Suggested Sequence of Topics and Learning Activities in a High School Biology Course

In the sequence proposed here, the major biological concepts build in a logical progression that uses earlier concepts to help students understand subsequent concepts and reinforces student understanding of earlier concepts as they are used in subsequent sections of the course. For example, students are introduced to DNA structure and function early in the course and then use their understanding of DNA structure and function to enhance their understanding of subsequent topics, such as genetics and cell structure and function.

These topics and learning activities are not a complete biology course, but they do provide a good basis for developing strong student understanding of a broad range of important biological concepts. The most important activities for introducing fundamental biological concepts are indicated by bold. Additional biology learning activities are available at https://serendipstudio.org/exchange/bioactivities.

Each of the learning activities (except the first) will help students meet the Next Generation Science Standards (NGSS) (http://serendipstudio.org/exchange/bioactivities/NGSS/listing). For each of these learning activities, we present a Student Handout (which can be used as is or edited) and Teacher Notes (which include instructional suggestions and background biology). As indicated by the similar titles, some activities are available both as hands-on activities learning activities and as analysis and discussion learning activities. Most of the analysis and discussion learning activities are available as GoogleDocs.

Topic	Description	Recommended Learning Activities	
		Analysis and Discussion	**Hands-on Activities**
Characteristics of Life	Characteristics that distinguish living things from non-living things	• **Characteristics of Life**	
Levels of Organization	Students are introduced to the levels of organization in biology, reductionism as an important approach to scientific understanding, and emergent properties.	• **Levels of Organization in Biology** • Coronaviruses – What They Are and How They Can Make You Sick	
Biological Molecules	Students learn about the chemistry and functions of biological molecules. They learn that proteins and DNA are not just abstract concepts in biology textbooks, but rather these important molecules have major effects on our bodies' characteristics.	• **Introduction to the Functions of Proteins and DNA**	• A Scientific Investigation – What types of food contain starch and protein? • Enzymes Help Us Digest Food
Introduction to DNA Structure and Function	Students learn about base-pairing and the double helix structure of DNA. This provides a basis for understanding DNA replication and function. A gene is a	• **DNA Structure, Function and Replication** • **How Genes Can Cause Disease – Understanding**	• **DNA** • **How Genes Can Cause Disease – Introduction to**

	segment of DNA that gives the instructions for making a protein. During transcription, the sequence of nucleotides in DNA determines the sequence of nucleotides in mRNA. During translation, the sequence of nucleotides in mRNA determines the sequence of amino acids in a protein. The sequence of amino acids determines the structure and function of the protein.	**Transcription and Translation**	**Transcription and Translation**
Structure and Function of Cells, Organs and Organ Systems	Students investigate how phospholipids and proteins combine to form the selectively permeable cell membrane, which regulates what gets into and out of the cell. Students learn how organelles cooperate to accomplish the multiple functions of a living cell. Students analyze examples of the relationship between structure and function in diverse eukaryotic cells, the small intestine, and the digestive system.	• **Introduction to Cells** • **Structure and Function of Cells, Organs and Organ Systems** • COVID-19 Vaccines – How do they work?	• Introduction to Osmosis • **Cell Membrane Structure and Function**
Homeostasis	Students learn how negative feedback helps to maintain homeostasis.	• **Negative Feedback, Homeostasis, and Positive Feedback**	• **Negative Feedback, Homeostasis and Positive Feedback – Examples and Concepts**
Energy and Biological Processes	To understand how organisms use energy, students first learn how the hydrolysis of ATP provides the energy for many biological processes. Then, students learn how cellular respiration produces ATP. Finally, students learn how photosynthesis produces sugars which are used both for cellular respiration and for biosynthesis to produce biomass.	• **How do organisms use energy?** • **Using Models to Understand Cellular Respiration** • **Using Models to Understand Photosynthesis** • **Photosynthesis and Cellular Respiration – Understanding the Basics of Bioenergetics and Biosynthesis** • Where does a tree's mass come from?	• **Photosynthesis, Cellular Respiration and Plant Growth**

