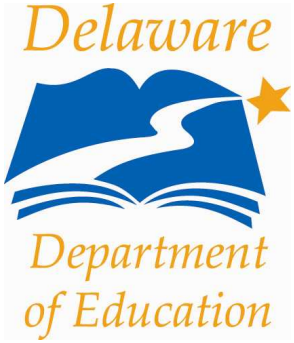
Delaware Science Coalition

Grade 10 Science Unit Template
Unit III Genetics and Biotechnology



Delaware Recommended Curriculum Unit

Preface: This unit has been created as a model for teachers in their designing or redesigning of course curricula. It is by no means intended to be inclusive; rather it is meant to be a springboard for teacher thought and creativity. The information we have included represents one possibility for developing a unit based on the Delaware content standards and the Understanding by Design framework and philosophy.

Subject/Topic Area: Science **Grade Level(s): 10**

Searchable Key Words:

Designed By: **District:**

Time Frame: Approximately 12 weeks (year-long course)

Reviewed by: **Date:**

Brief Summary of Unit

In this unit students investigate the storage of genetic information in DNA, its transmission from cell to cell and from generation to generation, and its expression during protein synthesis. Students investigate patterns of inheritance for various traits using principles of Mendelian and molecular genetics. Students also investigate the application of biotechnology for meeting human needs in the areas of genetics, reproduction, development, and evolution.

This unit, which follows *Unit II: The Chemical and Cellular Basis of Life*, completes the 10th grade instructional program.

Stage 1: Desired Results
(Determine What Students Will Know, Do, and Understand)

DE Content Standards

Standard 1: Understandings and Abilities of Scientific Inquiry

1. Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.
2. Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.
3. Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.
4. Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.
5. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. (American Association for the Advancement of Science, 2001)
6. Knowledge and skill from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.

Standard 7: Reproduction, Heredity, and Development

1. Hereditary/genetic information in chromosomes is contained in molecules of DNA. Genes are sections of DNA that direct syntheses of specific proteins associated with traits in organisms. These consist of various combinations of four different nucleotides that encode this information through their sequences.
2. Known patterns of inheritance can be used to make predictions about genetic variation.
3. Mutations in DNA of organisms normally occur spontaneously at low rates, but can occur at higher rates (i.e., exposure to pathogens, radiation and some chemicals). Most mutations have no effect on the organism, but some may be beneficial or harmful depending on the environment.
4. Only random mutations in germ cells (gametes) can create the variation that is inherited by an organism's offspring. Somatic mutations are not inherited, but may lead to cell death, uncontrolled cell growth, or cancer.
5. During the cell cycle, DNA of the parent cell replicates and the cell divides into two cells that are identical to the parent. This process is used for growth and repair of body tissues and for asexual reproduction.

6. Meiosis is the production of sex cells (gametes). The production and release of these gametes is controlled by hormones. In meiosis, the number of chromosomes is reduced by one-half and chromosomes may randomly exchange homologous parts to create new chromosomes with combinations not necessarily found in the parent cell. Independent assortment of chromosomes during meiosis also increases heritable variations within the species.
7. Upon fertilization, the fusion of the gametes restores the original chromosome number, and new gene combinations lead to increased genetic variation, which, in turn, increases the likelihood of survival of the species.
8. The sex chromosomes contain different genes, and therefore, certain traits will show patterns of inheritance based on gender.
9. Embryological development in plants and animals involves a series of orderly changes in which cells divide and differentiate. Development is controlled by genes whose expression is influenced by internal factors (i.e., hormones) and may also be influenced by environmental factors (i.e., nutrition, alcohol, radiation, drugs, and pathogens). Alteration in this balance may interfere with normal growth and development.

Standard 7: Diversity and Evolution

1. Evolution is a change in allelic frequencies of a population over time. The theory of evolution is supported by extensive biochemical, structural, embryological, and fossil evidence.
2. Organisms are classified into a hierarchy of groups and subgroups based on similarities in structure, comparisons in DNA and protein and evolutionary relationships.
3. Genetically diverse populations are more likely to survive changing environments.
4. Biological evolution is the foundation for modern biology and is used to make predictions for medical, environmental, agricultural and other societal purposes.

