MyStemKits.com

DNA and Genetics

A MyStemKits Curriculum Unit

Grades: *9-12*

Subjects: *Science, Engineering*

Strands: *Life Science*

DNA and Genetics

A MyStemKits Curriculum Unit

Introduction

This curriculum is intended to cover a complete unit on the fundamentals of genetics and DNA. It is recommended as part of a high school level Biology I course.

All lesson plans in this unit feature the use of 3D-printed kits intended to promote hands-on learning using models for visualization of the challenging, and often abstract, concepts to which students are exposed in classical and molecular genetics. The 3D-printed kits also serve the purposes of both familiarizing students with this technology and allowing them to experience a variety of applications of models in science education.

Recent research on science education and pedagogy are incorporated into this unit in order to create an engaging series of lessons that teach content while promoting student interest in the field of genetics, including exposure to career options in medicine.

This unit follows a central storyline focused on human medical genetics in which the student assumes the role of a graduate student in a genetic counseling master's degree program. The lessons are primarily centered on case studies of one fictional extended family.

While it is recommended that the modular lessons be taught together as a cohesive unit, they can be used individually at the teacher's discretion.

Color Key

All kits and lesson plans have been color-coded so you can more-easily find those relevant to you.

Mathematics *Interdisciplinary* *Science*

DNA and Genetics

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Utilized 3D Kits

Chromatin Kit

6-8
9-12

Science

Create 12 nucleosomes and model chromatin, the compacted form of DNA that is present in the nucleus of our cells - including zig-zag and solenoid models!

1 Standards-Driven Lesson Plan

Chromosomes Kit

6-8
9-12

Science

A hands-on learning tool great for studying mitosis and meiosis, as well as genetic inheritance.

2 Standards-Driven Lesson Plans

DNA Kit

6-8
9-12

Science

An adaptable and inclusive kit designed for studying all aspects of DNA, RNA, and protein synthesis.

3 Standards-Driven Lesson Plans

Karyotypes Kit

9-12

Science

Demonstrate independent assortment and explain genetic variance with these labeled chromosomes!

2 Standards-Driven Lesson Plans

Karyotypes Kit: Aneuploidy Expansion

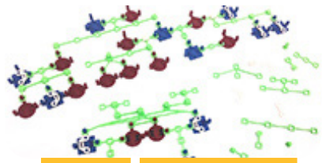
9-12

Science

Featuring labeled chromosomes for each of the most-common aneuploidies, this kit of eight chromosomes is perfect for digging deeper into genetics and genetic disorders.

1 Standards-Driven Lesson Plan

Pedigree Tree Kit



9-12

Science

Build and investigate family structures as you assemble a multi-generational pedigree! Plus, visualize how X-linked, autosomal, dominant and recessive mutations are passed from generation to generation.

1 Standards-Driven Lesson Plan

Punnett Square Dice (Gg) Kit

6-8
9-12

Science
Mathematics

An interdisciplinary kit that brings together statistics and biology by exploring Mendel's model of inheritance.

1 Standards-Driven Lesson Plan

Ribosome Kit

6-8
9-12

Science

Create a simple peptide chain and investigate the role of the ribosome in protein synthesis with this hands-on kit!

1 Standards-Driven Lesson Plan

Sickle Cell Kit

6-8
9-12

Science

A hands-on kit designed to clearly demonstrate the genetic effects of the sickle-cell anemia mutation.

1 Standards-Driven Lesson Plans

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Lesson Plans: High School

Patterns of Inheritance: Will My Child Inherit a Genetic Disorder?

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, students explore the transmission of genetic disease across generations and learn about Mendelian inheritance patterns. Students are introduced to the medical genetics unit storyline in this lesson: the student assumes the role of graduate student in a genetic counseling training program and interacts with an extended family in a clinical setting. In Lesson 1, the student meets the family's central character, Billy Jones, and completes a family pedigree and genetic counseling report to determine his risk of passing on a familial disease, Duchenne Muscular Dystrophy (DMD), to his future child. Students also complete a role play and model family pedigree using a 3D-printed kit as part of this lesson.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-1 NGSS.HS-LS3-2 NGSS.HS-LS3-3	NGSS Science & Engineering Practices: 1, 2, 5, 6, 7, 8	Pedigree Tree Kit

Mendelian Genetics: Blood Type Inheritance

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, students connect the process of meiosis to Punnett squares and Mendelian inheritance patterns. In our storyline, the genetic counseling student helps alleviate the concerns of Billy Jones's pregnant wife regarding Rh-factor blood type compatibility with her infant. Rh-factor is one of the few traits in humans known to follow a simple, single gene, dominant versus recessive Mendelian inheritance pattern. As such, clinicians are able to make accurate predictions about Rh-factor inheritance using Mendel's simple models, making it an ideal clinical example to use to demonstrate Mendel's principles in the classroom. Students use Rh-factor blood type as an example to learn about Mendelian genetics in this medical case study lesson. Students also investigate concepts by modeling with 3D-printed chromosomes and Punnett square dice.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-2	NGSS Science & Engineering Practices: 1, 2, 5, 6, 7, 8	Chromosomes Kit Punnett Square Dice Kit

Genetic Variation in Related Individuals: Identical Cousins?

