SCIENCE DEPARTMENT

The Department's Educational Philosophy

Students will engage in the process of science through scientific inquiry and application of the underlying scientific concepts. Students will use qualitative as well as computational thinking to analyze and interpret data. Students will develop the necessary skills to generate, interpret qualitative and quantitative data, evaluate scientific claims and provide evidence for scientific conclusions.

Guiding Principles

- Students will engage with the process of science by participating in hands-on activities and labs that help students to gain a better understanding of underlying concepts, elucidate concepts and relationships, or develop inquiry-based experiments.
- Students will apply their computational skills to interpret and represent data.
- Students will be able to evaluate the merits of conceptual models and apply the appropriate models and relationships .
- Students will be able to support scientific claims, provide evidence for those claims, and make conclusions based on qualitative and quantitative data.
- Students will work collaboratively.

ADVANCED BIOLOGY (H/AP): Course #451

Course Frequency: **Full year course**
Credits Offered: **Five**
Prerequisites: **Biology, Chemistry, and teacher recommendation.**
(Minimum grade of B in Biology (H) strongly preferred)

Background to the Curriculum

This course is aligned with the College Board AP Biology Curriculum. The course curriculum was developed over the past 20+ years to incorporate the most up-to-date AP Biology Curriculum Learning Objectives.

Core Topics/Questions/Concepts/Skills

- The History of Life on Earth
- Evidence of Evolution
- Metabolism
- Cell Respiration and Photosynthesis
- Ecosystem Structure
- Evolutionary Trade-Offs
- Population Change
- Macromolecules
- Enzymes and Cell Communication
- Protein Synthesis
- Organelles
- Mitosis and DNA Replication
- Meiosis and Heredity
- Variation and Populations
- Gene Regulation
- Biotechnology
- Ecological Relationships of Bacteria and Fungi
- Cellular Mechanisms of Antibiotic Resistance

- Transmission of Genes in Bacterial Cells
- Evolution of Antibiotic Resistance
- The Cell Membrane
- Transport Across Cell Membranes
- Cell Communication
- Human Impact on the Evolution of Ecosystems and Microbe Diversity
- The Cell Cycle and Division
- Cell-to-Cell Communication
- The Environment and Cancer

Course-End Learning Objectives

The History of Life on Earth

- Describe the scientific evidence that provides support for models of the origin of life on Earth. (SYI-3.E)
- Describe factors that lead to the extinction of a population. (EVO-3.G)
- Explain how the risk of extinction is affected by changes in the environment. (EVO-3.H)
- Explain species diversity in an ecosystem as a function of speciation and extinction rates. (EVO-3.I)
- Explain how extinction can make new environments available for adaptive radiation. (EVO-3.J)
- Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts. (EVO-1.B)
- Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes. (EVO-2.C)

Evidence of Evolution

- Describe the causes of natural selection. (EVO-1.C)
- Explain how natural selection affects populations. (EVO-1.D)
- Describe the types of data that provide evidence for evolution. (EVO-1.M)
- Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time. (EVO-1.N)
- Explain how shared, conserved, fundamental processes and features support the concept of common ancestry for all organisms. (EVO-2.A)

- Describe the fundamental molecular and cellular features shared across all domains of life that provide evidence of common ancestry. (EVO-2.B)
- Describe the types of evidence that can be used to infer an evolutionary relationship. (EVO-3.B)
- Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness. (EVO-3.C)

Metabolism

- Describe the role of energy in living organisms. (ENE-1.H)
- Describe the structural features of a cell that allow organisms to capture, store, and use energy. (SYI 1.F)

Cell Respiration & Photosynthesis:

- Describe the photosynthetic processes that allow organisms to capture and store energy. (ENE-1.I)
- Explain how cells capture energy from light and transfer it to biological molecules for storage and use. (ENE1.J)
- Describe the processes that allow organisms to use energy stored in biological macromolecules. (ENE-1.K)
- Explain how cells obtain energy from biological macromolecules in order to power cellular functions. (ENE-1.L)
- Describe the strategies organisms use to acquire and use energy. (ENE-1.M)
- Explain how changes in energy availability affect populations and ecosystems. (ENE-1.N)
- Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem. (ENE-1.O)
- Explain how community structure is related to energy availability in the environment. (ENE-4.C)

Ecosystem Structure

- Describe the structure of a community according to its species composition and diversity. (ENE-4.A)
- Explain how interactions within and among populations influence community structure. (ENE-4.B)
- Describe factors that influence growth dynamics of populations. (SYI-1.G)
- Explain how the density of a population affects and is determined by resource availability in the environment. (SYI-1.H)
- Explain the relationship between changes in the environment and evolutionary changes in the population. (EVO-1.G)

