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Genetically Engineering Cures for Single Gene Diseases

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This unit is suited for students enrolled in high school Biology and Biology AP. This unit examines the genetic makeup of a disease or medical condition and seeks out possible cures using genetic engineering. This unit is modeled around STEM education and involves project-based learning, which is aligned with the New Generation Science Standards that California schools will soon adopt. The material in the unit is extensive and, therefore, the unit will be carried out over 8 weeks because it requires students have a proficient understanding of fundamental DNA structure, function, mutations and biotechnology.

Introduction

DNA is considered to hold the secrets of life. Perhaps that was the case at one moment in time but we are witnessing a revolution in how DNA is viewed and how we are able to manipulate it. With modern technologies and expert research, the DNA that once symbolized a mystery to the diversity of life, is being replicated, studied and altered. Genetic engineering is pulling the cloak from the secrets that lie within DNA and allowing academics to become versed in the structure and function of DNA.

Where I Teach

My students live in the small urban city of Emeryville, Ca and surrounding neighborhoods, creating a rather diverse student population. Emery Secondary School is a small high school of approximately 240 students. Based on the most recent published numbers for Emery Secondary School, a majority of students are Black American (66%), Latino (22%), Asian including Middle Eastern (12%). My school's population comes from working class families and nearly 98% of students qualify for free or reduced lunches. English learners are 8% of the population and students with disabilities are 12% of enrollment. The learners in my classes demonstrate a large range of skill level and many of our ambitious young students are not provided the opportunities to explore the capabilities of their minds. I want to incorporate STEM education and project based learning into my curriculum in order to equip my students with tools to succeed in higher education.

What I Teach

I teach Biology to sophomore students who before coming to my class last had science education in the eighth grade. This will be the students first experience in high school level science, therefore I emphasize the use of

proper scientific methods while being scientists in my classroom. This course will be held three times a week due to a recently acquired modified block schedule. Two sections will be 90 minutes long and one will be 60 minutes long. I also teach AP Biology to juniors and seniors: I meet with these students four days a week. Monday, Tuesday, Thursday and Friday for 60 minutes a class. Students must have completed both first year biology and chemistry prior to enrolling in AP Biology. Students who take this course are preparing to take the AP test in Biology.

Class Structure

I use many modalities to educate my students and attempt to make the content as engaging and relatable as possible. Students spend half of their time in class completing activities in which they build, replicate or manipulate topics discussed in class. It is essential that I provide tactile learning for my students to conceptualize the microscopic organisms in biology but also to demonstrate processes. My classroom is designed to be student-led with my facilitation. I spend a considerable amount of time training the students in routines and expectations in the classroom. The purpose is that I equip the students with the tools they need in order to explore in an inquiry based learning environment. This style of teaching is necessary for my unit as will be discussed below.

Rationale

Unit Relevance and Importance

Cell Biology and Genetics were the two most interesting units for my students in past years. Although there is a large amount of content to cover, the students are generally engaged in understanding the structure of the most basic units of life. Students of all learning levels are capable of grasping a basic understanding of the structure of DNA and the purpose of our genes. During my Physiology unit last spring, I also observed the intense interest students have in disease and human health. Therefore, I suspect the students will be quite engaged when presented with this the material in this unit because it brings together their knowledge of how genes are determined from DNA and the resulting diseases that are expressed.

What Students Will Learn

This project is much more than an assignment for my class. It is a chance for the students to learn essential research skills, application of knowledge and professionalism. I am quite concerned with the student's ability to practice and execute professional presentations. Often times we teach to students and instruct them on every detail on what they are to know and be tested on. I believe students will greatly appreciate the opportunity to demonstrate their understanding and creativity. Furthermore, this project is an exciting way to measure the students' knowledge of the state standards that they are held to and tested upon in the spring.

Engineering Challenge

In this unit students will explore a genetic disease or medical condition of their choosing from a list provided of single gene disorders. The task is to research the disorder, explore the characteristics of the gene responsible, determine the method for testing it, and propose an idea of how a scientist and medical engineer could go about trying to find a cure using genetic engineering. The purpose of this unit is to deepen students

understanding of the structure and manipulation of DNA as well as familiarity with genetic disorders.

Objectives/ Review of Standards

This unit is unique in that it integrates a number of standards for learning to create one comprehensive set of requirements and expectations for students in the science courses. In 2014 my school will adopt the new Common Core Standards, but until then we will continue teaching with the California State Standards while trying to incorporate some of the new concepts with Common Core. Most currently, California schools refer to the California State Standards that are a set of topics students should know and understand. This includes structure of DNA and genetics as well as basic investigation and experimentation knowledge. California is soon progressing to the Common Core Standards for Humanities and Mathematics, which focus on project-based learning and require students to move beyond knowing to demonstration of understanding. Although science standards are not included in Common Core, they are addressed in the Next Generation Science Standards. Lastly, this unit ties in project based learning within STEM education. STEM (science, technology, engineering, mathematics) is currently a favorable program among California schools, which are looking to invest in challenging and engaging curriculum to help students develop interests in STEM fields. There is an aspect of each field throughout this unit.