Standard 7: Technology Applications

1. The expanding ability to manipulate genetic material, reproductive processes, and embryological development creates choices that raise ethical, legal, social, and public policy questions.
2. Recombinant DNA technology, which is a form of genetic engineering, involves the insertion of DNA from one cell into a cell of a different organism where the inserted DNA is expressed. Genetic engineering is being applied in biology, agriculture, and medicine in order to meet human wants and needs.
3. DNA is analyzed to determine evolutionary relationships, study populations, identify individuals, and diagnose genetic disorders.

Big Ideas

"Big Ideas" in Grade 10

▪ **Science As Inquiry**	Science is a way of knowing about the natural world by the use of empirical observations, experimental evidence, logical arguments, and healthy skepticism.
▪ **Evolution**	The theory of evolution explains the unity and diversity found among living things and is the foundation of modern biology.
▪ **Matter and Energy**	Living things transform and transfer matter and energy from one form to another to build their structures and conduct their life processes.
▪ **Structure and Function**	Living things organize matter into a variety of forms whose structure and function are complementary.
▪ **Regulation and Homeostasis**	Living things have mechanisms and behaviors that regulate their internal environments and respond to changes in their surroundings.
▪ **Genetic Continuity**	Living things reproduce, develop, and transmit heritable traits to their offspring.
▪ **Interdependence in Nature**	Living things and their environments are interconnected.
▪ **Science Technology Society**	The dynamic interaction of science and technology affects and is affected by society.

"Big Idea" Emphasis in Grade 10 Units

Unit I Nature of Science and Evolution	Unit II	Unit III Genetics/Biotechnology
Major Emphasis	***Major Emphasis***	***Major Emphasis***
Science As Inquiry Evolution	Science As Inquiry Matter and Energy Structure and Function Regulation and Homeostasis	Science As Inquiry Structure and Function Genetic Continuity Science Technology Society
Minor Emphasis	***Minor Emphasis***	***Minor Emphasis***
Genetic Continuity Interdependence in Nature Science Technology Society	Evolution Interdependence in Nature Science Technology Society	Evolution Interdependence in Nature

Unit Enduring Understandings

Students will understand that…

Enduring Understandings from Standard 1

1. Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying the explanations.

Enduring Understandings from Standard 7

1. Organisms reproduce, develop, have predictable life cycles, and pass on heritable traits to their offspring.
   a. Hereditary information encoded in DNA is organized in genes and chromosomes.
   b. DNA is copied and transmitted to new cells when cells divide.
   c. DNA directs the synthesis of proteins associated with traits in an organism.
   d. Asexual reproduction results in genetic continuity but produces little variation from one generation to the next.
   e. Sexual reproduction results in genetic continuity and variation from one generation to the next.
   f. Genes control the differentiation of cells during embryological development.
   g. Patterns of inheritance for many traits can be explained by Mendelian and molecular genetics.
2. The development of technology has allowed us to apply our knowledge of genetics, reproduction, development, and evolution to meet human needs and wants.
   a. Cancer results from a malfunction of genes that regulate the cell cycle.
   b. Analysis of DNA and proteins is useful in determining evolutionary relationships, studying populations, identifying individuals, and diagnosing disease.
   c. The modification of organisms by genetic engineering is being applied in areas such as agriculture and medicine.
   d. Biotechnology creates choices that raise ethical, legal, social, and public policy questions.

Unit Essential Questions

Essential Questions from Standard 1

1. What makes a question scientific?
2. What constitutes evidence?
3. When do you know you have enough evidence?
4. Why is it necessary to justify and communicate an explanation?

