GENETICS
GRADES 11-12

EWING PUBLIC SCHOOLS
2099 Pennington Road
Ewing, NJ 08618

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Written by: District Science Teachers

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In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

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PREFACE

This curriculum guide is intended to provide a vertical and horizontal framework for the science program of the Ewing Township Schools. It is designed to identify the essential components needed by teachers when they prepare instruction in science which will best meet the needs of their students.

The teacher's knowledge of their students' level of development, learning styles and general readiness of the student to learn should be the guiding factors in selecting the most appropriate ways to reach the goals and objectives defined by this guide.

The selected published materials are intended to provide resources to teachers in their preparation of instructional activities and teachers should feel free to integrate other resources where appropriate as long as they are consistent with the goals and philosophy as outlined. Integration of concepts and skill developed in science into other content areas is encouraged to stimulate real-life experiences and meaning.

All students are not the same. They have different needs, learning styles and levels of readiness. Therefore, teachers will need to make choices in planning instruction so that the needs of each student are addressed and the scope of the curriculum is accomplished.

COURSE DESCRIPTION AND RATIONALE

The need for scientific literacy in today's increasingly technological world has been well documented. All students can and must learn enough science to assume their role as concerned citizens equipped with needed information and decision making skills. Feelings that an understanding of fundamental scientific principles, or the development of these skills is limited on the basis of gender, economic status, cultural diversity or ability, can and must be dispelled.

Over the years, an enormous volume of scientific content has accumulated at an accelerated rate, causing textbooks to thicken as material is added and rarely deleted. Teachers have recognized this as a counterproductive trend. The following science curriculum, therefore, is an attempt to define what all students should know and be able to do as they grow towards scientific literacy in biology. Recognizing the need for the inclusion of fundamental understandings and the development of critical thinking skills is nonetheless considered to be of paramount importance. Science should not be taught at any level devoid of its connectivity with other subjects or the needs of society. It is expected that the relationship of the various disciplines of science to each other and of science to the overall learning experience will be strongly emphasized.

To this end, the planning, delivery and assessment of each student's learning and progress towards the necessary level of scientific literacy shall be guided by the following basic set of standards.

1. The study of science will promote intellectual honesty, skepticism, tolerance of ambiguity, open-mindedness, communication and sharing, positive attitudes and value, curiosity, reflection and a willingness to participate and take intellectual risks.
    a. Develop an awareness of the need for ethics when deciding socio-scientific issues.
    b. Evaluate scientific issues with respect to social, political, geographic and economic concerns.
    c. Take intellectual risks, actively participate in discussion, make judgments and form and defend their convictions based on accurate findings.
    d. Develop an appreciation of the role science in their everyday lives.

2. The study of science will develop problem solving, decision making and inquiry skills reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, conducting risk assessments, drawing conclusions and communicating results.
    a. Design and conduct an experiment that involves the selection and use of appropriate instrumentation.
    b. Recognize and explain the limitations of measuring devices, instruments or experimental design.

c. Prepare a presentation of experimental results using investigation.
d. Explain how experimental results may lead to further investigation.
e. Assess the impact of new technologies or patterns of human activity on the overall quality of life.

3. The study of genetics is designed for students who would like a more in depth study of the biology of inheritance and inheritance patterns. It focuses on classical Mendelian genetics, the DNA molecule and molecular genetics and on population genetics.
   a. Model and compare the phases of the asexually reproductive and sexually reproductive cell cycles.
   b. Explain the various ways that genes are transferred from parents to offspring.
   c. Explain the structure of DNA and chromosomes and how those structures contribute to our uniqueness.
   d. Explain how genetic anomalies can affect a population.
   e. Investigate the causes behind cancer.
   f. Investigate new genetic technologies and explain their impact on the world today.

UNIT 1: INTRODUCTION TO GENETICS/MITOSIS AND MEIOSIS

Why Is This Unit Important?

- Genes affect nearly all aspects of our lives, from our identities, to our health, to what we eat and how we interact with others.
- Our bodies are built of trillions of cells that interact in complex ways to keep us alive.
- All cells in a body use the same genome, but have different structures and functions because they access different parts of the genome.
- Our reproductive systems enable us to start a new generation.

Enduring Understandings

1. Genetics is the study of inherited traits and their variation.
2. Genetics can be considered at the levels of DNA, genes, chromosomes, genomes, cells, tissues, organs, individuals, families and populations.
3. A gene can exist in more than one form, or allele.
4. Comparing genomes among species reveals evolutionary relatedness.
5. Inherited traits are determined by one gene or by multiple genes and the environment.
6. Even the expression of single genes is affected to some extent by the actions of other genes.
7. Genetic determinism is the idea that an inherited trait cannot be modified.
8. Cells are the units of life.
9. Organelles subdivide specific functions.
10. Mitosis and apoptosis regulate cell numbers during development, growth and repair.
11. The cell cycle is controlled by checkpoints.
12. A stem cell self-renews and gives rise to any of several differentiated cell types. All cells descend from stem cells and progenitor cells, which do not self-renew.
13. Cells differentiate down cell lineages by differential gene expression.
14. Stem cells are present throughout life and provide growth and repair.
15. Stem cells in health care include embryonic stem cells, induced pluripotent stem cells and adult stem cells.
16. Meiosis maintains the chromosome number over generations and mixes gene combinations.
17. Crossing over and independent assortment generate further genotypic diversity by creating new combinations of alleles.
18. Teratogens are agents that cause birth defects.