Specific Standards in the Unit

Content on structure and function of cells and DNA addresses California State Standards in Cell Biology and Genetics. Within these standards, this unit addresses the structure and function of DNA, RNA and proteins. Students will understand the semiconservative structure and replication of the DNA and the mutations that can occur. These standards include knowledge of the pathway of the central dogma, the synthesis of proteins, reading of the genetic code, and understanding of the characteristics of proteins made from amino acids. Lastly, students will be introduced to biotechnology and how it is used in studying DNA when they complete their gel electrophoresis lab. The section on human health and single gene diseases covers the Physiology standards pertaining to knowledge of blood function in the circulatory system, waste excretion and nutrient intake of the respiratory system, and sense and perception in the nervous system. The challenge portion of the unit in which students manipulate the genes to cure known diseases incorporates CSS in Investigation and Experimentation that include analyzing situations and problem solving based on concepts from more that one area of science. Lastly, this unit covers standards in the Next Generation Science Requirements pertaining to modeling mutations and assessing the affect a mutation has on an organism.

Collaboration

Emery Unified is developing it's practice in STEM teaching and for that purpose I will collaborate with the mathematics departments and technology instructor. Determining possibility of disease is dependant on the genes of parents and the likelihood they are passed onto the offspring. Students will work in their statistics course to evaluate the incidence of the diseases to be studied. I want to students to understand the likelihood of a disease within a community by examining their own.

Many of my students do not own a computer at home and are hardly able to navigate through simple instructions when using one at school. To help them improve their skills, this unit will require students to document their work on a word file as well as create a presentation using power point. For that, I will collaborate with the technology instructor, who will give lessons on how to perform basic functions on the computers, such as tools for formatting. It is important that my students become fluent in the use of professional technology should they want to be successful in work or school. Students will learn to complete accurate science research using accredited sources and to report on them accurately. Students will also have the opportunity to complete lab activities using Gel Electrophoresis in the classroom to demonstrate the use of biotechnology in science specifically related to human health.

Essential Content/Background

This is a multi-step curriculum. In this unit, I cover nearly a fourth of my overall curriculum in order for students to engage and explore over the full range of biological knowledge. Below is an outline for the curriculum.

Cell Biology

This portion of the curriculum will involve learning the basic components of DNA. Students will learn the history of the discovery of DNA and the methods used to produce images of its structure. Students will learn of the Central Dogma to see the role of DNA as it is replicated, transcribed and translated into proteins. Once students demonstrate proficiency in the expression and function of genes, students will learn about the types of mutations that cause disease by changing the characteristics of the DNA.

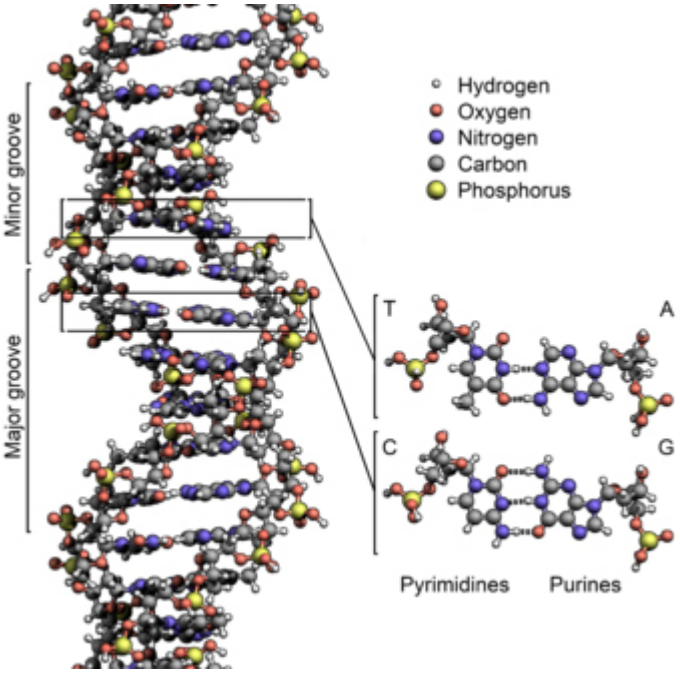
The human body is one organism, composed of a set of organs that provide essential functions, made up of layers upon layers of tissue, constructed from a specific grouping of cells. [1] We are a unique mosaic of eukaryotic cells that contain within them the intricate mechanisms for sustaining life. Organelles of varying structure serve a number of functions that control the integrity and life of the cell, which in turn keeps the body healthy and functioning properly. It's incredible to consider all the processes that occur within a microscopic cell. Nestling safe within all 50 trillion cells of the human body is our genetic blueprint, safe in the porous membrane of the nuclei that contain DNA.