Essential Questions from Standard 7

1. Why do offspring resemble their parents?
   a. How does genetic information encoded in DNA get translated into making traits in an organism?
   b. How does genetic information get copied and transmitted during the cell cycle to produce new cells identical to the parent cell?
   c. How does knowledge of genetics help to explain patterns of inheritance?
2. What are the advantages and disadvantages of different reproductive strategies?
   a. What are the advantages and disadvantages of asexual and sexual reproduction?
3. How do organisms change as they go through their life cycles?
   a. What controls growth and development during the life stages of an organism?
4. How are organisms of the same kind different from each other and how does this help them survive?
   a. How does sexual reproduction result in offspring with gene combinations that vary from those of their parents?
   b. How does genetic variation that results from sexual reproduction give members of a population survival advantage?
5. How does the understanding and manipulation of genetics, reproduction, development, and evolution affect the quality of human life?
   a. How is knowledge of the cell cycle used to understand cancer?
   b. How is biochemical evidence used to determine evolutionary relationships?
   c. How are genetic materials and reproductive processes manipulated to make desirable organisms and products, diagnose and treat disease, and identify individuals?
   d. What are some ethical, social, and legal issues are associated with biotechnology?

Knowledge & Skills

Students will know….

Note: The numbered items (1, 2, 3 etc.) contain the same wording found in the DE Standards as listed on pages 1-3 of this template. Lettered items (a, b, c etc.) have been added to clarify the standards. Note suggested wording changes shown in bold italics.

Standard 1: Understandings and Abilities of Scientific Inquiry

1. Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.
2. Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.
3. Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.
4. Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.
5. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. (American Association for the Advancement of Science, 2001)
6. Knowledge and skill from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.

Standard 7: Reproduction, Heredity, and Development

1. Hereditary/genetic information in chromosomes is contained in molecules of DNA. Genes are sections of DNA that direct syntheses of specific proteins associated with traits in organisms. These consist of various combinations of four different nucleotides that encode this information through their sequences.
   a. DNA consists of two long twisted strands of smaller molecules called nucleotides – A (adenine), T (thymine), C (cytosine), and G, (guanine). An A on one DNA strand pairs with T on the opposite strand, while C pairs with G. Thus, the order of nucleotides on one strand determines the order on the other strand.
   b. DNA is packaged in chromosomes that are located in the cell's nucleus.
   c. A genome is the entire set of genetic information in an organism.
   d. DNA is the hereditary molecule common to almost all living things.
   e. Triplets of nucleotides (codons) in DNA specify the sequence of amino acids that are assembled to form a particular protein.

f. Protein synthesis begins with copying or transcribing nuclear DNA into mRNA.

g. Protein synthesis (translation) occurs at ribosomes in the cytoplasm where amino acids are joined with the aid of tRNA in the sequence specified by mRNA codons.

h. Enzymes facilitate the chemical reactions involved in transcription and translation.

i. The sequence of amino acids in a protein determines its shape and function.

j. Gene expression is regulated in a cell. Genes may be turned on and off, and different genes may be active in different kinds of cells.

2. Known patterns of inheritance can be used to make predictions about genetic variation.

   a. Most genes exist in more than one form, or allele, with each allele having a slightly different nucleotide sequence.

   b. Chromosomes occur in homologous pairs. Each chromosome in the pair contains an allele for each trait encoded by the chromosome.

   c. The alleles for each trait on homologous chromosomes segregate during meiosis when chromosomes are divided among the gametes (Law of Segregation).

   d. The alleles for one trait assort among the gametes during meiosis independently of alleles for other traits (Law of Independent Assortment).

   e. The genotype for a trait is homozygous when both alleles are the same. The genotype for a trait is heterozygous when the two alleles are different.

   f. Dominant refers to an allele that masks the expression of another allele of the same gene in a heterozygous organism. Recessive refers to an allele whose expression is masked by the presence of another allele in a heterozygous organism.

   g. Phenotype refers to the expressed appearance or function of a genotype. Phenotype is the result of the interaction of an organism's genotype and its environment.

   h. Probability, a branch of mathematics, can be used to predict and explain results of allele combinations that result from matings.

   i. In addition to autosomal dominance and recessiveness, incomplete dominance, codominance, X-linkage, and multiple alleles also explain patterns of inheritance for some traits.

   j. Most traits, such as skin color and height, are multifactorial and result from the interaction of several genes and the environment.

   k. Nondisjunction, the failure of chromosomes to separate properly during meiosis, can result in abnormal chromosome numbers, which may be lethal to the organism or the cause a condition such as trisomy 21 (Down Syndrome).