Essential Questions

1. How has the study of genetics impacted the quality of human life?
2. How do gametes differ from somatic cells?

3. How does meiosis differ from mitosis?
4. What roles do sexual reproduction, random fertilization, crossing-over and independent assortment play in increasing genetic variation?
5. What impact has stem cell research had on the study of genetics?

Acquired Knowledge

1. Explain what genetics is and what it is not.
2. Distinguish between genes and genome.
3. Define bioethics.
4. Describe the levels of genetics, from nucleic acids to chromosomes, to cells, body parts, families and populations.
5. Explain how genetics underlies evolution.
6. Discuss how genes and environmental factors interact to sculpt traits.
7. Define genetic determinism.
8. Define differentiated cell.
9. Distinguish between mitosis and apoptosis.
10. Describe the events and control of the cell cycle.
11. List the characteristics of a stem cell.
12. Define stem cell and progenitor cell.
13. Explain why meiosis is necessary to reproduce.
14. Summarize the events of meiosis.
15. Define critical period.
16. List some teratogens.

Acquired Skills

1. Diagram phases of mitosis
2. Diagram phases of meiosis
3. Provide examples of how genetics is used in identification of people, in health care, in agriculture and in ecology.
4. Explain why it is important to know the cellular basis of a disease.

Benchmark or Benchmark or Major Assessments

- teacher generated quizzes
- teacher generated tests
- mitosis/meiosis simulation

Technology Connections

Stem cell webquest (http://www.wordexplain.com/scntwq.html)
www.livingto100.com
www.motherisk.org
www.mrcglobal.org

Accommodations or Modifications for Special Education, ESL or Gifted Learners

Enrichments
- Film Production: Meiosis

Supplements
- Math Problem: New skin cells
- Mitosis Drama

List of Applicable 2004 NJCCCS and Standards/CPIs Covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.A.4-5

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets
- KWL activity

In-Class Activities
- Lab: Doing it on the table
- Mitosis/meiosis flip books

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

UNIT 2: TRANSMISSION GENETICS

Why Is This Unit Important?

- Gregor Mendel deduced the basis of inheritance patterns. His two laws brilliantly described how chromosomes behave in meiosis, which had not yet been discovered.
- Patterns of inheritance can be obscured when genes have many variants, interact with each other or the environment, are in mitochondria, or are linked to the same chromosome.
- Sex affects our lives in many ways. Which sex chromosomes we are dealt at conception sets the development program for maleness or femaleness, but gene expression before and after birth greatly influences how that program unfolds.
- Who we are and how we feel arises from an intricate interplay among our genes and environmental influences. Understanding genetic contributions to traits and illnesses can suggest how we can alter our environments.
- Behavioral traits and disorders reflect effects and interactions of genes and environmental factors on the nervous system.

Enduring Understandings:

1. Single genes can determine trait transmission patterns, but usually other genes and/or the environment modify phenotypes.
2. Modes of inheritance reveal whether a single-gene trait is dominant or recessive and whether the gene that controls it is carried on an autosome or sex chromosome.
3. Genotypes vary in penetrance and expressivity of the phenotype.
4. Mitochondrial genes are maternally inherited and mutate rapidly.
5. Genes on the same chromosome are linked.
6. Traits carried on sex chromosomes display different modes of inheritance for males and females.
7. Polygenic traits are determined by more than one gene and vary continuously in expression.
8. Empiric risk applies population incidence data to predict risk of recurrence for a multifactorial trait or disorder.
9. Behavioral traits reflect genetic and environmental influences and arise from connections among the brain's 100 billion neurons.

Essential Questions:

1. How are traits passed down from parents to offspring?
2. Why is understanding Mendel's principles important in genetics today?
3. How can genotype determine phenotype?
4. How many factors other than genotype affect phenotypic expression?
5. How may an individual's sex influence inheritance and phenotype?

6. Why do some children have traits that cannot be found in either parent?
7. What is pedigree analysis? How is it utilized?
8. Why aren't height, weight and skin color controlled by typical Mendelian genetics?
9. What is behavior?
10. What methods are utilized for studying behavior?
11. What molecular mechanisms may bring about behavioral alterations?

Acquired Knowledge:

1. Define and distinguish heterozygote and homozygote; dominant and recessive; phenotype and genotype.
2. Explain how the law of segregation reflects the events of meiosis.
3. Explain how a gene alone usually does not solely determine a trait.
4. Explain how the law of independent assortment reflects the events of meiosis.
5. Explain how pedigrees show single-gene transmission.
6. Explain how genome sequencing in a family can reveal Mendelian inheritance patterns.
7. Explain how single-gene inheritance is not simple.
8. Discuss phenomena that can appear to alter expected Mendelian ratios.
9. Describe the mode of inheritance of a mitochondrial trait.
10. Explain how linkage is the basis of genetic maps and genome-wide association studies.
11. Describe the factors that contribute to whether we are and feel male or female.
12. Distinguish between X and Y chromosomes and their linkage.
13. Discuss the inheritance pattern of a trait that appears in only one sex.
14. Distinguish between single-gene and polygenic traits.
15. Identify the physical basis of behavioral traits in the brain.
16. Explain how genetics may be used to better understand behavioral disorders.