Not too long ago, approximately 60 years ago, one of the greatest discoveries in science occurred, changing the way scientists view the entire field. This is not to be taken lightly. The exponential growth in the study of DNA since it's discovery is remarkable. Within the 20 th century, scientists not only discovered the blueprint for life (DNA) but also were also able to determine the structure and characteristics to its structure. This breakthrough in science made a huge affect on the research and answers that followed. James Watson and Francis Crick in 1954 made the breakthrough discovery of an era, defended by the X-ray diffraction images developed by Rosalind Franklin, who is often overlooked as an essential contributor to the discovery of DNA. [1] DNA stands for deoxyribonucleic acid, which carries the genetic information for each individual. From one person to the next, our genetic information is nearly identical, however it's in the small differences between our DNA that makes us appear different. Each of our 50 some trillion cells that make our bodies carries the entire genome of a human. Compacted within every nucleus of a cell are 23 pairs of chromosomes that contain genetic material. If the DNA of our chromosomes from a single cell were to be laid out in a line, it

would reach nearly 20 meters in length.

Considering the importance of DNA, one might think that its structure is quite elaborate, however if you can picture a ladder, the structure is quite simple to grasp. DNA has a double helical structure, also referred to as a twisted ladder model. Two anti-parallel strands with a sugar-phosphate backbone outline the long stretch of genetic material. [2] The rails, or steps, of this ladder are constructed of nitrogenous bases (A, C, T, G), two bases per rail, with the paired bases held together with hydrogen bonds.

Figure 1



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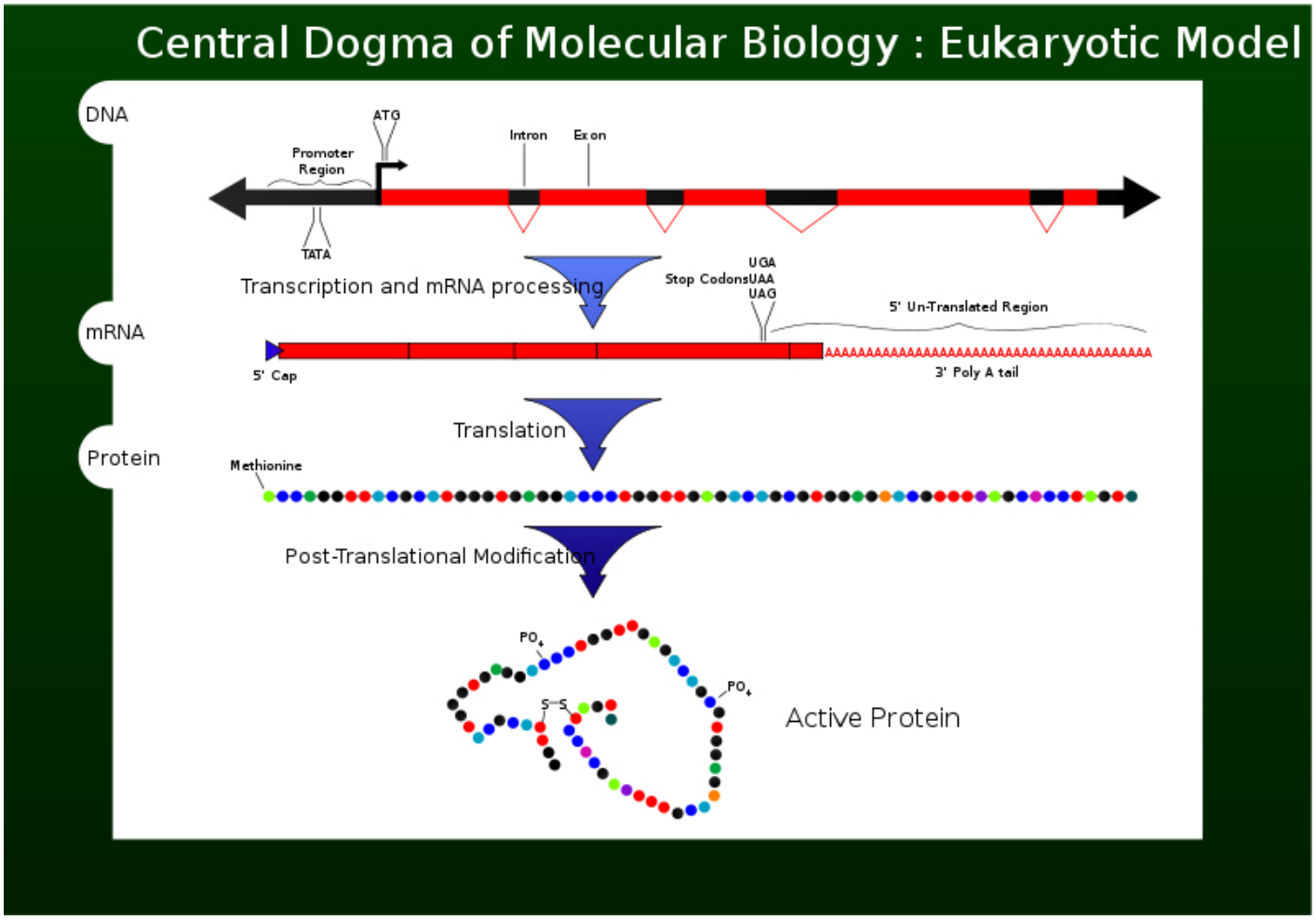
Genetics