3. Mutations in DNA of organisms normally occur spontaneously at low rates, but can occur at higher rates (i.e., exposure to pathogens, radiation and some chemicals). Most mutations have no effect on the organism, but some may be beneficial or harmful depending on the environment.

4. Only random mutations in germ cells (gametes) can create the variation that is inherited by an organism's offspring. Somatic mutations are not inherited, but may lead to cell death, uncontrolled cell growth, or cancer.

5. During the cell cycle, DNA of the parent cell replicates and the cell divides into two cells that are identical to the parent. This process is used for growth and repair of body tissues and for asexual reproduction.
   a. During the mitosis phase of the cell cycle replicated chromosomes are arranged in the cell so that when the cell divides each daughter cell receives the same number and type of chromosome found in the original cell.
   b. The cell cycle insures the continuity of genetic information from one cell generation to the next.
   c. Cancer develops when mutations occur in genes that normally operate to regulate cell division. This loss of control may result in an abnormal mass of cells (tumor) which may threaten an individual's life when its growth disrupts tissues and organs needed for survival.
6. Meiosis is the production of sex cells (gametes). The production and release of these gametes is controlled by hormones. In meiosis, the number of chromosomes is reduced by one-half and chromosomes may randomly exchange homologous parts to create new chromosomes with combinations not necessarily found in the parent cell. Independent assortment of chromosomes during meiosis also increases heritable variations within the species.
7. Upon fertilization, the fusion of the gametes restores the original chromosome number, and new gene combinations lead to increased genetic variation, which, in turn, increases the likelihood of survival of the species.
   a. Meiosis and fertilization are complementary processes that provide for both genetic continuity and variation from one generation to the next.
8. The sex chromosomes contain different genes, and therefore, certain traits will show patterns of inheritance based on gender. *Note: Also see 2.j. above.*
9. Embryological development in plants and animals involves a series of orderly changes in which cells divide and differentiate. Development is controlled by genes whose expression is influenced by internal factors (i.e., hormones) and may also be influenced by environmental factors (i.e., nutrition, alcohol, radiation, drugs, and pathogens). Alteration in this balance may interfere with normal growth and development.

Standard 7: Diversity and Evolution

1. Evolution is a change in allelic frequencies of a population over time. The theory of evolution is supported by extensive biochemical, structural, embryological, and fossil evidence. Note: Evolution in Unit I is defined as: "Evolution is a change in the hereditary characteristics of a population over the course of generations." Only biochemical evidence is addressed in Unit III. Refer to Unit I for structural, embryological, and fossil evidence.
5. Organisms are classified into a hierarchy of groups and subgroups based on similarities in structure, comparisons in DNA and protein and evolutionary relationships. *Note: Only DNA and protein comparisons are addressed in Unit III. Refer to Unit I for structural comparisons.*
6. Genetically diverse populations are more likely to survive changing environments.
7. Biological evolution is the foundation for modern biology and is used to make predictions for medical, environmental, agricultural, and other societal purposes. *Note: Also in Unit I.*

Standard 7: Technology Applications

1. The expanding ability to manipulate genetic material, reproductive processes, and embryological development creates choices that raise ethical, legal, social, and public policy questions.
2. Recombinant DNA technology, which is a form of genetic engineering, involves the insertion of DNA from one cell into a cell of a different organism where the inserted DNA is expressed. Genetic engineering is being applied in biology, agriculture, and medicine in order to meet human wants and needs.
3. DNA is analyzed to determine evolutionary relationships, study populations, identify individuals, and diagnose genetic disorders.