Acquired Skills:

1. Construct and interpret Punnett squares for various genetic problems.
2. Construct and interpret a pedigree.
3. Explain how linked traits are inherited differently from Mendelian traits.
4. Explain how continuously varying traits reflect genes and the environment.

Accommodations or Modifications for Special Education, ESL or Gifted Learners

Enrichments: The Blue People of Troublesome Creek

Benchmark or Major Assessments

1. Teacher generated quizzes
2. Teacher generated tests
3. Genetic disorder project part I

List of Applicable NJCCCS and Strands/CPI's Covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.E.1

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets

- Before/After Unit Questions
- In-Class Activities
- Punnett Square manipulations
- Lab: Differences in corn
- Hogwart's genetics
- Lab: What makes a gene recessive
- Cat Genetics

Technology

- The Gee in Genome (http://nature.ca/genome/index_e.cfm)
- Pedigree Webquest (https://www.msu.edu/~langley6/chs/Bio/Genetics/Pedigree.htm)
- Imprinted Gene Catalogue website
- Virtual Fly Lab: http://vcourseware3.calstatela.edu/VirtualFlyLab/IntroVflyLab.html

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

UNIT 3: DNA AND CHROMOSOMES

Why Is This Unit Important?

- DNA is the basis of life because of three qualities: it holds information, it copies itself and it changes.
- DNA sequences are the blueprints of life. Cells must maintain this information, yet also access it to manufacture proteins. RNA acts as the go-between, linking DNA to protein.
- Discovering the nature of the genetic material, determining the structure of DNA, cracking the genetic code and sequencing the human genome were steps on the way toward today's challenge: deciphering how the information in the human genome is accessed and used, through tissue and time.
- Mutations provide variation necessary for life to persist. Usually DNA repair protects against harmful mutations, but some mutations are helpful.
- A human genome has 20,000+ protein-encoding genes dispersed among 24 chromosome types. Abnormalities in chromosome number or structure can have sweeping effects, but mutation is a continuum. Chromosomal-level illnesses reflect disruption of individual genes.

Enduring Understandings:

1. In the 1940s, Griffith identified something that could be passed from one bacterium to another, which Avery, MacLeod and McCarty showed was DNA.
2. Hershey and Chase confirmed that DNA and not protein was the genetic material.
3. Using Chargaff's and Franklin's discoveries respectively, Watson and Crick deciphered the structure of DNA.
4. DNA replication occurs simultaneously at several points on each chromosome and the pieces join.
5. RNA is single-stranded, has uracil and ribose and has different functions than DNA.
6. The genetic code is triplet, non-overlapping, continuous, universal and degenerate.
7. A protein can fold in more than one way. Some conformations cause disease.
8. Gene expression patterns change over time and in different cell types.
9. Only a tiny portion of the genome encodes protein, yet the number of proteins greatly outnumbers known protein encoding genes.
10. Mutations add, delete or rearrange genetic material in a germline cell or somatic cell.
11. Mutations in a gene may cause either different versions of the same disease or distinct illnesses.
12. Genes have different mutation rates.

13. Mutagens are chemicals or radiation that increase the risk of mutation. Researchers use mutagens to more quickly obtain mutants, which reveal normal gene function.
14. How a mutation alters the phenotype depends upon its location in the gene.
15. Chromosomes can be visualized in any cell that has a nucleus and can be cultured.
16. Mitotic non-disjunction produces chromosomal mosaics.
17. Chromosome rearrangements can cause deletions or duplications.

Essential Questions:

1. What is the chemical composition and structure of DNA and RNA?
2. How is DNA organized?
3. What is the mechanism for replication?
4. How are genes regulated?
5. What are proteins?
6. What role do proteins have in cells?
7. What are metabolic pathways?
8. What is the relationship between amino acid mutations, enzyme defects and phenotypic effects?
9. What are pharmacogenetics and ecogenetics?
10. What is a mutation?
11. What factors cause mutation?
12. What is the molecular basis of mutations?
13. How are mutations detected?

Acquired Knowledge:

1. Describe the experiments that showed that DNA and not protein is the genetic material.
2. Explain how Watson and Crick deduced the structure of DNA.
3. List the components of a DNA nucleotide building block.
4. Explain how nucleotides join in two chains to form a DNA molecule.
5. List the steps of DNA replication.
6. List the major types of RNA molecules and their functions.
7. List the steps of transcription.
8. Discuss how researchers deduced the genetic code.
9. List the steps of protein synthesis.
10. Define the four components of a protein's shape.
11. Explain the importance of protein folding.
12. Define epigenetics.
13. Explain how division of genes into exons and introns maximizes the number of encoded proteins.
14. Distinguish between mutation and mutant.
15. Distinguish between mutation and polymorphism.
16. Describe other ways that mutations occur.

17. What types of damage do DNA repair mechanisms counter?
18. Describe the types of DNA repair.
19. List the major parts of a chromosome.
20. Describe the way that chromosomes are obtained, prepared and visualized.

Acquired Skills:

1. Construct a karyotype.
2. Simulate protein synthesis.
3. Explain the chemical basis of a spontaneous mutation.
4. Explain how atypical chromosome numbers arise.
5. Explain how atypical chromosome structures arise.

