Randolph Township Schools
Randolph High School
Genetics Honors Curriculum

"DNA was the first three-dimensional Xerox machine."
~Kenneth Ewart Boulding

Department Name
Anthony Emmons

Curriculum Committee
Brianna Malone
Lauren Poma

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Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Affirmative Action Statement
Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

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EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

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Introduction

This semester-long course is an elective designed for those students interested in a deeper understanding of the human genome and gene expression. Previous completion of a full-year Biology course is mandatory. This course will expand previous knowledge as students investigate biotechnology and medical applications, recent technological advancements in genetics, and ethical issues that arise. Genetics is an applied science that incorporates technology, mathematics, and basic science. The science of genetics changes rapidly. As such, this course aims to stay current with advancements as they occur. Exposure to sensitive issues such as genetic disease and epigenetics will promote a deeper understanding of self-care and respect for others. Students taking this course will have successfully completed A-level or Honors Biology or B-level Biology with a teacher recommendation.

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Curriculum Pacing Chart

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
8 weeks	**I**	**Molecular Genetics**
5 weeks	**II**	**Science of Genetics**
5 weeks	**III**	**Inheritance and Evolution**

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Unit I: Molecular Genetics

TRANSFER: Apply the scientific method to make observations, draw conclusions, and discover the importance of biotechnology in science.

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon- based molecules.	Heritable information provided the continuity of life.	• What story does DNA tell?
	DNA structure, translated by RNA, provides the instructions for building and maintaining the proteins, which form the body.	• How does genetic information flow in a cell?
	The deliberate human manipulation of the genetic code is both possible and, now, common. This power has unpredictable consequences.	• Should we genetically edit an embryo's DNA? If so, when?
	Matching DNA sequences can help to clarify relationships by establishing identity and reconstructing historical events.	• Does DNA evidence demand a verdict in a trial?
	Viruses can be used as vectors to target specific cells, treat genetic diseases as therapy tools, and create vaccines.	• How can viruses be used in the medical field?

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Unit I: Molecular Genetics

	KNOWLEDGE **Students will know:**	**SKILLS** **Students will be able to:**
	The structure of DNA.	Use a model to describe how DNA structure is the foundation of genetic function. Analyze DNA fragments to determine information stored within the sequence of its bases.
	DNA replication is necessary for transmission of information to the next generation.	Describe the semi-conservative nature of DNA replication. Describe the process by which DNA is replicated. Build a model of DNA replication.
	Protein synthesis involves both transcription and translation of the DNA molecule.	Create a model of transcription and translation. Differentiate between introns and exons. Model the process by which transfer RNAs mediate the translation of mRNA codons into amino acids. Identify mutations that become evident through the analysis of codons.

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Unit I: Molecular Genetics

	Basic operations used by researchers to study and manipulate DNA.	Cut DNA strands into smaller, manageable fragments using appropriate restriction enzymes. Utilize gel electrophoresis to compare various DNA samples. Amplify DNA samples using polymerase chain reaction (PCR). Create a recombinant DNA molecule using a vector and DNA fragment. Relate restriction enzymes, PCR, gel electrophoresis, and DNA fingerprinting. Describe the mechanism and applications of CRISPR.
	VOCABULARY: DNA, RNA, protein, replication, transcription, translation, gene expression, CRISPR, restriction enzymes, PCR, gel electrophoresis, DNA fingerprint, viruses, recombinant DNA, gene therapy	

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Unit I: Molecular Genetics

ASSESSMENT EVIDENCE: Students will show their learning by:

- Creating and presenting visual representations to outline and explain the flow of genetic information in a cell.
- Performing the scientific method to discover the importance of biotechnology focusing on crime scene investigation, disease prevention, agriculture, and the environment.
- Modeling how viruses can be used in the field of science.

KEY LEARNING EVENTS AND INSTRUCTION:

- Protein Project: Create and present an analogy (example: social media profile) for a protein to illustrate the importance of structure function relationships.
- Model of DNA Replication: Create and explain a model of DNA replication that depicts the stages, enzymatic activity, and overall function.
- Model of Protein synthesis/Gene Expression: Create and explain a model of gene expression to show the flow of genetic information in a cell.
- Biotechnology Simulations: Students navigate online simulations to view the action and importance of restriction enzymes, PCR, and gel electrophoresis.
- DNA Fingerprint Analysis: Analyze DNA fingerprints used for paternity testing, crime scene investigation, and gene isolation.
- Virus Project: Outline how viruses infect a cell and how manipulation of their genome can be used to create medicine, treat genetic conditions, and prevent infection.