Students will be able to…

Enduring Understanding

- Organisms reproduce, develop, have predictable life cycles, and pass on heritable traits to their offspring.
  - Hereditary information encoded in DNA is organized in genes and chromosomes.
  - DNA is copied and transmitted to new cells when cells divide.
  - DNA directs the synthesis of proteins associated with traits in an organism.
  - Asexual reproduction results in genetic continuity but produces little variation from one generation to the next.
  - Sexual reproduction results in genetic continuity and variation from one generation to the next.
  - Genes control the differentiation of cells during embryological development.
  - Patterns of inheritance for many traits are explained by Mendelian and molecular genetics.
- Describe the relationship between DNA, genes, chromosomes, proteins, and the genome.
- Explain that a gene is a section of DNA that directs the synthesis of a specific protein associated with a specific trait in an organism.
- Trace how a DNA sequence, through transcription and translation, results in a sequence of amino acids.
- Demonstrate that when DNA replicates, the complementary strands separate and the old strands serve as a template for the new complementary strands. Recognize that this results in two identical strands of DNA that are exact copies of the original.
- Illustrate how a sequence of DNA nucleotides codes for a specific sequence of amino acids.
- Use Punnett squares, including dihybrid crosses, and pedigree charts to determine probabilities and patterns of inheritance (i.e., dominant/recessive, co-dominance, sex-linkage, multi-allele inheritance).
- Analyze a karyotype to determine chromosome numbers and pairs. Compare and contrast normal and abnormal karyotypes.
- Explain how crossing over and Mendel's Laws of Segregation and Independent Assortment contribute to genetic variation in sexually reproducing organisms.
- Describe how exposure to radiation, chemicals and pathogens can increase mutations.
- Explain that mutations in the DNA sequence of a gene may or may not affect the expression of the gene. Recognize that mutations may be harmful, beneficial, or have no impact on the survival of the organism.

- Explain how the type of cell (gamete or somatic) in which a mutation occurs determines heritability of the mutation.
- Predict the possible consequences of a somatic cell mutation.
- Describe the cell cycle as an orderly process that results in new somatic cells that contain an exact copy of the DNA that make up the genes and chromosomes found in the parent somatic cells.
- Explain how the cell cycle contributes to reproduction and maintenance of the cell and/or organism.
- Recognize that during the formation of gametes, or sex cells (meiosis), the number of chromosomes is reduced by one half, so that when fertilization occurs the diploid number is restored.
- Explain why sex-linked traits are expressed more frequently in males.
- Compare and contrast the processes of growth (cell division) and development (differentiation).
- Recognize that any environmental factor that influences gene expression or alteration in hormonal balance may have an impact on development.
- Recognize random mutation (changes in DNA) and events that occur during gamete formation and fertilization (i.e. crossing-over, independent assortment, and recombination) as the sources of heritable variations that give individuals within a species survival and reproductive advantage or disadvantage over others in the species.
- Recognize that development of form in embryos is regulated by master control genes that turn other genes on and off at different times and places during the course of development.

Enduring Understanding

- The development of technology has allowed us to apply our knowledge of genetics, reproduction, development, and evolution to meet human needs and wants.
  - Cancer results from a malfunction of genes that regulate the cell cycle.
  - Analysis of DNA and proteins is useful in determining evolutionary relationships, studying populations, identifying individuals, and diagnosing disease.
  - The modification of organisms by genetic engineering is being applied in biology, agriculture, and medicine.
  - Biotechnology creates choices that raise ethical, legal, social, and pubic policy questions.
- Investigate how the human ability to manipulate genetic material and reproductive processes (e.g., genetic engineering, cloning, stem-cell research) can be applied to many areas of medicine, biology, and agriculture. Evaluate the risks and benefits of various ethical, social, and legal scenarios that arise from this ability.
- Explain the basic process of bacterial transformation and how it is applied in genetic engineering.
- Explain how developments in technology (e.g. gel electrophoresis, gene sequencing, bioinformatics, DNA fingerprinting, genetic amplification, proteinomics) are being used to identify individuals based on DNA as well as improve the ability to diagnose and treat genetic diseases.

- Discuss examples of how DNA and protein comparisons are used to classify organisms and determine evolutionary relationships.
- Recognize that cancer may result from mutations that affect the ability of cells to regulate the cell cycle.

Stage 2: Assessment Evidence
(Design Assessments to Guide Instruction)

Assessments

Note: The Genetics and Biotechnology Unit is divided into the subunits listed below. A summative assessment is appropriate at the completion of each subunit. A summative assessment is under development for the Patterns of Inheritance subunit (see attachment).