DNA is constantly replicating through cell division. Within the small confinement of the nucleus, replication occurs producing additional strands of DNA to insure the longevity of the organism. From duplicated DNA strands, a process called the Central Dogma beings. Refer to figure 2. This process takes DNA that has been replicated and transcribes the strand into mRNA using the nitrogenous bases (A, C, **U**, G). As you may notice, the thymine (T) of DNA is now substituted for uracil (U) in RNA. The strand of RNA leaves the nucleus and enters the cytoplasm of the cell until it locates a free ribosome at attaches to it. At the ribosome, codons (discussed below) pair with anti-codons that transport an amino acid. A combination of amino acids, and a specified folding of the strand, determines the translation of a protein that has specific functions in the organism.

Figure 2



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Codons are a set of three adjacent bases on mRNA that code for an amino acid. Since there are 4 bases in each position, there are 64 possible codons available to code for 20 different amino acids. [2] Varying amino acids come together to make proteins and each protein has its own specific function. The expression of proteins is responsible for our traits, both physical and at the cellular level. Certain proteins have vital responsibilities in the upkeep of an organism, while others can be harmful. We will be examining the harmful affects of proteins in the health section of this unit. The genetic code is a table that is used to determine the codons that represent a specific amino acid. In Figure 3 below, you can see that the position of the first, second, and third bases correlate with an amino acid.

Figure 3

Standard genetic code

1st base	2nd base								3rd base
	U		C		A		G		
U	UUU	(Phe/F) Phenylalanine	UCU	(Ser/S) Serine	UAU	(Tyr/Y) Tyrosine	UGU	(Cys/C) Cysteine	U
	UUC		UCC		UAC		UGC		C
	UUA	(Leu/L) Leucine	UCA		UAA	Stop (*Ochre*)	UGA	Stop (*Opal*)	A
	UUG		UCG		UAG	Stop (*Amber*)	UGG	(Trp/W) Tryptophan	G
C	CUU		CCU	(Pro/P) Proline	CAU	(His/H) Histidine	CGU	(Arg/R) Arginine	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	(Gln/Q) Glutamine	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	(Ile/I) Isoleucine	ACU	(Thr/T) Threonine	AAU	(Asn/N) Asparagine	AGU	(Ser/S) Serine	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	(Lys/K) Lysine	AGA	(Arg/R) Arginine	A
	AUG[A]	(Met/M) Methionine	ACG		AAG		AGG		G
G	GUU	(Val/V) Valine	GCU	(Ala/A) Alanine	GAU	(Asp/D) Aspartic acid	GGU	(Gly/G) Glycine	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	(Glu/E) Glutamic acid	GGA		A
	GUG		GCG		GAG		GGG		G

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In the DNA a set of nitrogenous bases code for a gene. This gene goes through the Central Dogma process to find its way to producing its protein. It is a miraculous organism, the human body, but it is not without faults. You can relate to that. For instance, we add numbers on a daily basis. It is not a complicated task; it almost feels mind numbing. However, we sometimes make mistakes. Even the simplest mistake can produce an absolute wrong answer. Our DNA functions very much like we do. Although it DNA is replicated continuously through life, as we replace some of our trillions of cells, it is prone to mistakes, referred to as mutations. There are a number of possible mutations including substitution, insertion, deletion and frameshift. [3]

Table 1

Substitution	Insertion	Deletion	Frameshift
CTGGAG CTGGGG	CTGGAG CTGGTGGAG	CTGGAG CTAG	CTA GGT ACT TAG GTA CT

