Lab Components

Purpose

The lab activities for science subjects provide learners with hands-on exposure to the scientific concepts they are studying and exploring. Science instruction is as much about learning how to do science, as it is about developing a conceptual understanding – labs bring those two elements together.

Approach

This course uses a blended model for lab experiences. Some lab experiences are provided using online and alternative approaches as noted below. The twelve primary lab experiences that form the basis of an advanced course in Biology are designed to be conducted in person with the planning and guidance of a teacher. They are modeled on the labs provided in the *College Board AP Biology Lab Manual for Students.* The schedule of these in-person labs is listed in the Lab Schedule section below.

Alternate approaches:

- **Informal labs:** Sometimes called “kitchen sink” labs, these activities use materials readily available at home or in non-lab facilities within a school. They will provide true hands-on exposure to phenomena without the use scientific experimental equipment. For example, the lesson “Water: An Essential of Life” described above includes a series of such informal hands-on experiences that do not require lab equipment to carry out.

- **Interactive simulations**: These rich, interactive simulations are open-ended and multi-dimensional. They allow learners to adjust various factors in a simulated experimental situation to see how the outcome of the procedure changes in reaction to their inputs. The simulations allow for open-learner exploration, as well as more structured and guided inquiry into various phenomena. For the topic Evolution in Unit 6 of Semester A, an online simulation on Natural Selection provides learners with the chance to change certain variables and observe successive generations of species as the population adapts to the environmental conditions.

- **Analysis of experimental data:** Experiencing the practice of science need not involve doing every step of the gathering of data by hand. Many scientists share data sets from observations or experiments, and the questions posed, calculations performed, and the analysis and interpretation of the results can be quite a powerful lab experience. The tasks included in this course will point learners to existing data sets, show them an analytical approach, then ask them to perform calculations, graph, analyze, and report back on that data using solid principles of scientific inquiry.

- **Simulated labs:** Using various media, such as videos and microscope slides, learners will observe experiments virtually and then carry out analysis and interpretation of that experience as if they had performed the steps themselves. The lesson “The Cell Cycle” in Unit 3 of Semester A, provides an example of this alternate approach to labs. It uses a series of photographs of microscope slides to simulate the experience of taking onion skin cell samples. The microscope slides are presented for the learner to identify the cell cycle phases and then put the phases in the right sequence.

Lab Schedule

Below is a unit-by-unit schedule of labs. These labs are based on the College Board AP Biology Lab Manual for Students. Each lab requires teacher planning and supervision, lab facilities, and equipment. The labs are sequenced based on the order of the lessons that relate most directly to the labs. The lab numbers reference their sequence in the lab manual. Some units do not have labs associated with them.

Unit 1 - Nature of Life
This unit has no labs.

Unit 2 - The Chemistry of the Cell
Lab 2 – Enzyme Catalysis – pp. 19-29

Unit 3 – Cell Structures and Functions
Lab 1 – Diffusion and Osmosis – pp. 1-18
Lab 5 – Cell Respiration – pp. 54-63
Lab 4 – Plant Pigments and Photosynthesis – pp. 45-53
Lab 3 – Mitosis – pp. 29-34

Unit 4 - Descriptive Genetics
Lab 3 – Meiosis – pp. 35-44
Lab 7 – Genetics of Organisms – pp.78-89

Unit 5 - Molecular Genetics
Lab 6 – Molecular Biology – pp.64-77

Unit 6 –Evolution
Lab 8 – Population Genetics and Evolution – pp. 90-98

Student Evaluation

Multiple evaluation tools will be used to assess understanding at all appropriate cognitive levels and to reflect AP assessment methodology:

- **Lesson-Level Mastery Tests:** Each lesson will be accompanied by an AP-style multiple-choice mastery test to assess mastery of the basic lesson concepts.
- **Self-Assessment Lesson Activities:** Especially useful in constructivist/inquiry lessons, self-assessment activities will provide sample responses against which learners can assess their own learning.
- **Teacher-Graded Lesson Activities:** These lesson activities will require teacher assessment, employing AP-style objective rubrics. Students will be provided with the rubrics for each assignment.
- **Unit-Level Posttests:** Each unit will have a multiple-choice assessment to confirm that all the material within the unit has been retained and can be applied in a larger context than a single-lesson format.
- **Unit-Level Culminating Activities:** Learners will have the chance to apply their knowledge of the concepts that cut across the lessons within a unit. Most of the units will include this teacher-graded activity for evaluation of higher order thinking skills.
- **End-of-Semester Tests:** At the end of each of the two semesters, learners will take a multiple-choice test to assess mastery of lesson concepts and provide additional practice for a long-form exam like the AP exam.

AP Biology Semester A Course Outline

- **Unit**
  This course will be structured in 18-week semester with the following unit:

  <u>Semester A</u>

Nature of Life
The Chemistry of the Cell
Cell Structures and Functions
Descriptive Genetics
Molecular Genetics
Evolution

- **Readings**

  This course will employ the following textbook as a resource for deep research and learning:

  Campbell, N.A, and Reece, J.B. *Biology AP Edition*. San Francisco: Pearson Education, Inc., 2005.

  Online lessons will provide instructional content that approximates the classroom experience for this content, but will not be comprehensive on its own. In addition, in some instances, published articles available online may be referenced for instructional purposes.

- **Schedule, Topics, and Objectives**

  The units will proceed through two semesters following the schedule below.

  <u>Advanced Biology - Semester A</u>

  Unit 1 – Nature of Life (4 Weeks, 8 Lessons)

  What Is Biology? - Understand how human curiosity is channeled by the scientific method into purposeful inquiry about living things

  - List and explain the eight themes of the AP Biology course
  - Explain the interdisciplinary nature of biology
  - Describe and explain how scientists use the scientific method to add new knowledge to biology
  - Apply the scientific method to scientific problems and laboratory investigations
  - Use appropriate math skills to analyze data

  Conducting Biology Research – Use lab equipment safely and properly to carry out a biology experiment

- Students will be able to recognize by name and use appropriately and safely equipment such as Bunsen burners, graduated cylinders, microscopes, balances, etc.

Communicating Your Results - Communicate results of scientific investigations

- Students will be able to organize data into charts and graphs and do necessary calculations

The Chemical Nature of Biology - Understand enough about basic chemistry to better understand biology

- Explain the following basic concepts of chemistry: structure of an atom, isotopes, ions, ionic and covalent bonds, solutions, suspensions, and colloids
- *Textbook support - Campbell and Reece, Ch. 2*

Water: An Essential for Life - Describe the properties of water that make it an essential molecule of life

- Describe the chemical structure of water
- List and explain the properties of water significant to life
- *Textbook support - Campbell and Reece, Ch. 3*

Acids, Bases, and Buffers - Explain the nature and role of acids, bases, and buffers in biology

- Distinguish chemically between acids, bases, and salts
- Explain differences in pH values
- Describe what aqueous buffers do
- *Textbook support - Campbell and Reece, Ch. 3*

Carbon: A Central Building Block - Explain the unique chemistry of the carbon atom and why it is central to building organic compounds

- Explain the tetravalent nature of carbon and its tendency to form covalent bonds
- Describe the formation of double and triple carbon bonds

- Describe the formation and naming of hydrocarbon isomers
- *Textbook support - Campbell and Reece, Ch. 4*

Building the Molecules of Life - Identify and explain the six basic functional groups used to build the molecules of life

- Recognize the six basic functional groups (hydroxyl, carboxyl, carbonyl, amino, sulfhydryl, phosphate) and describe their reactivity
- Explain the resonant nature of some of these groups
- *Textbook support - Campbell and Reece, Ch. 4*

Unit 2 – The Chemistry of the Cell (2 Weeks, 5 Lessons)

Polymers: Combinations of Monomers - Explore and explain how polymers are made up of monomers and why that is important in biology