1. Storage of Genetic Information (assessment not developed)

   Topics: Structure of DNA, genes, chromosomes, and the genome

   Knowledge:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: Reproduction, Heredity, and Development 1a-d

   Skills:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: 1 and 2

2. Transmission of Genetic Information from Cell to Cell (assessment not developed)

   Topics: Cell cycle (DNA replication and mitosis) mutations, and cancer

   Knowledge:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: Reproduction, Heredity, and Development 3, 4, 5a-c

   Skills:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: 4, 5, 12, 13, 14, 25

3. Expression of Genetic Information (assessment not developed)

   Topics: Protein synthesis, mutations, genetic engineering, embryological development

   Knowledge:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: Reproduction, Heredity, and Development 1e-i, 3
   - Standard 7: Diversity and Evolution 1, 5, 7
   - Standard 7: Technology Applications 1, 2, 3

   Skills:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: 2, 3, 5, 9, 21, 22, 24

4. Transmission of Genetic Information from Generation to Generation (assessment not developed)

Topics: Sexual life cycle (meiosis and fertilization, sources of variation, and embryological development

Knowledge:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: Reproduction, Heredity, and Development 1j, 4, 6, 7, 9

Skills:

- Standard 7: 8, 11, 15, 17, 18, 19, 20

5. **Patterns of Inheritance** (see attachment for assessment)

Topics: Mendelian and molecular genetics, genetic disorders, biotechnology, and bioethical issues

Knowledge:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: Reproduction, Heredity, and Development 1j, 2a-k, 8
- Standard 7: Diversity and Evolution 7
- Standard 7: Technology Applications 1, 2, 3

Skills:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: 6, 7, 8, 16, 21, 23

Rubrics/Checklists for Performance Tasks

Refer to attached Patterns of Inheritance assessment rubric (diagnostic double-digit rubric).

Other Evidence

Student Self-Assessment and Reflection

Stage 3: Learning Plan
(Design Learning Activities to Align with Goals and Assessments)

Key Learning Events Needed to Achieve Unit Goals

1. Storage of Genetic Information

   Topics: Structure of DNA, genes, chromosomes, and the genome

   Knowledge:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: Reproduction, Heredity, and Development 1a-d

   Skills:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: 1 and 2

   Lesson 1a: DNA Extraction

   Students extract and spool DNA from a variety of organisms and learn that DNA is readily observable in large amounts in a diversity of organisms.

   Lesson 1b: Size of the Genome

   (Note: It is recommended that the gelatin capsule cell model be replaced with one that reduces the amount of time it takes to complete this activity.)

   Students use models to simulate the size and structural relationships of DNA, genes, chromosomes, the genome, and cells.

   Lesson 1c: DNA Structure and the Genetic Code

   Students construct models of DNA and learn that the order of nucleotides is related to the genetic coding functions of DNA.

2. Transmission of Genetic Information from Cell to Cell

   Topics: Cell cycle (DNA replication and mitosis) mutations, and cancer

   Knowledge:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: Reproduction, Heredity, and Development 3, 4, 5a-c

   Skills:
   - Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
   - Standard 7: 4, 5, 12, 13, 14, 25

   Lesson 2a: DNA Replication and the Cell Cycle

   Students use models to understand the process of DNA replication and its importance in the cell cycle and the life of the organism.

Lesson 2b: Mitosis and the Cell Cycle

Students use models to understand the sequence of events in the cell cycle involving chromosome replication and distribution to daughter cells. Students also explain the significance of each new daughter cell receiving the same amount and kind of chromosomes present in the parent cell.

Lesson 2c: The Faces of Cancer

Students relate the incidence of cancer to family history, age, and risk factors.

Lesson 2d: Cancer and the Cell Cycle

Using CD-ROM videos and animations, students learn that cancer is associated with damage to genes which regulate the cell cycle.

3. Expression of Genetic Information

Topics: Protein synthesis, mutations, genetic engineering, molecular evidence for evolution

Knowledge:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: Reproduction, Heredity, and Development 1e-i, 3
- Standard 7: Diversity and Evolution 1, 5, 7
- Standard 7: Technology Applications 1, 2, 3

Skills:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6

Lesson 3a: Protein Synthesis

Students use models to understand how the genetic code in DNA is transcribed into RNA and translated into proteins. Students also explain how differences in the genetic code can result in the assembly of different kinds of proteins associated with traits.

