

A New Way- Through DNA!

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Overview

We are all afraid of the mad scientist. Society has been afraid of science since its inception. Scary fictional novels like Frankenstein fueled the fear in the imaginations of society for several decades. Humans have always been fascinated with the possibility of a half man, half something creature for centuries. Movies like Planet of the Apes and X-Men keep the fire on fear burning at a subconscious level. DNA technology through gasoline on the fire and ignited a firestorm of human concern over cloning and Recombinant DNA technology. This fear is indeed understood. We are constantly reminded of the “dark side” of mankind through the horrific events of Slavery in the United States and the Holocaust. However, we take for granted the tremendous amounts of “good” science that is studied and applied daily, like vaccinations, medications, micro-technology, and imaging equipment. These technologies have revolutionized the way that many diseases are treated and cured. DNA technology has the possibility of unlocking the door to of deeper understanding of life and its origins. With this understanding we can march forward into the future with a better plan for disease diagnosis, disease treatment, and gene identification. Many key issues concerning gene testing and cloning are being hotly debated before Congress, the nations Court Systems, and Judges; students must be equipped to enter the debate at some level. Students must be offered a chance to examine the factual data and information regarding DNA technology.

From test tube babies to Dolly and transgenic corn, DNA technology is shaping the future of human society. Molecular biologists can design organisms (bacteria, plants, and animals) much the same way that an engineer designs a bridge. Careful consideration is involved into which materials to use, as well as, the function of these materials. Students must be aware of the fact that “pure” science is not performed with a sinister plot in mind or to make a cool, freaky, creature. Scientists learn a great deal of information from experimentation with genes.

With the current frightening cloning fiascos (the alleged woman impregnated with a human clone), students need a greater understanding of recombinant DNA technology and its applications to genetic engineering. Through the text and other resources, students will: Learn about the DNA molecule, how the DNA molecule makes copies of itself, the importance of DNA, and the techniques that scientists use to manipulate genes- using restriction enzymes and gene splicing. Through this unit students will (hopefully) gain a realistic perspective of DNA technology and its limitations. Many ethical concerns are and always will be raised concerning genetic testing. Decisions become harder to make when people are unknowledgeable, uninformed, and fearful. One of my greatest hopes as a teacher is to instill with in my students the ability to seek facts for themselves.

Rationale

The current text adopted by Pittsburgh Public Schools, to teach Biology One and mainstreamed Biology One, is called Biology: The Dynamics of Life. This text was written by Daniel Blaustein and published in 1995, by Glencoe/McGraw-Hill. The curriculum endorsed by the district recommends that we only introduce the first section of Chapter 13 (DNA the Molecule of Heredity). In my opinion, the entire portion of Chapter 13 should be presented in order to ensure an accurate conception of Recombinant DNA technology, cloning, PCR (Polymerase Chain Reaction), and gel electrophoresis. With further thought, I also felt that Chapter 13 should be taught along side of Chapter 16 DNA technology. This sequence works well and is introduced after Chapters 12, 14, and 15, which all deal with Mendelian genetics, incomplete dominance, codominance, multiallelic inheritance, polygenic inheritance, and genetically inherited disorders. By the end of these chapters, students have a basic understanding of heredity, the many ways traits are inherited, pedigrees, and genetic disorders. After the DNA molecule, replication, transcription, translation, and mutations are taught (Chapter 13 topics), DNA technology and cloning will be introduced (Chapter 16). However, before this takes place a few topics should be reviewed: Mitosis, meiosis, traits dominance, recessiveness, codominance, incomplete dominance, multiple alleles, sex- linked inheritance, polygenic inheritance, and environmental influences on inheritance. This can be achieved through a multi- chapter examination of sorts. This unit

is designed for a tenth grade, mainstreamed, Biology One class and is set up to last approximately two to three weeks. It is possible that it can last four weeks.

Objectives

Chapter Thirteen

In this unit, students will analyze the structure of DNA and determine how the structure of DNA enables it to reproduce itself accurately. This study will give students a better understanding of the structure and composition of the DNA molecule. The process of replication of the DNA molecule and its importance to organisms are emphasized (Biology 310).

Students will also relate the concept of the gene to the sequences of nucleotides in DNA. Students will sequence the steps involved in protein synthesis. This will enable students to learn how DNA, genes, and proteins are related. The relationship between genes and the nucleotide sequence will be discussed. Finally, the steps involved in the formation of mRNA and the role of tRNA in translation will be discussed (Biology 316).

In the final section of Chapter 13, students will: categorize the different kinds of mutations that can occur in DNA and compare the effects of different kinds of mutations on cells of organisms. Point mutations and frame shift mutations and their effects on the coding of proteins will be discussed. The chromosomal mutations- insertions, deletions, translocations, and inversions, are examined, along with errors in disjunction that cause monosomies and trisomies (Biology 324). Trisomy is already discussed in an out of sequence format, from Chapter 15, so this will be an in-depth review.