Substitutions are simple to identify in table 1 above. These mutations are easy to comprehend but not so easy to identify in DNA. A single nitrogenous base is substituted for another. If the base that is substituted codes for the same amino acid as the original, the mutation is considered silent. Although this change is subtle, it can lead to the expression of mutated proteins, such as in sickle cell anemia, discussed in detail below. Some

times when mutations occur, it can change the amino acid that is next in line, for instance if the substitution prematurely signals a STOP codon, an incomplete protein will be produced: the incomplete protein likely won't function as it should. Insertions are additional bits of DNA added to the existing strand. In the above example, TGG is added making the initial strand longer. Deletion is caused by the loss of bases from the strand. Lastly, frameshift may seem similar in concept to deletion however the differing factor is that the deletion that occurs shifts every proceeding frame of DNA causing the translation of an entirely different protein that originally instructed. Other types of mutations exist, but for the purpose of this unit I will only address these four.

Physiology (Disease and Human Health)

The design challenge for students will be based on 4 different diseases: Huntington's Disease, Sickle Cell Anemia, Hemophilia and Cystic Fibrosis. These are chosen because each are caused by a single gene mutation and are relevant to many in my student population. My students know Sickle Cell Anemia and Hemophilia because many of their family and friends either have or know someone who has it. The students are rather interested in these two in particular and it would be great for them to learn more while completing the assignment.

The first of the single gene diseases that will be studied is Sickle Cell Anemia. It is a condition that produces deformed red blood cells (RBCs), which are essential for oxygen transportation throughout the body. The disfigured sickle (crescent) shape of the cell keeps the cells from adequately transporting oxygen to organs and tissues. Red blood cells contain hemoglobin, which is a protein that is responsible for the transport of oxygen. Abnormal hemoglobin is found in sickle cells, which determines the sickle shape of the cell. Unlike the circular donut shape of normal RBCs, this sickle shape causes the cell to be rigid and sticky. This keeps blood from moving freely throughout the vessels and causes backed up and blocked blood flow, often resulting is severe pain and organ damage for the individual. Sickle cells also have a much shorter life span of 10-20 days compared to that of normal RBCs, which live for nearly 120 days in the circulation. [4] Because of this short life span, it is difficult for the bone marrow to produce new RBCs fast enough to replace the ones that are disappearing: this causes a decreased RBC count, or anemia. Sickle Cell Anemia is an inherited condition that requires both parents to pass the trait to their offspring in order for it to be expressed.

People with sickle cells experience chronic pain and fatigue. Unfortunately, there is no cure for sickle cell but sufferers can be closely monitored and cared for to control their symptoms. Sickle Cell is a common disease among those with ancestors from Africa and it affects millions of people worldwide. In America, sickle cell affects somewhere between 70,000 to 80,000 individuals and roughly one in every 500 African Americans and one in every 1,000 Hispanic Americans. [4] Sickle Cell Anemia occurs from a mutated gene known as HBB located on chromosome 11. Healthy hemoglobin has four units, two known as alpha-globin and two known as beta-globin. Mutations of the HBB gene prevent growth of adequate beta-globin numbers. The HBB gene results in a number of different mutations, in sickle cells: in particular, both beta-globin units are replaced with HbS (hemoglobin S). [4] This mutation leads to the short life of sickle cells and inefficient transport of oxygen discussed above.

Huntington's Disease is the next single gene disease. It is a brain disorder that causes uncontrolled movements, emotional instability and degeneration of cognition. The inherited gene usually remains silent through adolescent years and begins to show signs when a person reaches their thirties or forties, which is referred to as adult-onset. In the beginning symptoms are mild and less frequent, they include irritability, depression, small involuntary movements, lack of coordination and cognitive troubles. [5] Huntington's disease is most recognized by jerking movements or twitches known as chorea, which is where Huntington's gets its

other name of Huntington's Chorea. When the disease has progressed, inflicted individuals experience great difficulty in mundane physical tasks such as walking and their speech becomes slurred and incomprehensible. From the first clinical signs of Huntington's affected individuals have a life expectancy of about 15-20 years. Another less common form of Huntington's disease is referred to as juvenile and begins in childhood and early adolescence. The signs and symptoms are similar to that of adult-onset Huntington's but, in this case, 30-50% of individuals affected experience seizures as a result of the disease. Unfortunately, with juvenile Huntington's individuals live about 10-15 years from onset. In contrast to Sickle Cell Anemia, Huntington's disease is most common among those of European ancestry affecting approximately seven people in 100,000. [5]