Lesson 3b: Entangled in the Web

In this extensive series of activities, students learn about the process of genetic transformation that is currently being used to enable goats to make spider silk. Students also complete a lab protocol in which they transform bacterial cells by inserting into them a gene from a jellyfish that produces a protein that glows green under fluorescent light.

Lesson 3c: Molecular Genetics and Evolution

Students perform a simulated immunoassay comparing various species, and then synthesize models of a section of DNA from those species. By comparing the results form the immunoassay, and comparing the sequences of bases on the DNA models, students should be able to develop hypotheses to explain how the various species are related.

Supplemental Lesson 4c: Investigating Evolution Using Online Molecular Data Bases

Students analyze beta hemoglobin amino acid sequences to answer questions about evolutionary relationships among various vertebrate species.

4. Transmission of Genetic Information from Generation to Generation

Topics: Sexual life cycle (meiosis and fertilization), sources of variation, and embryological development

Knowledge:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: Reproduction, Heredity, and Development 1j, 4, 6, 7, 9
- Standard 7: Diversity and Evolution 6

Skills:

- Standard 7: 8, 11, 15, 17, 18, 19, 20

Lesson 4a: Meiosis and Genetic Variation

Note: Consideration should be given to modifying this activity so that it is completed as a demonstration rather than a team lab activity.

Using models, students learn about the sequence of events during meiosis that reduces the chromosome number from diploid to haploid during gamete formation, independent assortment and crossing over, and the importance of genetic variation resulting from meiosis and fertilization.

Lesson 4b: Potato Head Genetics

Using Mr. Potato Head kits, students model independent assortment for seven sets of alleles to produce a "baby potato head" with a different phenotype than its parents and the other "baby potato heads" produced by the class.

Lesson 4c: Embryological Development

Note: This activity has not been developed.

Students learn that development of form in embryos is regulated by master control genes that turn other genes on and off at different times and places during the course of development. Students also learn that internal and environmental factors can affect development.

5. Patterns of Inheritance

Topics: Mendelian and molecular genetics, genetic disorders, biotechnology, and bioethical issues

Knowledge:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: Reproduction, Heredity, and Development 1j, 2a-k and 8
- Standard 7: Diversity and Evolution 7
- Standard 7: Technology Applications 1, 2, 3

Skills:

- Standard 1: Understandings and Abilities of Scientific Inquiry 1-6
- Standard 7: 6, 7, 8, 16, 21, 23

Lesson 5a: The Frequency of Blood Types Using Simulated Blood

Note: Optional Activity 2 about the Hardy-Weinberg equation has been eliminated from this lesson.

Students use simulated blood sera and antibodies to determine the ABO blood type of unknown blood samples. Students also calculate the frequency distribution of the blood groups in the population tested and determine which ethnic groups the population might represent.

Lesson 5b: Mystery of the Crooked Cell

In this extensive lab activity, students use simulated blood samples and gel electrophoresis to diagnose members of a hypothetical family for sickle cell anemia. Students also conduct a simulation activity with bean seeds to model how selective forces can change allele frequencies in a population.

Lesson 5c: Bioethics Case Studies

Note: This lesson has not been developed.

In this activity students investigate social, ethical, and legal issues that can arise from the application of genetics and biotechnology to the diagnosis and treatment of genetic disorders and to the manipulation of genetic material and reproductive processes.

Supplemental Lesson 5d: Recovering the Romanovs

In this extensive interactive web activity, students use pedigree analysis to trace the inheritance of hemophilia in the Romanov family. Students also examine DNA and other forensic evidence to determine the legitimacy of Ana Anderson's claim to be Anastasia, a member of the Romanov family.

Resources & Teaching Tips

- What text/print/media/kit/web resources best support this unit?