Accommodations or Modifications for Special Education, ESL or Gifted Learners

- Enrichments: Abnormal karyotype
- Supplements: Non-dysjunction reinforcement

Benchmark or Major Assessments

1. Teacher generated quizzes
2. Teacher generated tests
3. Genetic Disorder Project part II

List of Applicable NJCCCS and Strands/CPIs Covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.A.6
5.3.12.D.1-3
5.3.12.E.1

Suggested Learning Experiences and Instructional Activities

<u>Anticipatory Sets</u>

- KWL activity
- In-Class Activities
- Lab: Karyotyping
- Lab: Protein Synthesis
- Protein Synthesis Role Play

Technology

- Web Karyotyping (Genetic Science Learning Center at the Eccles Institute of Human Genetics at the University of Utah website)

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

UNIT 4: POPULATION GENETICS

Why Is This Unit Important?

- Human genetics at the population level considers allele frequencies. Parts of the genome that have changed over time enable us to trace our origins, migrations and relationships. Parts of the genome that do not change provide a way to distinguish individuals.
- Non-random mating, migration, genetic drift, mutation and natural selection are the forces that mold populations and drive evolution.
- Our genes and genomes are informational molecules and their sequences hold clues to our deep past as well as our present diversity.

Enduring Understandings:

1. Population genetics is the study of allele frequencies in groups of organisms of the same species in the same geographic area.
2. The genes in a population comprise its gene pool.
3. Microevolution reflects changes in allele frequencies in populations. It is not occurring if allele frequencies stay constant over generations.
4. Five factors can change genotype frequencies; non-random mating, migration, genetic drift, mutation and natural selection.
5. In Hardy-Weinberg equilibrium, allele frequencies remain constant from one generation to the next.
6. DNA profiles are based on copy number variants.
7. Each person has a unique genetic signature (except multiples)
8. DNA profiling introduces privacy issues.
9. People choose mates for many reasons and they don't contribute the same numbers of children to the next generation. These practices change allele frequencies in populations.
10. Migration alters genotype frequencies by adding and removing alleles from populations.
11. Geographical barriers and language differences often create great differences in allele frequencies.
12. Mutation alters genotype frequencies by introducing new alleles.
13. Different alleles are more likely to confer a survival advantage in different environments.
14. Eugenics is the control of individual human reproduction for societal goals, maximizing the genetic contribution of those deemed acceptable and minimizing the contribution from those considered unacceptable.
15. The more recently two species shared an ancestor, the more alike their DNA and protein sequences and chromosome banding patterns.
16. Molecular clocks apply mutation rates to timescales to estimate when two individuals or types of organisms most recently shared ancestors.
17. Different genes evolve at different rates.

Essential Questions:

1. How are genetics and evolution linked?
2. What factors contribute to the diversity of a population?
3. What is the Hardy-Weinberg principle?
4. What is microevolution?

Acquired Knowledge:

1. State the unit of information of genetics at the population level.
2. Define gene pool.
3. List the five processes that cause microevolutionary change.
4. State the consequence of macroevolutionary change.
5. State the genotypes represented in each part of the Hardy-Weinberg equation.
6. Explain the condition necessary for Hardy-Weinberg equilibrium.
7. Explain how the Hardy-Weinberg equilibrium uses population incidence statistics to predict the probability of a particular phenotype.
8. Explain how parts of the genome that are in Hardy-Weinberg equilibrium can be used to identify individuals.
9. Discuss how mutation affects populations.
10. Provide examples of negative, positive and artificial selection.
11. Explain how balanced polymorphism maintains diseases in populations.
12. Explain how eugenics attempts to alter allele frequencies.
13. Distinguish between hominoids and hominins.
14. Distinguish between Australopithecus and Homo.
15. Explain what genome sequencing has revealed about the ancestry of Neanderthals and us.
16. Explain how DNA information can be used to shed light on evolution.
17. List genes that were important in our evolution.
18. Explain how chromosome banding patterns and protein sequences reveal evolutionary trends.
19. Describe how people expanded out of Africa and then Eurasia, populating the world.

Acquired Skills:

1. Construct a map showing how genetic anomalies spread through a population
2. Explain how non-random mating changes allele frequencies in populations.
3. Explain how migration changes allele frequencies in populations.
4. Explain how genetic drift affects genetic diversity.

Accommodations or Modifications for Special Education, ESL or Gifted Learners

Enrichments: Spreading our genes
Supplements: Our 6th digit

Benchmark or Major Assessments

1. Teacher generated quizzes
2. Teacher generated tests
3. Genetic Disorder Project part III

List of Applicable NJCCCS and Strands/CPIs Covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.C.1-2

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets

- Where are you from?
- In-Class Activities
- Lab: population prediction

Technology

Go to CDC website: Access the journal Emerging Infectious Diseases. Describe a disease that is evolving and cite evidence for this.

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

UNIT 5: IMMUNITY AND CANCER

Why Is This Unit Important?

- The immune system enables us to share the planet with other organisms. Genes control the immune response. We can alter immunity to enhance health.
- A few cells probably escape the controls of the cell cycle in each of us but are usually squelched by the immune system. In one in three of us, though, such errant cells continue to divide and invade healthy tissue, causing cancer. The many forms of cancer reflect mutations in particular cell types.