Evolutionary Trade-Offs

- Explain how the same genotype can result in multiple phenotypes under different environmental conditions. (SYI-3.B)

Evolutionary Response

- Explain how evolution is an ongoing process in all living organisms. (EVO-3.A)
- Describe the conditions under which new species may arise. (EVO-3.D)

Population Change

- Describe the change in the genetic makeup of a population over time. (EVO-1.J)
- Describe the conditions under which allele and genotype frequencies will change in populations. (EVO-1.K)
- Explain the impacts on the population if any of the conditions of Hardy-Weinberg are not met. (EVO-1.L)
- Describe the rate of evolution and speciation under different ecological conditions. (EVO-3.E)
- Explain the processes and mechanisms that drive speciation. (EVO-3.F)
- Vocab: Natural, artificial, and sexual selection; population, gene pool, Hardy-Weinberg principle
- Ecological Stress & Climate Change

Learning Objectives:

- Explain how humans can affect diversity within a population. (EVO-1.F)
- Explain the relationship between changes in the environment and evolutionary changes in the population. (EVO-1.G)
- Explain how invasive species affect ecosystem dynamics. (SYI 2.A)
- Describe human activities that lead to changes in ecosystem structure and/ or dynamics. (SYI 2.B)
- Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics. (SYI 2.C)
- Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments. (SYI-3.A)

Macromolecules

- Describe the properties of the monomers and the types of bonds that connect monomers in biological macromolecules. (ENE-1.A)

Enzymes and Cell Communication

- Describe the properties of enzymes. (ENE-1.D)
- Explain how enzymes affect the rate of biological reactions. (ENE-1.E)
- Explain how changes to the structure of an enzyme may affect its function. (ENE-1.F)
- Explain how the cellular environment affects enzyme activity. (ENE-1.G)

- Describe positive and negative feedback mechanisms in regard to homeostasis. (ENE-3.A, ENE-3.B, ENE-3.C)
- Explain how the behavioral and/or physiological responses of an organism are related to changes in the internal or external environment. (ENE-3.D)
- Describe the different types of cellular responses elicited by a signal transduction pathway. (IST-3.F)
- Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway. (IST-3.G)

Protein Synthesis

- Describe the structural similarities and differences between DNA and RNA. (IST-1.A)
- Describe the mechanisms by which genetic information flows from DNA to RNA to protein. (IST-1.N)
- Describe how the phenotype of an organism is determined by its genotype. (IST-1.O)
- Explain how the binding of transcription factors to promote regions affects gene expression and the phenotype of the organism. (IST-2.C)
- Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms. (IST-2.D)

Organelles

- Describe the structure and function of subcellular components and organelles. (SYI-1.D)
- Describe the membrane-bound structures of the eukaryotic cell. (ENE-2.K)
- Explain how internal membranes and membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions. (ENE-2.L)
- Explain how subcellular components and organelles contribute to the function of the cell. (SYI-1.E)
- Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells. (EVO-1.A)
- Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment. (ENE-1.C)

Mitosis & DNA Replication

- Describe the events that occur in the cell cycle. (IST-1.B).
- Explain how mitosis results in the transmission of chromosomes from one generation to the next. (IST-1.C).
- Describe the role of checkpoints in regulating the cell cycle. (IST-1.D).
- Describe the mechanisms by which genetic information is copied for transmission between organisms. (IST-1.M).

Meiosis & Heredity

- Explain how meiosis results in the transmission of chromosomes from one generation to the next. (IST-1.F).
- Explain the inheritance of genes and traits as described by Mendel's laws. (IST-1.I).
- Explain deviations from Mendel's model of the inheritance of traits. (IST-1.J).
- Describe the characteristics of DNA that allow it to be used as the hereditary material. (IST-1.L).
- Explain how the process of meiosis generates genetic diversity. (IST-1.H)
- Explain how chromosomal inheritance generates genetic variation in sexual reproduction. (SYI-3.C)

Variation & Populations

- Explain how random occurrences affect the genetic makeup of a population. (EVO-1.H).
- Explain the interaction between the environment and random or preexisting variations in populations. (EVO-1.O).

Gene Regulation

- Describe the types of interactions that regulate gene expression. (IST-2.A).
- Explain how the location of regulatory sequences relates to their function. (IST-2.B)

Biotechnology

- Explain the use of genetic engineering techniques in analyzing or manipulating DNA. (IST-1.P).