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Unit I: Molecular Genetics

SUGGESTED TIME ALLOTMENT	8 weeks
SUPPLEMENTAL UNIT RESOURCES	Case Studies: National Center for Case Study Teaching in Science- example case studies for this unit include: 1. *"Selecting the Perfect Baby: The Ethics of Embryo Design"* 2. *"Pharmacogenetics: Using Genetics to Treat Diseases"* 3. *"Wiggles isn't Wiggling: Gene Expression Edition"* Online Interactives: 1. Virtual Lab/Simulation - Gel Electrophoresis: http://learn.genetics.utah.edu/content/labs/gel/ 2. Virtual Lab/Simulation - Polymerase Chain Reaction: http://learn.genetics.utah.edu/content/labs/pcr/ 3. WebQuest - Stem Cells and Gene Expression: http://learn.genetics.utah.edu/content/stemcells/sctypes/ Paper Lab: Restriction Enzymes and Insulin Video: GATTACA Lab: Brownie Synthesis Lesson Plan: Gene Editing: How Far Should We Go? (Gene Editing Scenarios and Discussion)

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Unit II: Science of Genetics

<table>
<tr><td colspan="3">TRANSFER: Analyze evidence to develop models that explain scientific phenomena.</td></tr>
<tr><td rowspan="7">STANDARDS / GOALS:

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Heritable information provides the continuity of life.</td><td>• What story does DNA tell?</td></tr>
<tr><td>Fertilization results in an individual who is a unique combination of two parents.</td><td>• How did I become who I am?</td></tr>
<tr><td>Some cells of the body undergo a special form of division to reduce their number of chromosomes and differentiate to specialize for reproduction.</td><td>• How does life create more life?</td></tr>
<tr><td>The environment and genes impact the expression of biological traits.</td><td>• To what extent does the environment impact who I am?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>Exact reproduction of eukaryotic cells is accomplished by mitosis, which duplicates and then apportions chromosomes.</td><td>Demonstrate the sequence of mitosis using manipulatives or in a self-made video.</td></tr>
</table>

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Unit II: Science of Genetics

	Sexual reproduction offers many advantages and some disadvantages relative to cloning.	Examine data showing the effects of sexual and asexual reproduction in a sample population. Demonstrate three ways that sexual reproduction increases variety in a population.
	Sexual reproduction is possible only in diploid organisms, which replicate, shuffle, recombine, and sort their chromosomes into specialized gametes that contain one set of the genes only.	Demonstrate the sequence of meiosis using manipulatives.
	Fertilization fuses the cells from two parents to make one zygote. Errors in the processes of chromosome replication, assortment, and apportionment lead to dosage-related genetic disorders in offspring.	Explain the genotypic and phenotypic result of replication and nondisjunction. Predict the effects of monosomy and trisomy on phenotype. Research and present environmental factors that affect the rate of chromosome abnormalities.
	Gametes may or may not be specialized into two genders.	Debate the ethical issues involved in prenatal testing for gender in humans. Distinguish between sex and gender. Use a model to compare the difference between sexual and asexual reproduction in a small population.

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Unit II: Science of Genetics

	A variety of tests can diagnose and predict the phenotype problems that result from chromosomal damage or duplication.	Use karyotypes to diagnose chromosomal disorders. Distinguish between chromosomal and allelic disorders. Research and present the technique involved in genetic tests such as amniocentesis, chorionic villi sampling, and karyotyping.
	Cancer is uncontrolled cell division. It can be caused by both inherited and environmental factors.	Identify the molecular causes of cancer including the role of tumor suppressor genes (p53) and telomerase. Research significant environmental risk factors for cancer. Examine data from twin studies to identify the impact of nature vs. nurture. Epigenetic alterations of the DNA molecule can alter the expression of various genes.
	Reproductive cloning produces identical copies of whole organisms through the process of somatic cell nuclear transfer.	Simulate the process of reproductive cloning. Construct a timeline of the history of cloning. Debate the bioethics of human cloning.

