



Reinventing High School Biology Curricula

These units are designed for College Preparatory (CP) Biology students, providing hands-on activities to investigate key principles and current topics within biology. Students learn the material, apply the content in an experimental context, and relate their knowledge to current topics in biology – improving their scientific literacy in the process. The unit topics are based on Next Generation Science Standards (NGSS) as well as relevance to students’ lives. Units can be done independently as a supplement or as a replacement to comparable units in a curriculum. The complete sequence can start at Natural Selection and Population Dynamics or The Tragedy of the Commons and proceed in order from either. The units can also be scaffolded for AP, emerging learners, augmented instruction, and middle school.

■ Sequential Syllabus Order ■ Module ■ Proposed NGSS Performance Expectations

1 (or 5)	Natural Selection and Population Dynamics	Evolution by natural selection is a keystone concept in biology. It provides an application for genetics and cell biology and order for ecology and populations. Students will learn how an environment shapes the organisms that live there, and will begin by exploring the basic tenets of evolution by natural selection. They will perform simulations that look at the adaptability of populations to survive in variable environments; and learn that some adaptations are more successful than others. This framework will provide an anchor point for students as they learn about the world at different scales through each unit.	HS-LS4-1 HS-LS4-2 HS-LS4-3 HS-LS4-4
2	Cell Biology: CRISPR, RNAi, and genetic engineering	Gene Editing has the power to rewrite the human germ line and cure diseases. However, for every problem it solves, new concerns are raised. The landscape of genetic engineering has changed with the use of CRISPR gene editing in humans, and we all must understand how in order to engage with this technology as it develops in real time. The central dogma and tenets of molecular and cell biology are an ossified part of the biology curriculum. This module will allow students to learn about the theory in new ways, explore how gene editing can be done responsibly, and discuss the ethics of its use. Students will use CRISPR to change prokaryotic genes and their associated phenotypes by performing – and then designing – their own CRISPR experiment. Students will also perform RNAi in <i>C. elegans</i> to investigate a second means of genetic engineering called gene silencing in eukaryotes, which will form the basis of the next unit.	HS-LS1-1 HS-LS1-3 HS-LS3-1 HS-LS4-5
3	Bioinformatics: Cladistics and Phylogeny	Technology and life sciences merge in <i>bioinformatics</i> , the act of using computer databases to identify organisms by their genotypes. Students will use bioinformatics to genetically compare organisms from all kingdoms to discern evolutionary relationships, common ancestors, and time since divergence. The predicted mutation rates of genomes will also be studied. This will introduce students to the concepts of speciation and the circumstances by which new species create themselves. This unit is a continuation of the RNAi lab; students will use bioinformatics to identify and confirm genotypes of their <i>C. elegans</i> .	HS-LS3-3 HS-LS4-1 HS-LS4-3
4	Inheritance and the Life of the Cell	The cell cycle is a 4-step life cycle controlled by a plethora of biological factors. By learning about the cell cycle, students will be able to understand how the complexity and genetic diversity of living organisms occur, as well as the mechanisms by which cell cycles fail, potentially leading to diseases such as cancer. The module includes activities to study mitosis in onion root cells by stimulating them with a chemical that causes a cancer-like state. They will also explore cross fungi to generate recombined mutants through alterations in meiosis. These projects will provide a platform for students to learn about Mendelian inheritance and genetics and make connections to their own health.	HS-LS1-4 HS-LS3-1 HS-LS3-2

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5 (or 1)	The Tragedy of the Commons	Carrying capacity sets the boundaries for the amount of life that can be sustained in a given organism. The tragedy of the commons is a thought experiment that describes the tendency of prized resources in an ecosystem to be used to exhaustion. These two concepts combine when students conduct a simulation in which they are heads of families fishing in a pond. They cannot see the entire fish population, and must catch enough to survive without surpassing the pond's carrying capacity. The data that the students collect and analyze will help them to understand how limited resources drive competition and sets the standard for the amount of life in an ecosystem. This activity will teach students about how an ecosystem sets limits on the number of organisms that can live there. This unit provides an introduction to ecosystems and the context for the lessons that follow; the syllabus can also start from here instead of with Natural Selection and Population Dynamics.	HS-LS2-1 HS-LS2-2 HS-LS2-7 HS-LS2-8 HS-LS4-6
6	Biomes and Butterflies	The geochemical cycles and their relationships to ecosystems and the living organisms within form the backbone of ecology. Students will create their own aquatic, compost, and terrestrial ecosystems in stacked soda bottles to study how energy and resources cycle. By controlling the biotic and abiotic components of an ecosystem, students will be able to see how populations interact, look for evidence of geochemical cycling, and discover how they are used to measure the health of an ecosystem. Students will also culture butterflies to investigate the effect of pollinators on an ecosystem as well as how environmental signals control the butterfly's life cycle. This experiment will use student's knowledge of carrying capacity to flesh out their understandings of ecosystems and the underlying science of how atoms and molecules within the geochemical cycles shape an environment.	HS-LS2-6 HS-LS2-7 HS-LS2-8 HS-LS4-5 HS-LS4-6
7	Your Body is an Ecosystem!	All living organisms are covered in a thin film of microbes from multiple kingdoms. Recent evidence suggests that whenever its host is exposed to environmental cues, the microbiome responds first and then the host responds accordingly. This behavior reveals an infinite number of connections between the host's physiology and its microbiome. Students will investigate their own microbiomes to learn about the diversity of microbes on their skin. This unit will also investigate how two body systems – integumentary and cardiovascular – select for microbes. Students will learn that the skin is not a homogenous environment; different parts of the body will select for different microbes, demonstrating that selection and adaptability are not just for forests and water systems. This unit will also expand students' understanding of ecosystems and realize that the same underlying natural phenomenon and biodiversity that govern large ecosystems are mirrored in small scale ones.	HS-LS1-2 HS-LS1-3 HS-LS2-2 HS-LS4-4
8	Feeding a Growing Population	Students will learn about botany and agriculture in the 21st century, as well as how to feed an ever growing population on a limited amount of land. By splicing seeds and producing genetically modified plants using ancient methods, students will learn about botany and plants as it has progressed throughout history. Topics will include photosynthesis, cellular respiration, the carbon cycle, and other topics central to botany and agriculture. Students will understand how agriculture and biology align to grow more food on less space as well as produce crops that are resistant to droughts. It will also introduce them to ways scientists use natural laws of ecosystems to cultivate land and grow crops.	HS-LS1-5 HS-LS1-6 HS-LS1-7 HS-LS2-3 HS-LS2-4 HS-LS2-5
9	What Should We Eat? Nutrition and Metabolic Disease	This section covers basic biochemistry and macromolecules. Students will learn about the purpose of the core building blocks of living organisms and how to plan a diet that balances the physiological needs of a diverse population, using nutrition and food labels. Students will also learn about metabolic disease and participate in simulations where they diagnose "patients" with associated conditions and design diets for them. In this final unit, students will learn about how agricultural advancements from the prior unit have shaped their diets and empower them to make decisions that are both healthy for them and for their environment.	HS-LS1-6 HS-LS1-7 HS-LS4-6



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