Ecological Relationships of Bacteria and Fungi

- Explain how interactions within and among populations influence community structure. (ENE-4.B)*
- Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem. (ENE-1.O)*

Cellular Mechanisms of Antibiotic Resistance

- Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells. (EVO-1.A)*
- Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules. (SYI-1.B)
- Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule. (SYI-1.C)
- Describe the role of the cell wall in maintaining cell structure and function. (ENE-2.D)

Transmission of genes in bacterial cells

- Describe the structures involved in passing hereditary information from one generation to the next. (IST-1.K)
- Describe the mechanisms by which genetic information flows from DNA to RNA to protein. (IST-1.N)*
- Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection. (IST-4.B)
- Explain the use of genetic engineering techniques in analyzing or manipulating DNA. (IST-1.P)*

Evolution of Antibiotic Resistance

- Describe the causes of natural selection. (EVO-1.C)*
- Explain how natural selection affects populations. (EVO-1.D)*
- Explain how evolution is an ongoing process in all living organisms. (EVO-3.A)*
- Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures (SYI-3.D)
- Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time. (EVO-1.N)*
- Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness. (EVO-3.C)*

The Cell Membrane

- Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment. (ENE-1.B)
- Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell. (ENE-2.A)
- Describe the Fluid Mosaic Model of cell membranes. (ENE-2.B)
- Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function. (SYI-1.A)

Transport Across Cell Membranes

- Explain how the structure of biological membranes influences selective permeability. (ENE-2.C)
- Describe the mechanisms that organisms use to maintain solute and water balance. (ENE-2.E)
- Describe the mechanisms that organisms use to transport large molecules across the plasma membrane. (ENE-2.F)
- Explain how the structure of a molecule affects its ability to pass through the plasma membrane. (ENE-2.G)
- Describe the processes that allow ions and other molecules to move across membranes. (ENE-2.J)
- Explain how concentration gradients affect the movement of molecules across membranes. (ENE-2.H)
- Explain how osmoregulatory mechanisms contribute to the health and survival of organisms. (ENE-2.I)

Cell communication

- Describe the ways that cells can communicate with one another. (IST-3.A)
- Explain how cells communicate with one another over short and long distances. (IST-3.B)
- Describe the components of a signal transduction pathway. (IST-3.C)
- Describe the role of components of a signal transduction pathway in producing a cellular response. (IST-3.D)
- Describe the role of the environment in eliciting a cellular response. (IST-3.E)
- Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population. (IST-5.A)

Human Impact on the Evolution of Ecosystems and Microbe Diversity

- Explain how invasive species affect ecosystem dynamics. (SYI-2.A)
- Describe human activities that lead to changes in ecosystem structure and/ or dynamics. (SYI-2.B)
- Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics. (SYI-2.C)
- Describe the relationship between ecosystem diversity and its resilience to changes in the environment. (SYI-3.F)
- Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long- term structure. (SYI-3.G)

The Cell Cycle & Cell Division

- Describe the role of random processes in the evolution of specific populations. (EVO-1.I)
- Describe the effects of disruptions to the cell cycle on the cell or organism. (IST-1.E)
- Describe similarities and/ or differences between the phases and outcomes of mitosis and meiosis. (IST-1.G)
- Describe the events that occur in the cell cycle. (IST-1.B)
- Explain how mitosis results in the transmission of chromosomes from one generation to the next. (IST-1.C)
- Describe the role of checkpoints in regulating the cell cycle. (IST-1.D)
- Describe the various types of mutation. (IST-2.E)
- Explain how changes in genotype may result in changes in phenotype. (IST-4.A)

Cell-to-Cell Communication

- Describe the role of the environment in eliciting a cellular response. (IST-3.E)
- Describe the ways that cells can communicate with one another. (IST-3.A)
- Explain how cells communicate with one another over short and long distances. (IST-3.B)
- Describe the components of a signal transduction pathway. (IST-3.C)
- Describe the role of components of a signal transduction pathway in producing a cellular response. (IST-3.D)
- Explain how the binding of transcription factors to promote regions affects gene expression and the phenotype of the organism. (IST-2.C)
- Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms. (IST-2.D)

The Environment & Cancer

- Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population. (IST-5.A)
- Describe the various types of mutation. (IST-2.E)*

Assessment

Student learning will be measured through tests, quizzes and lab work, including lab practicals.

Materials and Resources

Campbell, N., Williamson, B. and Heyden, R. (2006). *Biology*. Needham, Mass.: Pearson.