- Understand that most biomolecules are polymers of smaller molecules called monomers
- Understand the energy input/output (exergonic and endergonic reactions) of polymers
- Understand the type of bonds formed (covalent, but one type is relatively weak like starch as it needs to be easily broken, and some are very strong like cellulose that form structures)
- *Textbook support - Campbell and Reece, Ch. 5*

Carbohydrates, Lipids, Proteins, and Nucleic Acids - Describe how the four major groups of biological molecules function in natural systems

- Recognize by name the three major groups of carbohydrates: monosaccharides, disaccharides, and polysaccharides
- Recognize by name the three major groups of lipids: trigylcerides, phospholipids, and steroids
- Recognize the basic structure of an amino acid and how it forms peptide bonds
- Describe the four levels of protein structure and several environmental factors that can cause proteins to become denatured

- Recognize the structure and types of nucleotide and describe how they bond together to form polynucleotides
- State the common functions of each of the molecules learned in this section
- *Textbook support - Campbell and Reece, Ch. 5*

Transforming Energy - Recognize that energy transformation through metabolic pathways is a core process which defines life

- Explain the difference between catabolism and anabolism
- Discuss free energy (delta G) in relation to exergonic and endergonic reactions
- Describe how the unique structure of ATP allows for the energy transformations metabolism requires
- *Textbook support - Campbell and Reece, Ch. 8*

Enzymes - Explain the structure, function, and denaturation of enzymes

- Explain how unique enzyme structure and function results from its primary, secondary, tertiary, and quaternary levels of formation
- Discuss the "induced fit" hypothesis in enzyme action
- *Textbook support - Campbell and Reece, Ch. 8*

Cells: Prokaryotic and Eukaryotic - Compare prokaryotic and eukaryotic cells.

- Identify the structures and size of a prokaryotic cell
- Compare it to a eukaryotic cell
- *Textbook support - Campbell and Reece, Ch. 6*

Unit 3 – Cell Structures and Functions (3 Weeks, 6 Lessons)

Overview of Cell Structures and Functions - Describe the general structure of cells, the structures inside of cells and how biologists study the way these structures function in cells

- Describe techniques used by biologists to study cell ultra-structures and functions

- Identify and describe the structure and function of all the eukaryotic cell organelles
- Compare plant and animal cell ultrastucture
- *Textbook support - Campbell and Reece, Ch. 6*

Osmosis, Diffusion, and Cellular Transport - Explain how materials are transported in and out of cells

- Describe the fluid-mosaic model for cell membrane
- Explain how materials cross cell membrane by simple diffusion
- Describe the factors controlling osmosis and diffusion in cells
- Predict the rate and direction of osmosis in and out of cells
- Relate the terms hypotonic, hypertonic, and isotonic to homeostasis in cells
- Describe ways in which materials are actively transported across cell membranes
- *Textbook support - Campbell and Reece, Ch. 7*

Energy in Cells - Discuss in detail how cells use organic compounds as their energy source

- Discuss the major phases and reactions of cellular respiration showing net energy yields
- Compare fermentation and anaerobic respiration to cellular respiration
- Explain how ATP is generated in the mitochondrial membrane by chemiosmosis
- *Textbook support - Campbell and Reece, Ch. 9*

Photosynthesis - Discuss photosynthesis in detail as the process through which plants convert light energy into chemical energy in a stable form for all life to use

- Discuss the major phases and reactions of photosynthesis showing how glucose is generated
- Explain the chemical relationship between respiration and photosynthesis
- *Textbook support - Campbell and Reece, Ch. 10*

The Cell Cycle - Describe the cell cycle and how it functions

- List the two primary purposes of somatic cell division
- Describe what occurs in each phase of the cell cycle
- Recognize, describe, and identify by name each phase of somatic cell division
- Describe the similarities and differences between plant and animal somatic cell division
- Textbook support - Campbell and Reece, Ch. 12

Regulating the Cell Cycle - Explain how the cell cycle is controlled and regulated in a cell