Huntington's disease is an inherited condition that only requires inheritance from one parent for it to be expressed because it is an autosomal dominant trait. In other words, the trait for Huntington's disease is dominant; therefore just one allele with the trait and the offspring will be affected. HTT is the gene found on chromosome 4 that correlates with Huntington's disease. The normal function of the HTT gene has not been found but it is known to contribute to the function of the nervous system. From the HTT gene a protein called Huntingtin is formed. The mutation has very specific characteristics involving only the bases adenine, cytosine, and guanine in a trinucleotide repeat. In a normal gene the bases CAG are repeated a short 10-35 times; however, in people with Huntington's disease CAG repeats 36-120 times in a row resulting in a larger strand of DNA. [5] Those with juvenile Huntington's tend to have longer strands (<60) of the repeating nucleotides whereas adult onset tends to be between 40 and 50 repeats. The shorter an individuals repeats of bases CAG of their HTT gene the less likely they will have Huntington's and the less possibly of passing it on to their offspring. The elongated strand of CAG repeats causes a mutated huntingtin protein which may have a role in disrupting normal neural functions that characterized Huntington's disease.

Hemophilia is a bleeding disorder in which the clotting time of blood is slowed, causing those affected to bleed excessively and for prolonged periods of time. Simple cuts can require immediate medical attention because of the risk of too much blood loss. For more severe forms of hemophilia there is even risk of spontaneous unprovoked bleeding that leads to more serious complications. There two types of hemophilia: Hemophilia A, the most common type, and hemophilia B. Both exhibit the similar signs and symptoms but they are caused by mutations in different genes. Controlled blood clotting is necessary to keep the body from losing too much blood. Without the body's natural ability to control blood clotting, it is crucial to be aware of the condition. For the purpose of this unit, focus will be on hemophilia A. The gene corresponding with hemophilia is found on the X chromosome (sex chromosome 23). Hemophilia A occurs in 1 in 4,000 males worldwide, with hemophilia B occurring in 1 in 20,000 newborn males. [6]

As mentioned above, the gene for hemophilia is located on chromosome 23. It is an inherited X-linked recessive disorder. Since the trait is only carried on the X chromosome, inheritance of one altered copy of the gene is sufficient enough to cause the condition. If a female were to get one altered and one wild type of the gene, she will be unaffected, therefore hemophilia is less common among females. On the X chromosome the gene F8 is located and has the blueprint for synthesizing a protein called coagulation factor VIII. [6] Coagulation factors are essential in the blood clotting mechanism. Mutations of the F8 gene results in production of the coagulation factor VIII that reduces the amount of proteins available which is the cause of the disorder. A lower coagulation factor count correlates with a more severe condition.

Cystic Fibrosis is the last of the single gene diseases this unit covers. It is an inherited life-threatening condition affecting a number of systems in the human body. It is the most common lung disease in children and young adults. Thick, sticky mucous builds up in the lungs and digestive tract due to an abnormal transport of chloride and sodium across tissue. Severe difficulty breathing and dangerous lung infections are the most

common conditions due to this disorder. These symptoms can be treated with antibiotics and other medications, but treatment is rarely complete. Cystic fibrosis is most common among Caucasians, affecting roughly one in every 3,000 individuals. [7] Fetuses and infants are tested for CF so proper precautions and necessary transplants can be carried out.

Cystic fibrosis is another autosomal recessive gene, meaning a child would have to receive a recessive allele from both parents in order for the condition to be expressed. The gene for cystic fibrosis is found on chromosome 7: its official name is transmembrane conductance regulator (CFTR). [7] The protein made from this gene, which creates chloride channels, is responsible for the maintenance of normal mucous secretions that reside on epithelial tissue. Viscosity of secretions is regulated by the normal chloride transport, keeping it thin and permeable. Any change in the CFTR gene will produce proteins that are insufficient to carry out their chloride transport function. There are thousands of possible mutations that leads to the production of CF. They differ in the system it affects. Some individuals experience more complications with the respiratory system and other with the gastrointestinal system. Since CF affects secretions of the cells throughout the body, complications generally occur throughout. Some mutations of CFTR are very mild, allowing CFTR to maintain some its function. But severe forms involve only small changes in CFTR. For example, a single amino acid change or deletion in the CFTR gene can result in channel proteins that do not reach the cell membrane and therefore cannot properly transport chloride ions.

Biotechnology

Students will explore different methods to read DNA to identify specific genes and compare the genes of specific offspring with their parents. Specifically, students will learn about Gel electrophoresis and how it is used to test for the Huntingtin Gene. Students will conduct a lab using gel electrophoresis apparatuses and fake blood samples.