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, we learn how genetic variation occurs through random assortment and independent segregation of chromosomes, both fundamental principles of meiosis. We are introduced to Billy Jones's sisters, a pair of identical twins who have recently married and are now expecting children with another set of identical twins! The genetic counseling graduate student protagonist must investigate how genetic variation occurs even in the children of identical twins and answer the question: could the children of two sets of identical twins be "identical cousins"? Students model chromosomes and karyotypes with 3D-printed kits and complete mathematical calculations of relatedness, among other activities.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-1 NGSS.HS-LS3-2 NGSS.HS-LS3-3	NGSS Science & Engineering Practices: 1, 2, 3, 4, 5, 6, 7	Karyotypes Kit Chromosomes Kit

Epigenetic Control of Identity: Are Identical Twins Always Identical?

Grades: 9, 10, 11, 12

Strands: Life Science

Gene expression is how our genetic information is transcribed and translated into who we are and what we do. We each have a combination of chromosomes contributed by our parents, each with allelic versions of their gene set. In order for all the DNA of these parent cells to fit into the nucleus of a zygote, there is highly ordered manner in which the DNA is packaged that includes a protein-DNA complex called chromatin. In this lesson, students will model chromatin formation with 3D-printed materials and visualize the scale of DNA compactions. Epigenetic factors such as diet, stresses, and pollutants can change how our DNA functions by controlling accessibility to genes. In this way, identical twins that are born with identical genomes often look and behave differently over their lifespan. Much of this can be accounted for in their epigenomes. In the unit storyline, the genetic counseling student is prompted to investigate these concepts after meeting Billy Jones's identical twin sisters.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-2	NGSS Science & Engineering Practices: 1, 2, 5, 6, 7, 8	Chromatin Kit

A Case Study in Chromosomal Disorders

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, students investigate a case study during which they diagnose a case of aneuploidy in the newborn infant of one of Billy Jones' sisters. Students learn about specific types of chromosomal disorders and how they occur, and then diagnose healthy versus abnormal karyotypes using a 3D-printed karyotype model.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-1 NGSS.HS-LS3-2	NGSS Science & Engineering Practices: 1, 2, 3, 6, 7, 8	Karyotypes Kit Karyotypes Kit: Aneuploidy Expansion

Lesson Plans: High School (continued)

DNA Structure and Replication: Cell Division in a Rapidly-Growing Fetus

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, our genetic counseling graduate student helps a patient, one of Billy Jones' sisters, better understand DNA replication as related to her developing fetus. When an organism grows and develops, its cellular genetic material must be replicated as cells divide. Deoxyribonucleic acid, DNA, composes the genetic material and forms a stable double helix that contains the individual genes that make us all unique. The process of DNA replication is modeled in this lesson using a 3D-printed kit of the molecular components of DNA. Students will assemble nucleotides, the building blocks of DNA, and link them to form a strand of DNA. Following the rules of DNA replication, a complementary strand will be assembled from other nucleotides and associated with the original strand to demonstrate a DNA double helix.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-1	NGSS Science & Engineering Practices: 1, 2, 4, 6, 8	DNA Kit

Protein Synthesis and DNA Mutation: Sickle Cell Hemoglobin

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, students explore the key concept of protein synthesis and the pathway from DNA to RNA to protein within the cell. Students use the example of sickle cell disease as a framework to investigate how protein is synthesized and the potential consequences of mutations in the genetic code. The storyline in this lesson focuses on Billy Jones seeking help from the protagonist in the unit, a genetic counseling student, for his brother, Amaud, who is suffering from sickle cell disease. Students complete a guided reading, model the structure of normal hemoglobin molecules and molecules carrying the sickle cell mutation, and model a hemoglobin B gene as it is transcribed into RNA and finally into a hemoglobin peptide. The lessons ends with the students evaluating a potential new cure for Amaud.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS1-1 NGSS.HS-LS3-1 NGSS.HS-LS3-2	NGSS Science & Engineering Practices: 1, 2, 5, 6, 7, 8	DNA Kit Sickle Cell Kit

The Role of the Ribosome: Antibiotic Defense against Infection

Grades: 9, 10, 11, 12

Strands: Life Science

In this lesson, students closely examine the ribosome complex. All living cells contain ribosomes and they are at the heart of a cell's ability to translate a DNA sequence to RNA and then to a protein molecule. The ribosome provides a workbench to hold the players in place (mRNA, tRNA, and a growing peptide) and the chemical environment to allow peptide synthesis to occur. While the ribosome was mentioned in discussion of protein synthesis covered in Lesson 7, students explore this topic in much greater depth in this lesson. The storyline continues with Billy Jones's great uncle visiting and subsequently receiving a diagnosis of tuberculosis, a serious respiratory disease typically treated with antibiotics. Students model a ribosome structure and investigate how antibiotics interact with the ribosome to cure bacterial infection.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-LS3-1	NGSS Science & Engineering Practices: 1, 2, 6, 7, 8	Ribosome Kit

Biotechnology and Ethics: Editing Genes with CRISPR

Grades: 9, 10, 11, 12

Strands: Engineering Design

This lesson finds our genetic counseling graduate student preparing for a prestigious internship supporting patients in some of the first human clinical trials testing the gene editing technology CRISPR-Cas9. As the extended case study draws to a close, students learn about the remarkable potential of CRISPR technology and explore bioethical considerations through a close reading, 3D modeling, debate, and writing.

Standards Addressed		*3D Kits Utilized*
NGSS.HS-ETS1-3	NGSS Science & Engineering Practices: 1, 2, 6, 7, 8	DNA Kit