- Explain the internal and external control systems that regulate the rate of cell division
- Relate loss of regulatory control in the cell cycle to the onset of cancer
- Textbook support - Campbell and Reece, Ch. 12

Unit 4 – Descriptive Genetics (2 Weeks, 5 Lessons)

Sexual Reproduction - Describe how sexual reproduction contributes to genetic diversity

- Compare and contrast sexual and asexual reproduction
- Describe how chromosomes assort into sex cells during meiosis and compare it to mitosis
- Show how the recombination of chromosome pairs during fertilization results in an offspring with different genetic makeup than either parent
- Textbook support - Campbell and Reece, Ch. 13

Meiosis in Life Cycles - Explain the process and role of meiosis in sexual life cycles.

- Outline the steps of meiosis during gametogenesis.
- Describe the pattern of assortment of chromosomes during meiosis into sex cells.

- Differentiate between spermatogenesis and oogenesis.
- Identify the sources of genetic diversity produced by meiosis.
- Mendelian Genetics
- Textbook support - Campbell and Reece, Ch. 13

Mendelian Genetics - Explain and solve problems involving basic Mendelian genetics

- Show how Mendel's experiments led him to develop his four laws of inheritance
- List and explain Mendel's Laws of Inheritance
- Use probability laws to solve genetics problems
- Solve mono and dihybrid genetic problems using Punnett squares
- Textbook support - Campbell and Reece, Ch. 14

Gene-Based Inheritance - Explain and solve problems involving gene-based inheritance

- Describe six patterns of inheritance at the gene level (incomplete and co-dominance, multiple alleles, pleiotropy, epeistasis, and polygenic inheritance) discovered since Mendel
- Textbook support - Campbell and Reece, Ch. 14

Chromosomal Inheritance - Describe experiments that led to the discovery of, and solve problems related to, chromosomal inheritance.

- Distinguish between gene based inheritance and chromosome based inheritance
- Show how geneticists use recombinant frequencies to construct gene maps
- Explain how sex is determined genetically
- Show how each of the following change Mendel's expected ratios in a genetic cross: crossing over, sex-linkage, non-disjunction, chromosomal mutations
- Textbook support - Campbell and Reece, Ch. 15

Unit 5 – Molecular Genetics (3 Weeks, 6 Lessons)

Overview of DNA - Describe DNA, its structure, and how it functions, including replication and repair

- Describe in detail the anti-parallel structure of DNA
- Describe the replication of DNA
- List and explain the role of enzymes in DNA replication
- Describe how DNA is proof-read and repaired
- Textbook support - Campbell and Reece, Ch. 16

DNA and Genes - Explain what a gene is and how it functions

- Describe RNA transcription
- Explain the similarities and differences between the three types of RNA
- Describe how a protein is translated, from initiation to termination
- Textbook support - Campbell and Reece, Ch. 17

Mutations of Cells - Explain the nature and role of mutations in altering protein structure.

- Explain how insertion, deletion, and substitution mutations can alter the structure of a translated protein.
- Describe the effects mutations may have upon cells.
- List common environmental factors that cause mutations.
- Textbook support - Campbell and Reece, Ch. 17

Genetic Control - Describe how genetic control in prokaryotes occurs

- Explain how protein synthesis is controlled in prokaryotic cells by both inducible and repressible operons
- Explain the role of gene regulation upon cellular differentiation
- Textbook support - Campbell and Reece, Ch. 18

Gene Splicing - Describe the organization and control of genes on eukaryotic chromosomes and experimentally isolate a gene (or DNA fragment), inserting it into a foreign host to have it be active

- Describe the levels of structure of a eukaryotic chromosome
- Suggest several uses for non-coding DNA
- Compare protein synthesis in eukaryotic cells to prokaryotic cells
- Discuss how eukaryotic gene control differs from prokaryotic gene control
- Experimentally, insert a foreign gene (plasmid) into bacteria and determine the efficiency of transformation of the bacterial genetics
- Perform a gel electrophoresis and analyze band structure to determine the size of unknown, isolated DNA fragments
- Textbook support - Campbell and Reece, Ch. 19-20