Enduring Understandings:

1. The immune system consists of cells and biochemicals that distinguish self from non-self antigens.
2. Pathogens include microorganisms and infectious agents.
3. The immune system consists of physical barriers; an innate immune response of inflammation, phagocytosis, complement, collectins and cytokines; and an adaptive immune response that is diverse, specific and remembers.
4. Inherited immune deficiencies affect innate and adaptive immunity.
5. In autoimmune disorders, autoantibodies attack healthy tissue.
6. Vaccines are disabled pathogens or their parts that illicit an immune response against infection by the active pathogen.
7. Immunotherapy uses immune system components to fight disease.
8. Knowing the genome sequence of a pathogen can reveal how it evades the human immune system.
9. Crowd diseases happen when infectious agents are introduced into a population that hasn't encountered them before.
10. Bioterrorism is the use of pathogens – either in their natural state or genetically manipulated – to kill people.
11. Cancer is genetic, but not usually inherited.
12. Cancer occurs when cells divide faster or more times than normal.
13. Determining which mutations are present in particular stages of a cancer can reveal the sequence of gene actions.
14. Large-scale studies of genetic changes in cancer are revealing shared abnormalities in the same pathways in different cancer types.
15. Environmental factors can cause mutations in or alter the expression of genes that raise cancer risk.
16. Treatments for cancer target the characteristic of cancer cells.
17. Diagnosis and treatment of cancer will increasingly consider genetic and genomic information that enables physicians to better match patient to treatment.

Essential Questions:

1. What is the connection between the cell cycle and cancer?

2. How does the immune system protect the body?
3. What is the immune response?
4. What is the role of the immune system in transplantation?
5. Why do we have allergies?
6. What are viruses and how do they attack the immune system?
7. What is HIV?
8. What is epidemiology?

Acquired Knowledge:

1. List the components of the immune system.
2. Distinguish among physical barriers, innate immunity and adaptive immunity.
3. Distinguish between the humoral and cellular immune responses.
4. Discuss conditions that result when the immune system is underactive, overactive and misdirected.
5. Describe how medical technologies boost or suppress immunity to prevent or treat disease.
6. Discuss what we can learn from studying the genomes of pathogens.
7. Describe cancer cells.
8. List ways that cancer cells arise.
9. Discuss how mutations in several genes contribute to cancer.
10. Discuss environmental factors in cancer.
11. Discuss how cancer diagnosis and treatment have become personalized.

Acquired Skills:

1. Explain how loss of cell cycle control causes cancer.
2. Explain how most cancers are not inherited, but are genetic.
3. Explain the genetic causes of cancer.

Accommodations or Modifications for Special Education, ESL or Gifted Learners

Enrichments: Cancer panel

Benchmark or Major Assessments

1. Teacher generated quizzes
2. Teacher generated tests
3. AIDS project

List of Applicable NJCCCS and Strands/CPIs Covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.A.6

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets

- HIV debate
- In-Class Activities
- Lab: Transmission of a disease
- The Nature of Cancer

Technology

www.cancerquest.org
http://cancergenome.nih.gov

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

UNIT 6: GENETIC TECHNOLOGY

Why Is This Unit Important?

- Ancient biotechnologies gave us bakeries and breweries. Modern biotechnologies manipulate DNA to give us new ways to study, monitor and treat disease and alter the environment.
- DNA-based tests have moved the realm of a health care setting to wide availability, thanks to the Internet. Such tests are not simple and can have effects beyond the individual. At the same time, gene therapy has recovered from setbacks with recent successes.
- Assisted reproductive technologies provide intriguing and sometimes complex variations on the process of conceiving a child and carrying it to term.
- Just over a decade ago we saw the first human genome sequences. Today the cost has plummeted to the point that personal genome sequencing is possible. The question is now not could we, but should we?

Enduring Understandings:

1. Biotechnology is the use or modification of cells or biological molecules for a specific application.
2. DNA patenting is evolving to embrace genome-wide applications.
3. In recombinant DNA technology, a cell receives a cloning vector that contains foreign DNA encoding a protein of interest.
4. Recombinant DNA technology is used to manufacture large amounts of a pure protein in single cells and to create multicellular transgenic organisms.
5. Bioremediation uses natural abilities to detoxify environmental contaminants, including genetic modification and experimental evolution.
6. DNA microarrays enable researchers to track gene expression.
7. RNA interference occurs when short, single-stranded RNAs are introduced into a cell and bind to their complements in mRNAs, preventing translation.
8. Gene targeting uses homologous recombination to knock out a specific gene, revealing the gene's function by removing it.
9. A genetic counselor provides information to individuals, couples expecting children and families about modes of inheritance, recurrence risks, genetic tests and treatments.
10. Gene therapy has had a rocky history. Initial success in the early 1990s was followed by several deaths. Using safer vectors, gene therapy has resurged in recent years.
11. Assisted reproductive technologies provide innovative ways to conceive offspring.
12. Male and female infertility are affected by different factors.
13. Embryos in research add to our knowledge of early human development.
14. Human genome sequencing was built on linkage and cytogenetic information from decades of work.

15. The idea to sequence the human genome emerged in the mid-1980s with several goals. The project officially began in 1990.
16. Comparative genomics infers evolutionary relationships from conserved DNA sequences.

Essential Questions:

1. How have human technological advances increased our knowledge of genetics and influence on inheritance?
2. What is genetic counseling?
3. What are the techniques used in cloning?
4. How are clones characterized?
5. How have recombinant DNA techniques revolutionized gene mapping?
6. What are the applications of DNA fingerprinting?
7. What are DNA chips?
8. What is the Human Genome Project?
9. What are the applications of the Human Genome Project?
10. What ethical, social and legal issues surround these most recent advances in biotechnology?