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Unit II: Science of Genetics

	VOCABULARY: mitosis, meiosis, gametes, fertilization, zygote, haploid, diploid, amniocentesis, chorionic villi sampling, nondisjunction, karyotyping, monosomy, trisomy, prenatal testing, cancer, somatic cell nuclear transfer	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Using manipulatives to compare and contrast mitosis and meiosis.
- Analyzing a karyotype to determine genetic abnormalities and gender of an individual.
- Comparing the impact of nature vs. nurture on gene expression.
- Summarizing scientific technologies that manipulate mitosis and meiosis (cancer therapeutics and somatic cell nuclear transfer).

KEY LEARNING EVENTS AND INSTRUCTION:

- Reproduction Models: Create and explain models of mitosis and meiosis to compare and contrast the two divisions and illustrate their importance in the human body.
- Research Project: Analyze a karyotype, research, and present a genetic abnormality.
- Primary Source Analysis: Summarize from a primary source scientific journal the role of tumor suppressor genes or telomerase in cancer.
- Case Study on Epigenetics: Complete “Lick Your Rats” Learn Genetics interactive to compare the impact of nature and nurture on the expression of genes.
- Timeline Activity: Construct a timeline of the history of cloning.
- Cloning Simulation: Simulate the process of somatic cell nuclear transfer using Learn Genetics Utah “Click and Clone.”
- Debate: Bioethics of human cloning.

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Unit II: Science of Genetics

SUGGESTED TIME ALLOTMENT	5 weeks
SUPPLEMENTAL UNIT RESOURCES	Interactive: Lick Your Rats: https://learn.genetics.utah.edu/content/epigenetics/rats/ POGIL: Asexual and Sexual Reproduction Paper Lab: Construct and Analyze a Karyotype Virtual Labs: 1. Make a Karyotype: https://learn.genetics.utah.edu/content/basics/karyotype/ 2. The Cell Cycle and Cancer: http://glencoe.mheducation.com/sites/0078695104/student_view0/unit2/chapter9/virtual_labs.html 3. Click and Clone: https://learn.genetics.utah.edu/content/cloning/clickandclone/ 4. DNA Microarray: https://learn.genetics.utah.edu/content/labs/microarray/ Database for Primary Source Science Journals: https://pubmed.ncbi.nlm.nih.gov/ Lesson Plans - Classifying Cancer Genes and Examining Patient Data: https://www.biointeractive.org/classroom-resources/classifying-cancer-genes-and-examining-patient-data Lesson Plans - You've Come a Long Way Dolly: https://teach.genetics.utah.edu/content/cloning/YouveComeALongWayDolly.pdf Video: NOVA: Ghost in Your Genes

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Unit III: Inheritance and Evolution

TRANSFER: Analyze evidence to illustrate the relationships between systems or between components of a system.

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms. lacking this trait.	Fertilization results in an individual who is a unique combination of two parents.	• How do I become who I am?
	The type and number of genes passed through families is predictable using the methods of probability.	• What does it mean to be family?
	Combinations of a few elements can result in an infinite variety of outcomes.	• How can each of us be unique if there are 7 billion people?
	Evolution acts of variations in populations to cause change over time.	• How do species originate?
	KNOWLEDGE **Students will know:**	**SKILLS** **Students will be able to:**
	Fertilization fuses the cells from two parents to make one zygote. Each offspring contains one set of genes from each parent; siblings share ½ of their DNA, grandchildren 14 and so on. Family members share, within fractions, exact DNA.	Explain fertilization, emphasizing that it occurs after meiosis. Describe how variations created during meiosis and fertilization create unique allelic combinations.

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Unit III: Inheritance and Evolution

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	Probability theory can be used to predict the results of sexual reproduction and thereby predict the phenotypes of offspring. Each new organism represents a crossing of all the traits of two parents. The two alleles in a diploid organism may be identical or different, resulting phenotypes may reflect one or both alleles, these molecular relationships are not predictable but are consistent and can be studied mathematically. The presence and nature of particular alleles can be inferred from the study of outcomes of multiple crosses even when the gene is not understood.	Use Punnett squares and probability calculations to predict the outcome of defined crosses. Perform probability calculations to predict the outcome of defined crosses. Calculate phenotypic and genotypic probabilities based of the following types of Punnett squares: dominance, codominance, incomplete dominance, and sex linkage. Use both Punnett squares and probability calculations to infer the parentage of a set of offspring. Follow the effects of a cross into three generations. Infer allelic relationships including dominance, codominance, incomplete dominance, and sex linkage from given data. Use known allelic relationships in several different genes to produce a predicted pattern of offspring phenotypes. Evaluate outcomes from a dihybrid cross to determine if genes are linked.