		• Food, Energy and Body Weight • How do muscles get the energy they need for physical activity?	
Mitosis, Meiosis and Fertilization	Students learn how the cell cycle produces genetically identical daughter cells. They use model chromosomes to understand how DNA replication and mitosis ensure that each new cell gets a complete set of chromosomes with a complete set of genes. Then, students use model chromosomes to understand how meiosis produces haploid gametes. Finally, students model meiosis and fertilization in a format that mimics a Punnett square. Thus, students develop a basic understanding of how genetic information is passed from one generation to the next.	• **Mitosis and the Cell Cycle – How the Trillions of Cells in the Human Body Developed from a Single Cell** • **Understanding How Genes are Inherited via Meiosis and Fertilization** • Melanoma, Mutations and Abnormal Cell Cycles • How Mistakes in Meiosis Can Result in Down Syndrome or Death of an Embryo	• **Mitosis – How a Single Cell Develops into the Trillions of Cells in a Human Body** • **Meiosis and Fertilization – Understanding How Genes Are Inherited**
Genetics	Students learn (1) how genotype influences phenotype via the effects of genes on protein structure and function and (2) how genes are transmitted from parents to offspring through the processes of meiosis and fertilization. Students analyze the probabilistic patterns of inheritance and Punnett square predictions. Additional concepts covered include polygenic inheritance, incomplete dominance, and co-dominance.	• **Introduction to Genetics – Similarities and Differences between Family Members** • The Genetics of Sickle Cell Anemia and Sickle Cell Trait • Genetics and Probability – Sex Ratios of Births • A mistake in copying DNA can result in dwarfism. • Soap Opera Genetics – Genetics to Resolve Family Arguments	• **Genetics** • Were the babies switched? – The Genetics of Blood Types
Molecular Biology	Students learn more about molecular biology and are introduced to genetic engineering.	• Mutations and Muscular Dystrophy • Cell Differentiation and Epigenetics	

		• Genetic Engineering Challenge • Gene Editing with CRISPR-Cas	
Evolution	Students develop a basic understanding of natural selection. Then, students use their understanding of natural selection to understand several examples of evolution.	• **What is natural selection?** • **Natural Selection and the Peppered Moth** • Evolution of Fur Color in Mice – Mutation, Environment and Natural Selection • Coronavirus Evolution and the COVID-19 Pandemic • **How Whales Evolved – Evidence and Scientific Arguments** • **How Eyes Evolved – Analyzing the Evidence**	• **Evolution by Natural Selection**
Population Growth	Students learn how processes at the organism level result in exponential and logistic population growth. Then, students analyze examples where the trends in population size do not match the predictions of the exponential or logistic population growth models. They learn that models are based on simplifying assumptions and a model's predictions are only accurate when the simplifying assumptions are true for the population studied.	• **Understanding and Predicting Changes in Population Size – Exponential and Logistic Population Growth Models vs. Complex Reality**	
Ecological Succession vs. Stable Communities	Students analyze multiple types of evidence to understand how ecological relationships contribute to stability or change in biological communities.	• **Stability and Change in Biological Communities**	

Food Webs	Students learn about food webs and how interactions in food webs can influence trends in population size. Then, students use their understanding of trophic relationships in food webs, photosynthesis and cellular respiration to develop an understanding of energy flow through ecosystems, carbon cycles, and trophic pyramids. Thus, students use their understanding of processes at the cellular-molecular and organismal levels to understand several ecological phenomena.	• **Carbon Cycles and Energy Flow through Ecosystems and the Biosphere** • **Trophic Pyramids** • Food, the Carbon Cycle and Global Warming – How can we feed a growing world population without increasing global warming?	• **Food Webs, Energy Flow, Carbon Cycle and Trophic Pyramids** or • **Food Webs – Understanding What Happened When Wolves Returned to Yellowstone**

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