Gel electrophoresis is a technique used to determine lengths of particular strands of DNA. Gel electrophoresis does not provide detailed information about the particulars of a DNA strand however the length of a strand can provide relative information that is useful in genetic testing. DNA has a negative charge due to the phosphate group in the rails of the double helix. Gel electrophoresis exploits the negative charge of DNA: an electrical field in an apparatus drives the DNA towards the positive end. [1] DNA travels through an agarose gel bed that can be made with different concentrations to change the density of the matrix within the gel. The higher concentration of matrix, or webbing, in the gel, the more confined larger strands of DNA are, thus hindering them from moving. Short strands of DNA can move more freely down the gel. Gel electrophoresis is useful when determining the presence of large strands of DNA caused by large genes, such as HTT, which is a marker for Huntington's disease. Information from gel electrophoresis is amplified with the use of PCR (Polymerase chain reaction) a process that produces thousands of copies of the particular DNA strand. [7] Many copies allows researchers to compare the DNA across several magnitudes to collect more solid information about the gene present.

Cells in our body each contain all or our genes, but only a small portion of those genes will be expressed in a cell. All organs and tissues have specific functions and the cells in that tissue will express only the genes necessary for proper function. Synthesizing proteins from DNA requires transcription factors that bind to specific regions that initiate the transcription of the gene. [8] If a gene is not transcribed than the protein is not made and the gene is not expressed. Gene control can also occur during RNA transcription by creating different splices of mRNA. The differences in mRNA will alter the expected protein. These differences can cause inactivation of the protein desired. Blocking the expression of a gene can potentially have the ability to

silence the expression of a mutated gene; at least this is an idea that students will ponder on.

Blocking of gene expression can occur in a number of ways. There are single stranded antisense oligonucleotides with a short life span that can be used to bind to base pairs in DNA to block transcription or RNA to block translation. There are also small interfering RNAs (siRNA) that are used to target degradation of specific mRNA transcripts. [8] This process allows for the gene in the DNA to be expressed (i.e. transcribed to mRNA) however at the transcription phase siRNA can silence mRNA and therefore turn off protein production. This method could potentially be helpful in treatment of Huntington's disease. These methods of gene therapy are relatively simple to comprehend but it is not without its limitations. This offers great room for students to consider possibilities and create methods that seem plausible to cure their studied disease.

This section of the content is tied in with moral and ethical discussions related to genetic testing, screening and engineering. Are these processes useful to mankind? Harmful? What implications can be made considering the growth and use of genetic screening in determining life? What does it mean for human evolution?

Unit Activities

Considering the length and depth of this unit students will be involved in a number of activities. There will be a combination of teacher led lessons, student group work, lab activities, student led debates, persuasive papers, and presentations. The DNA section of this unit will involve a number of small class activities for the students to engage in. Aside from direct instruction, students will participate in constructing DNA and completing online webquests as they gain a deeper understanding of the content.

Lesson One: DNA

This lesson begins with a video and power point presentation about the history of DNA. Students will take notes and answer "check for understanding" questions through the lesson. With the use of an online source (learngenetic.utah.edu) students will complete an online webquest that will assist in reinforcing the concepts and idea discussed in the introductory lesson. A lot of practice with building DNA structures will be done following the webquest. Students will work in groups to create strands of DNA using a DNA toolkit provided by my schools science department. Students will better understand base pair rules and general structure of DNA after this activity. Using those same kits, students will learn the process of transcription. With the double strand of DNA students will created single-stranded RNA uses the appropriate bases. A number of worksheets and small assessments will follow to make sure students understand the base pairing rules of transcription.

I then introduce students to codons. This is done through direct instruction using power point, video, and good old-fashioned board work. Using models and drawings, students will learn the structure of a ribosome (where translation occurs) and the function of RNA once it attaches to it. This part of the lesson will involve a lot of vocabulary review and practice to best prepare students for the more complex processes to follow. Translation brings upon some of the more exciting activities in this unit. To prepare for learning of the genetic code, I will have the students complete puzzles that require them to associate a number code with a word. When they show mastery in that ability, students will be introduced to the genetic code. To gain familiarity with the code and how to read it, we will play a number of Bingo games uses charts the students have filled in with amino

acids. There is an activity called "Snorks" that the students will complete. This is practice with the genetic code so students can become more familiar with coding and determine traits from those resulting proteins. To end this lesson, students will complete a Translation Lab. Using a variety of colored gummy candies and the DNA structure kits, the students will demonstrate from beginning to end how RNA is transcribed and proteins are translated. They will create their own code correlating candy to amino acid, and as a group come up with a name and function of their resulting protein. The assessment for this section is a comprehensive exam that students will complete in class.