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Unit III: Inheritance and Evolution

	The probability of inheriting genetic disorders can be calculated through multiple generations.	Build a linkage map based on recombination frequencies to determine relative location of genes on a chromosome. Build a pedigree using disease data to determine phenotypic probabilities of inheriting genetic disorders.
	Variation makes evolution possible.	Correlate mutations to the continuous variation within a species. Calculate the inclusive fitness and coefficient of relatedness of your family. Explain exactly what family members do and do not share. Explain why all populations evolve all the time. Model the effects of environmental events on variable and less variable populations.
	Analysis of comparative genomes and genes at the molecular level can be used to establish evolutionary relationships.	Describe the genetic mechanisms by which organisms can become a new species. Compare molecular data using BLAST to determine evolutionary relationships between two different species. Construct and analyze a phylogenetic tree based upon gene sequence data.

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Unit III: Inheritance and Evolution

	VOCABULARY: variation, allele, loci, genotype, phenotype, diploid, chromosome, zygote, Punnett square, dominant, recessive, codominant, incomplete dominant, monohybrid, dihybrid, heterozygous, homozygous, sex-linked, autosome, pedigree, phylogenetic tree, natural selection, speciation, evolutionary fitness	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Determining the traits of a pigeon by shuffling genes and completing Punnett square crosses.
- Researching a genetic disorder and construct a pedigree to show the inheritance through a family.
- Analyzing molecular data to determine evolutionary relationships.
- Constructing a phylogenetic tree to show the evolutionary relationships.

KEY LEARNING EVENTS AND INSTRUCTION:

- Punnett Square Analysis: Complete dominance, codominance, incomplete dominance, and sex linkage Punnett squares.
- Group Activity: Create a pedigree of the nicotine addiction gene from the learn genetics case study PI: Pedigree Investigator, On the Case of Nicotine Addiction.
- Pedigree Project: Select a genetic disorder and construct a pedigree to show the inheritance of that disorder through a family.
- Analysis of Evolutionary Relationships using Evidence: Compare evidence between a giant panda, red panda, and a bear to determine the evolutionary relationship of the giant panda.
- Analysis of Evolutionary Relationships using BLAST: Use the BLAST tool to compare mitochondrial DNA samples of whales.
- Phylogenetic Tree Project: Construct a phylogenetic tree of Caminalcules.

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Unit III: Inheritance and Evolution

SUGGESTED TIME ALLOTMENT	5 Weeks
SUPPLEMENTAL UNIT RESOURCES	Virtual Labs: 1. Build a Bird - The Pigeon Gene Shuffle: https://teach.genetics.utah.edu/content/pigeons/build-a-bird.pdf 2. PI - Pedigree Investigator, On the Case of Nicotine Addiction: https://learn.genetics.utah.edu/content/addiction/pi/ Lesson Plans - A Tale of Two Pandas Case Study & Phylogenetic Tree: https://teach.genetics.utah.edu/content/evolution/ancestry/pdfs/panda-teacher-guide.pdf Lesson Plans - A Whale of a Tale BLAST: https://www.mbari.org/a-whale-of-a-tale/ Interactive - Bears, Species, DNA & Phylogenetic Tree: https://learn.genetics.utah.edu/content/evolution/bears/ Paper Lab: Create a Phylogenetic Tree of Caminalcules

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APPENDIX A

RESOURCES:

- University of Utah: Learn Genetics website
- Pubmed Database
- Monterey Bay Aquarium Research Institute
- Howard Hughes Medical Institute website
- PBS NOVA
- University of Buffalo: National Center for Case Study Teaching in Science

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APPENDIX B

ASSESSMENTS:

- Daily quizzing/do-now/problem puzzles
- Paper and pencil quizzes and tests, including both objective and open-answer formats
- Problem solving assessments, for example medical case studies
- Interpretation of data, for example electrophoresis gels, pedigrees, and cross outcome phenotype numbers
- Lab reports, both written an oral, formal and informal
- Individual projects which may include self-designed experiments and library research
- Group projects, particularly experiments
- Homework questions and problem sets

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APPENDIX C

INTERDISCIPLINARY LINKS

Genetic technology is in constant use today as it affects medical treatment, family planning, conservation biology, and agriculture.

Opportunities exist for interdisciplinary units with social studies, mathematics, environmental science, botany, health and physical education.