Acquired Knowledge:

1. Discuss the history of patenting organisms and DNA.
2. Identify current problems and controversies concerning patenting DNA sequences.
3. Explain how the polymerase chain reaction makes many copies of a DNA sequence.
4. List uses of DNA amplification.
5. Distinguish between recombinant DNA and transgenic organisms.
6. Describe applications of recombinant DNA technology.
7. Explain how a DNA microarray is used to monitor gene expression.
8. Describe ways to decrease gene expression.
9. List uses of gene silencing.
10. Describe the services that a genetic counselor provides.
11. Explain the uses of preconception comprehensive carrier testing.
12. Explain how a fetal genome can be sequenced.
13. Describe the basis of most newborn screening tests.
14. Discuss the benefits and limitations of direct –to-consumer genetic testing.
15. Define pharmacogenetics and pharmacogenomics.
16. Describe three approaches of correcting inborn errors of metabolism.
17. Explain how an existing drug can be “repurposed” to treat a genetic disease.
18. Explain what gene therapy does.
19. Discuss the ups and downs of the history of gene therapy.
20. Explain how a child can be conceived to provide tissue for an older sibling.
21. Define assisted reproductive technology.
22. Distinguish infertility from subfertility.

23. Describe causes of infertility in males and females.
24. List infertility tests.
25. Describe assisted reproductive technologies that donate sperm, uterus, or oocyte.
26. List the steps of in vitro fertilization.
27. Explain how preimplantation genetic diagnosis avoids the birth of a child with a particular genetic disease.
28. Discuss uses for extra embryos resulting from assisted reproductive technologies.
29. Explain how linkage studies led to the idea to sequence the human genome.
30. Distinguish between the two approaches used to sequence the human genome.
31. Describe the Sanger method of DNA sequencing work.
32. Describe how newer methods of DNA sequencing work.
33. Define synthetic genome.
34. Define human microbiome.

Acquired Skills:

- Extract DNA from an organism

Accommodations or Modifications for Special Education, ESL or Gifted Learners

Enrichments: Extract your own DNA

Benchmark or Major Assessments

1. Teacher generated quizzes
2. Teacher generated tests
3. Genetic Disorder Project part III

List of Applicable NJCCCS and Strands/CPIs covered in This Unit

5.1.12.A.1-3
5.1.12.B.1-4
5.1.12.C.1-3
5.1.12.D.1-3
5.3.12.D.1-3

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:
- KWL activity
- Ethics scenarios
- In-Class Activities
- Lab: DNA extraction
- Lab: recombinant DNA
- Cloning debate

Technology

- Invent an “omics” (Omics.org)
- Personal Genome Project (www.personalgenomes.org) (http://www.genome.gov/10001618)
- www.medomics.com

Instructional Materials

Human Genetics Concepts and Applications (10th Edition). Ricki Lewis. McGraw Hill, 2012

APPENDIX A: APPLICABLE NEW JERSEY CORE CONTENT STANDARDS

5.1 Science Practices: All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing and interpreting the natural and designed world.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Mathematical, physical and computational tools are used to search for and explain core scientific concepts and principles.	5.1.12.A.1	Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.
12	Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.	5.1.12.A.2	Develop and use mathematical, physical and computational tools to build evidence-based models and to pose theories.
12	Revisions of predictions and explanations are based on systematic observations, accurate measurements and structured data/evidence.	5.1.12.A.3	Use scientific principles and theories to build and refine standards for data collection, posing controls and presenting evidence.

B. Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical and computational tools that need to be applied when constructing and evaluating claims.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.	5.1.12.B.1	Design investigations, collect evidence, analyze data and evaluate evidence to determine measures of central tendencies, causal/correlational relationships and anomalous data.
12	Mathematical tools and technology are used to gather, analyze and communicate results.	5.1.12.B.2	Build, refine and represent evidence-based models using mathematical, physical and computational tools.
12	Empirical evidence is used to construct and defend arguments.	5.1.12.B.3	Revise predictions and explanations using evidence and connect explanations/arguments to established scientific knowledge, models and theories.
12	Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.	5.1.12.B.4	Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

C. Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Refinement of understandings, explanations and models occurs as new evidence is incorporated.	5.1.12.C.1	Reflect on and revise understandings as new evidence emerges.
12	Data and refined models are used to revise predictions and explanations.	5.1.12.C.2	Use data representations and new models to revise predictions and explanations.
12	Science is a practice in which an established body of knowledge is continually revised, refined and extended as new evidence emerges.	5.1.12.C.3	Consider alternative theories to interpret and evaluate evidence-based arguments.

D. Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which aresocial practices that are governed by a core set of values and norms.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions and small-group work.	5.1.12.D.1	Engage in multiple forms of discussion in order to process, make sense of and learn from others' ideas, observations and experiences.
12	Science involves using language, both oral and written, as a tool for making thinking public.	5.1.12.D.2	Represent ideas using literal representations, such as graphs, tables, journals, concept maps and diagrams.
12	Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly and ethically.	5.1.12.D.3	Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.3 Life Science: All students will understand that life science principles are powerful conceptual tools for making sense of the complexity, diversity and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world and the order of natural systems can be modeled and predicted through the use of mathematics.