Lesson Two: Health/Disease

To connect the DNA content with the human health portion, students will be introduced to case studies of individuals living with a genetic disease. Each day for this lesson we will exam a system of the body: circulatory, respiratory and nervous. Through direct instruction students will learn of the basics of each system to give them a good understanding of the diseases they will study. Students will complete graphic organizers for each disease using online resources. I have small video clips of stories about individuals with CF, Sickle cell, Huntington's and hemophilia that the students will watch and discuss. For students to become more aware of the hardships that come with these genetic diseases, they will participate in role-playing in a story line called "Family Genes". There are five parts to this story and after each part students will assess new information found in the story about the family and questions they have for the next part. The purpose of this activity is for students to consider the implications of knowing the health of an individual's future. Students will complete a journal entry addressing the ethical question of whether or not individuals should be told of their impending diseases. This entry will come into play again during the genetic engineering lesson in the unit.

Lesson Three: Biotechnology

Accompanying the study of disease will be the introduction to biotechnology through simulations of PCR and a class lab in which students test their skills at Gel Electrophoresis. Through direct instruction students will learn of the basics in gel electrophoresis. They will examine gel plates and make inferences on what they see. Before completing a wet lab, students will play with online simulations of gel electrophoresis and the use of PCR in determining the characteristics of the DNA strands run through gel electrophoresis. Students will use these sources to complete their simulations found online at http://learn.genetics.utah.edu/content/labs/gel/. Students will be introduced to micropipettes and they will practice pipetting in an activity entitled "Issa's Secret Serum Activity" (ISSA). They will learn how to set micro-pipettes and how to properly dispense materials and avoid contamination. Once students show mastery in their pipetting abilities, we will complete the Gel Electrophoresis lab.

This lab will take quite a few days of class time to complete. The first will be the making of gel plates. Students will follow a lab protocol in order to make suitable plates. While we wait for the plates to harden, students will begin writing a formal lab report. I have handouts that scaffold each section of a lab report and students will first hand write and then begin typing their reports. Through this process, students will practice peer editing and constructive feedback. Once the gels are ready, students will perform part two of the lab protocol. In this portion students will load their gels with samples from a "family" that wants to test for Huntington's disease. This lab requires a lot of attention to detail on the students part and a lot of supervision on my part. Once the students run their gels they will write a short analysis of the results they obtained. They are to determine, based on their test, who in the "family" should be diagnosed with Huntington's disease. Students will then complete their lab reports and turn it in typed and completed to fulfill the assessment for

this lesson.

Lesson Four: Genetic Engineering

Upon completion of the three prior lessons, the students will engage in a JIGSAW activity. JIGSAWs are when students meet in a home group of students and each is assigned a different assignment. They then break up and find students in the class who are given the same assignment and they complete it together. Students then return to their home group and share their newly acquired knowledge with their classmates. There are six articles that I have obtained from online resources that present cases of genetic engineering. Half the articles are pro genetic engineering and the other half is against. The students complete a graphic organizer within their JIGSAW group and become masters in the article they read. When the return to their home group, they are responsible to share the ideas and arguments of the article they read. Students will study their notes and write a one-paragraph opinion assignment about their position on genetic engineering.

Their knowledge of the articles read will prepare the students for an in class debate. Students will be randomly assigned a position and will need to use their notes to create arguments for the position their represent, regardless of their own opinion. This activity is meant to engage the students in considering two sides of a controversial process and just out of pure curiosity on my part. I like to hear what argument students create to support their side. Lastly, students are given a persuasive essay assignment. Given the structure and purpose of a persuasive essay, students will identify their position on the use of genetic engineering using evidence from the articles read and discussed in class. This essay should follow all standard requirements of a written assignment and it will be used as the final assessment for this lesson.

Lesson Five: Design Challenge

All the content objectives discussed above lead to the final project of the unit. Students will research one of the four diseases in the unit. They will be required to know the details of the disease including symptoms and treatments as well as the molecular characteristics that lead to the expression of the disease. Students will be challenged with the prospect of determining how they would change the expression of their particular disease from taking place. Students will choose a method they would experiment with if they were genetic engineers and will have to defend their proposed techniques. Based on class activities and content objectives students will also develop an understanding of genetic testing and engineering and the implications on society.

Students will need to document their research in a formal written report. Students will discuss their research, describe their method of DNA manipulation and take a position on the implications of genetic screening. To demonstrate understanding and conviction of their work, students will present to a panel and defend their research. The final project will consist of a typed 3-5 page report and a professional power point presentation that will be delivered to a panel that will challenge the design.

Bibliography

Resources

[1] Biology: A Human Approach 10 th Edition NSCS.

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[5] Huntington's Disease http://ghr.nlm.nih.gov/condition/huntington-disease

[6] Hemophilia http://ghr.nlm.nih.gov/condition/hemophilia

[7] Cystic Fibrosis http://ghr.nlm.nih.gov/gene/CFTR

[8] Saltzman, Mark. Biomolecular Principles: Nucleic Acids. Chapter 3.

Genetics Home Reference: http://ghr.nlm.nih.gov/