Web Resources: General

- **Wiley Interscience**
  - http://www3.interscience.wiley.com:8100/legacy/college/boyer/0471661791/structure/dna/dna.htm
  - View DNA tutorial.
- **Science Technologies**
  - http://www3.interscience.wiley.com:8100/legacy/college/boyer/0471661791/structure/dna/dna.htm
  - View DNA tutorial.
- **Genetics Science Learning Center at the University of Utah**
  - http://gslc.genetics.utah.edu/
  - DNA structure, transcription, translation, karyotyping, genetic disorders, biotechniques, stem cells, genetic disorders, pharmocogenetics, cloning, and drug addiction.

- **Cells Alive**
  - http://www.cellsalive.com/mitosis.htm and http://www.cellsalive.com/cell_cycle.htm
  - View mitosis, meiosis, and the cell cycle animations.
- **You Tube** – view mitosis and meiosis animations
  - http://www.youtube.com/watch?v=s1ylUTbXyWU
  - http://video.google.com/videoplay?docid=-7061264765331138726&q=mitosis
  - http://www.youtube.com/watch?v=VlN7K1-9QB0
  - http://www.youtube.com/watch?v=CzPGhYiGyZ8&NR
  - http://www.youtube.com/watch?v=D1_-mQS_FZ0
- **Inside Cancer** – extensive resource on cancer
  - http://www.insidecancer.org/ OR http://www.dnai.org/
- **Dolan DNA Learning Center**
  - http://www.dnalc.org/ddnalc/mediashowcase/index.html?id=613
  - View animation of cancer metastasis as well as a wide range of text and questions.
- **Molviz at the University of Massachusetts**
  - http://www.umass.edu/molvis/tutorials/dna/
  - View Jmol DNA molecule visualization tutorial.
- **Human Genome Project**
  - http://www.genome.gov/
  - *Understanding the Human Genome Project*, a multimedia, educational CD created in 2002 and updated in 2006 by NHGRI.
- **Genome News Network**
  - http://www.genomenewsnetwork.org/
  - Genomes, sequencing technique, and the 180 genomes that have been sequence since 1995.
- **Howard Hughes Medical Institute/Biointeractive**
  - http://www.hhmi.org/biointeractive/
  - Order free DVDs (Stem cells, Evolution, etc.) and other resources. Also view animations, videos, and virtual labs.
- **The Biology Project at the University of Arizona**
  - http://www.biology.arizona.edu/ – View two meiosis animations that are part of a meiosis tutorial. Scroll to the bottom of the page at http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html To learn more about how meiosis and fertilizations create genetic diversity open the General Biology Lesson Plans page and scroll to the bottom of the page for the lesson "Sources of Genetic Diversity" by Susan Furr. http://biology.arizona.edu/sciconn/lessons2/lessons.html
    PBS/NOVA How Cells Divide http://www.pbs.org/wgbh/nova/baby/divide.html# On a split screen, view and compare mitosis and meiosis animations.

- **Biotechnology Institute**
  - http://biotechinstitute.org/
  - Navigate to Educational Resources to download back issues of *Your World*, a biotech magazine for students.
- **Rediscovering Biology: Molecular to Global Perspectives**
  - http://www.learner.org/channel/courses/biology/index.html
  - Each of the 13 units in this professional development course for biology teachers contains a 30-minute video, an online textbook, and lesson activities.
- **DNA Interactive**
  - http://www.dnai.org/
  - Extensive resource for animations, videos, and other information about DNA.
- **National Institute of Health**
  - http://science.education.nih.gov/customers.nsf/HSCancer.htm
  - *Cell Biology and Cancer* Curriculum Supplement

Web Resources: Mystery of the Crooked Cell

- **National Institute of Health, National Heart, Lung, and Blood Institute**
  - http://www.nhlbi.nih.gov/
  - Download a PDF file of *The Management of Sickle Cell Disease*. NIH Publication No. 02-2117. This 188-page document describes the current approach to counseling and also the management of many of the medical complications of sickle cell disease. Also download a PDF file of *Facts About Sickle Cell Anemia*. NIH Publication No: 96-4057, 6 pages. This fact sheet provides concise, accurate information on the causes, populations affected, signs and symptoms, diagnoses, and treatments.

- What tips to teachers of the unit can you offer about likely rough spots/student misunderstandings and performance weaknesses, and how to troubleshoot those issues?

Accommodation/Differentiation Ideas and Tips