A. Organization and Development: Living organisms are composed of cellular units (structures) that carry out functions required for life. Cellular units are composed of molecules, which also carry out biological functions.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Cells are made of complex molecules that consist mostly of a few elements. Each class of molecules has its own building blocks and specific functions.	5.3.12 A.1	Represent and explain the relationship between the structure and function of each class of complex molecules using a variety of models.
12	Cellular processes are carried out by many different types of molecules, mostly by the group of proteins known as enzymes.	5.3.12.A.2	Demonstrate the properties and functions of enzymes by designing and carrying out an experiment.
12	Cellular function is maintained through the regulation of cellular processes in response to internal and external environmental conditions.	5.3.12.A.3	Predict a cell's response in a given set of environmental conditions.
12	Cells divide through the process of mitosis, resulting in daughter cells that have the same genetic composition as the original cell.	5.3.12.A.4	Distinguish between the processes of cellular growth (cell division) and development (differentiation).
12	Cell differentiation is regulated through the expression of different genes during the development of complex multicellular organisms.	5.3.12.A.5	Describe modern applications of the regulation of cell differentiation and analyze the benefits and risks (e.g., stem cells, sex determination).
12	There is a relationship between the organization of cells into tissues and the organization of tissues into organs. The structures and functions of organs determine their relationships within body systems of an organism.	5.3.12.A.6	Describe how a disease is the result of a malfunctioning system, organ and cell and relate this to possible treatment interventions (e.g., diabetes, cystic fibrosis, lactose intolerance).

B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food and some organisms obtain their food directly from other organisms.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities) ***and*** between living systems and the physical environment, chemical elements are recombined into different products.	5.3.12.B.1	Cite evidence that the transfer and transformation of matter and energy links organisms to one another and to their physical setting.

12	Each recombination of matter and energy results in storage and dissipation of energy into the environment as heat.	5.3.12.B.2	Use mathematical formulas to justify the concept of an efficient diet.
12	Continual input of energy from sunlight keeps matter and energy flowing through ecosystems.	5.3.12.B.3	Predict what would happen to an ecosystem if an energy source was removed.
12	Plants have the capability to take energy from light to form sugar molecules containing carbon, hydrogen and oxygen.	5.3.12.B.4	Explain how environmental factors (such as temperature, light intensity and the amount of water available) can affect photosynthesis as an energy storing process.
12	In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules.	5.3.12.B.5	Investigate and describe the complementary relationship (cycling of matter and flow of energy) between photosynthesis and cellular respiration.
12	All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.	5.3.12.B.6	Explain how the process of cellular respiration is similar to the burning of fossil fuels.

C. Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs.

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms.	5.3.12.C.1	Analyze the interrelationships and interdependencies among different organisms and explain how these relationships contribute to the stability of the ecosystem.
12	Stability in an ecosystem can be disrupted by natural or human interactions.	5.3.12.C.2	Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations.

D. Heredity and Reproduction: Organisms reproduce, develop and have predictable life cycles. Organisms contain genetic information that influences their traits and they pass this on to their offspring during reproduction**.**

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	Genes are segments of DNA molecules located in the chromosome of each cell. DNA molecules contain information that determines a sequence of amino acids, which result in specific proteins.	5.3.12.D.1	Explain the value and potential applications of genome projects.

12	Inserting, deleting, or substituting DNA segments can alter the genetic code. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.	5.3.12.D.2	Predict the potential impact on an organism (no impact, significant impact) given a change in a specific DNA code and provide specific real world examples of conditions caused by mutations.
12	Sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations in the offspring of any two parents.	5.3.12.D.3	Demonstrate through modeling how the sorting and recombination of genes during sexual reproduction has an effect on variation in offspring (meiosis, fertilization).

E. Evolution and Diversity: Sometimes, differences between organisms of the same kind provide advantages for surviving and reproducing in different environments. These selective differences may lead to dramatic changes in characteristics of organisms in a population over extremely long periods of time**.**

By the end of Grade	Content Statement	CPI #	Cumulative Progress Indicator (CPI)
12	New traits may result from new combinations of existing genes or from mutations of genes in reproductive cells within a population.	5.3.12.E.1	Account for the appearance of a novel trait that arose in a given population.
12	Molecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.	5.3.12.E.2	Estimate how closely related species are, based on scientific evidence (e.g., anatomical similarities, similarities of DNA base and/or amino acid sequence).
12	The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms.	5.3.12.E.3	Provide a scientific explanation for the history of life on Earth using scientific evidence (e.g., fossil record, DNA, protein structures, etc.).
12	Evolution occurs as a result of a combination of the following factors: • Ability of species to reproduce • Genetic variability of offspring due to mutation and recombination of genes • Finite supply of the resources required for life • Natural selection, due to environmental pressure, of those organisms better able to survive and leave offspring	5.3.12.E.4	Account for the evolution of a species by citing specific evidence of biological mechanisms.

APPENDIX B: SCOPE OF ESSENTIAL LEARNING IN SCIENCE K-12

Standard 5.1 Scientific Processes All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.	
Big Ideas: • Science is a way of thinking about and investigating the world in which we all live. • Science cannot be practiced or learned without appreciation of the role of mathematics in discovering and expressing natural laws. Tables, graphs and equations are alternative ways of representing information or relationships, each with advantages and disadvantages.	
Essential Questions	**Enduring Understandings**
Strand A. Understanding Scientific Explanations • How do we build and refine models that define and explain the natural and designed world?	• Measurement and observation tools are used to categorize, represent and interpret the natural world.
Strand B. Generate Scientific Evidence Through Active Investigations • What makes a question scientific? • What constitutes useful scientific evidence?	• Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory and communicating and justifying explanations. • Evidence is used for building, refining and/or critiquing scientific explanations.
Strand C. Reflect on Scientific Knowledge • How is scientific knowledge constructed?	• Scientific knowledge builds upon itself over time.
Strand D. Participate Productively in Science • How does scientific knowledge benefit – deepen and broaden – from scientists sharing and debating ideas and information with peers?	• The growth of scientific knowledge involves critique and communication – social practices that are governed by a core set of values and norms.