Genetic Engineering - Describe common methods of genetic engineering and some of their applications

- Describe natural methods of recombining DNA that viruses and bacteria do
    - Describe the basic structure of a virus and its life cycle to show how it can change (mutate) a gene in another organism
    - Show how bacterial plasmids can enter cells and alter host gene action
- Explain methods used to artificially modify an organism's genetics by inserting a foreign gene
- Explain the importance of restriction enzymes in genetic engineering
- Explain some common types of genetic engineering technology currently in use
- Discuss both useful and potentially harmful aspects of genetic engineering technology
- Textbook support - Campbell and Reece, Ch. 20

Unit 6 – Evolution (4 Weeks, 8 Lessons)

Darwin and Natural Selection - Explain how Darwin developed his theory of natural selection

- List the contributions of earlier scientists that Darwin needed to develop his concept of natural selection
- List and explain Darwin's five main points to natural selection
- Apply Darwin's theory to an example of evolution through natural selection (ex finches)
- Compare and contrast the evolutionary theories of Darwin and Lamarck
- Textbook support - Campbell and Reece, Ch. 22

Gene Frequencies - Show how changes in gene frequencies can lead to evolutionary changes

- Determine the frequency of a dominant and recessive allele observed in a population
- Calculate the expected frequency of the homozygous dominant, heterozygous dominant, and heterozygous recessive members of a population for an observable trait
- List the conditions necessary for the Hardy-Weinberg Equilibrium to show that a population will not evolve
- Use the Hardy-Weinberg Equilibrium to show the effects of various selective pressures upon gene frequency in a population
- Relate these selection pressures to evolution in a population
- Textbook support - Campbell and Reece, Ch. 23

Microevolution - Define microevolution and understand how it results from changes in gene frequencies in a living population

- Explain how changes in gene frequencies in a population lead to microevolution
- Describe five factors that change gene frequencies in a population and result in microevolution
- Textbook support - Campbell and Reece, Ch. 23

Adaptive Evolution - Explain how adaptive evolution can result from the genetic variation that arises in living populations

- Describe how genetic variation occurs and is maintained in a population
- Describe three patterns of natural selection and the condition that causes each to occur in nature
- Textbook support - Campbell and Reece, Ch. 23

Speciation - Explain the most common mechanisms in evolution that lead to speciation

- Define a species biologically
- Show how allopatric and sympatric mechanisms lead to speciation
- Compare and contrast adaptive radiation and convergent evolution
- Textbook support - Campbell and Reece, Ch. 24

Macroevolution - Describe the concept of punctuated equilibrium and how it contributes to macroevolution

- Describe the theory of punctuated equilibrium and how it explains macroevolution
- Compare and contrast punctuated equilibrium and gradualism
- Textbook support - Campbell and Reece, Ch. 24

Phylogeny - Describe how biologists trace the phylogeny of organisms by obtaining evidence of evolution using a variety of methods

- Describe four common methods of study that evolutionary biologists use to trace phylogeny (fossils, anatomy, embryos, molecules)
- Explain how each method ultimately relates to changes in gene frequencies and speciation
- Explain a cladistic analysis used in constructing a phylogenic tree
- Describe how the geological time scale provides evidence of evolution and mass extinctions
- Textbook support - Campbell and Reece, Ch. 25

Evolution of Life on Earth - Outline the history of the evolution of life on Earth

- Describe the formation of the Earth and its original primordial condition
- Describe the chemical evolution which occurred to create the molecules of life in the "primordial soup" and experiments to support this theory
- Explain the heterotroph hypothesis and describe the nature of the earliest protocells
- Explain how natural selection led to the development of primitive photosynthesis
- Describe how the "oxygen revolution" transformed Earth and paved the way for advanced life
- Textbook support - Campbell and Reece, Ch. 26