Standard 5.2 All students will understand that physical science principles, including fundamental ideas about matter, energy and motion, are powerful conceptual tools for making sense of phenomena in physical, living and Earth systems science.	
Big Ideas: • Materials exist throughout our physical world. The structures of materials influence their physical properties, chemical reactivity and use. • The flow of energy drives processes of change in all biological, chemical, physical and geological systems. The conservation of energy is a law that can be used to analyze and build understandings of diverse physical and biological systems.	
Essential Questions	**Enduring Understandings**
Strand A. Properties of Matter • How do properties of materials determine their use?	• The atomic structures of materials determine their properties.
Strand B. Changes in Matter • What determines the type and extent of a chemical reaction?	• There are several ways in which elements and compounds react to form new substances and each reaction involves the flow of energy.

Strand C. Forms of Energy • How do we know that things have energy?	• Energy takes many forms. • These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy) and types of energy associated with the position of mass and with energy fields (potential energy).
Strand D. Energy Transfer and Conservation • What happens to the total energy in a system during interactions?	• Entropy is a natural process. • While the total energy in the universe may be constant the energy changes form and location with a constant 'loss' of energy from 'usable' to non-usable' forms.
Strand E. Forces and Motion • How would the universe be different if one or more of the laws of motion were suspended?	• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.

Standard 5.3 Life Science All students will understand that life science principles are powerful conceptual tools for making sense of the complexity, diversity and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world and the order of natural systems can be modeled and predicted through the use of mathematics.	
Big Idea: The natural world is defined by organisms and life processes which conform to principles regarding conservation and transformation of matter and energy. Knowledge about life processes can be applied to improving human health and well being.	
Essential Questions	**Enduring Understandings**
Strand A. Organization and Development • How does structure relate to function in living systems from the organismal to the cellular level?	• Living systems, from the organismal to the cellular level, demonstrate the complementary nature of structure and function.
Strand B. Matter and Energy Transformations • How is matter transferred and energy transferred/transformed in living systems?	• All organisms transfer matter and convert energy from one form to another. • Both matter and energy are necessary to build and maintain structures within the organism.
Strand C. Interdependence • How are organisms dependant on each other?	• The survival of organisms is affected by interactions with each other and their environment and can be altered by human manipulation.
Strand D. Heredity and Reproduction • How is genetic information passed through generations?	• There are predictable patterns of inheritance. • The variation that exists within a species is related to its mode of reproduction.
Strand E. Evolution and Diversity • How does natural selection encourage inter and intra-specific diversity over time? • How does this help them reproduce and survive?	• The diversity and changing of life forms over many generations is the result of natural selection, in which organisms with advantageous traits survive, reproduce and pass those traits to offspring.

Standard 5.4 Earth Systems Science
All students will understand that Earth operates as a set of complex, dynamic and interconnected systems and is a part of the all-encompassing system of the universe.

Big Idea:

- Earth's dynamic systems are made up of the geosphere, hydrosphere, atmosphere and biosphere. Interactions among these spheres have resulted in ongoing changes to the system. Some of these changes can be measured on human time scale, but others occur so slowly that they must be inferred from geological evidence.
- Our Solar System is part of the Milky Way Galaxy which is one of many galaxies in the known Universe. While the composition of planets varies considerably, their components and the applicable laws of science are universal.

Essential Questions	Enduring Understandings
Strand A. Objects in the Universe • Is there order to the Universe? • What characteristics does our Sun share with other stars? • How are planets and other objects in the Solar System similar to and different from Earth? • What implication does this have for the existence and sustaining of life?	• The universe is composed of galaxies, each of which is composed of solar systems having the same elements and governed by the same laws. • The Sun is star. • Physical characteristics of planets depend on their distance from the Sun and their size.
Strand B. History of Earth • How do geologic events occurring today provide insight into Earth's past?	• Earth's components form systems. These systems continually interact at different rates of time affecting the shape of the Earth's surface regionally and globally.
Strand C. Properties of Earth's Materials • How does understanding the properties of Earth materials and the physical laws that govern behavior lead to prediction of Earth events?	• Earth systems can be broken down into individual components which have observable measurable properties.
Strand D. Tectonics • Is the structure of the Earth's land and water masses the same as it was in the past and will be in the future?	• Convection currents in the upper mantle drive plate motion. Plates are pushed apart at spreading zones and pulled down into the crust at subduction zones.
Strand E. Energy in Earth Systems • Where does the energy driving the systems on earth come from?	• The sun is a major external source of energy for Earth's global energy budget. • Earth's systems have internal and external sources of energy, both of which create heat.
Strand F. Climate and Weather • How do changes in one part of an Earth system affect other parts of the system?	• Earth's components form systems. These systems continually interact at different rates of time affecting the Earth regionally and globally.
Strand G. Biogeochemical Cycles • How do humans impact the diversity and stability of ecosystems?	• Humans can alter the living and non-living factors within an ecosystem, thereby creating changes in the overall system.