Chapter Sixteen

Chapter Sixteen summarizes the steps used to engineer transgenic organisms. Students will also be asked to give examples of applications and benefits of genetic engineering. Students will learn that genetic engineering involves using restriction enzymes to cleave DNA and recombining the pieces with DNA from another source. The result is recombinant DNA, which can be inserted into an organism. This organism is known as a transgenic organism. Students will explore techniques used to sequence DNA and applications of DNA technology in agriculture, industry, and medicine. This section will conclude with discussions of transgenic bacteria, plants, and animals (Biology 376).

Chapter Sixteen ends with section two. Students will analyze how the effort to completely map and sequence the human genome will advance human knowledge and predict future applications of the Human Genome Project to diagnose genetic disorders, as a gene therapy, and in DNA fingerprinting (Biology 386). This section is a little bit dated in this section, so a few websites will be used to bring students up to speed and supplement the text.

Strategies and Classroom Activities

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Word Wall

In this unit, there are five sections. The terms or vocabulary words for this section can be intimidating. At the beginning of each section, the terms and their definitions will be placed on the wall, in the front of the room. This will be the “Word Wall”. At the end of each section the words will be removed to one of the shades in the room. This area on the shade will be designated as the “Word Bank”. The terms of the new section will replace the terms moved from the “Word Wall” to the “Word Bank”. This will continue until the unit is completed.

Twenty-Five Book Standard

Students of the Pittsburgh Public School District are required to read twenty-five age appropriate books each school year. In our school, discipline is required to assign three books to read by their students. These readings will be applied to the twenty-five book standard, adopted by the school district. During the course of this unit, students will be assigned the novel Jurassic Park, by Michael Crichton. Each day during this unit students will be assigned a portion of the text to read as homework. When returning to class they will have a mini quiz on the reading material as a warm up exercise to the day’s lesson. At the end of the novel students will be asked to write to the prompt: If you were a character in this story, what would you have told Dr. Hammond about his attempts to recreate dinosaurs? Be sure to include positive and negative aspects of recreating dinosaurs. Also include the scientific insights that might be gained from being able to re- create extinct life forms.

Chapter Thirteen, Section One- DNA: The Molecule of Heredity

To the chapter, students will be presented an introduction/review of DNA, the DNA molecule, nitrogen bases, nucleotides, and nucleotide sequence through notes. (Notes can be found in the appendix- labeled 13.1 Background Information). At the end of section A-3 of the notes, students will begin a mini lab to extract DNA. Since we will be discussing DNA, students would gain a better understanding of DNA and its properties by extracting DNA and observing its appearance. Last year we performed this experiment with a

large white onion. It worked well, however the smell really upset the students. During this unit, we will try a DNA extraction with wheat germ instead of onion. The wheat germ lab exercise was found on the Genetic Science Learning Center website under the title- DNA extraction for Wheat Germ. The protocol can be found at <http://gslc.genetics.utah.edu/basic/wheatgerm/>.

After the DNA extraction lab, students will be introduced to the nitrogen bases that make up DNA, by covering sections B and C of the 13.1 Background Information notes. Students will observe the nitrogen bases and their structure. Students will determine that the double ring bases (Adenine and Guanine) are called purines and the single ringed bases (Cytosine and thymine) are pyrimidines. Using figure 13.1 of the Biology text (page 310), students will be given a worksheet (not included in the appendix) that shows the nitrogen bases unlabeled. Students must label each nitrogen base as adenine, guanine, cytosine, thymine, as well as, deoxyribose and phosphate group. Students will also have to label the pyrimidines and purines and explain how they came to this conclusion. Students will also color their nucleotides. To review the structure of the DNA molecule students will complete Transparency Sheet number twenty-eight from the Biology: The Dynamics of Life Curriculum.

On the third day, students will review the structure of the DNA molecule. Students will examine figure 13.2, to observe how nucleotides bond to each other to form a DNA molecule. Students will learn that the sugar of nucleotides is joined to the phosphate group of the next nucleotide by covalent bonds (covalent bond: the sharing of electrons that holds atoms together) and a hydrogen bond holds the bases together. It is imperative that students note, that in a DNA molecule, cytosine always forms hydrogen bonds with guanine and thymine always forms hydrogen bonds with adenine. At this time, students will be shown a three-dimensional model of DNA. (These models can be made with various materials or order through a science supply warehouse, such as Carolina Biological or Sergeant Welch.) After seeing the DNA molecule students will finish the notes from part D of the Background Information for 13.1.

Instead of first talking about DNA replication, student will act out DNA replication. Based on a class size of approximately 18 to 25 students, we will review the notes through a replication activity. Students will act out the steps that take place during replication by completing the Replication Activity, which can be found in the appendix. After students have performed their Replication class activity and completed the summary, the emphasis will be made that during mitosis and meiosis, genetic material (DNA) is copied by the process of replication. It will also be emphasized that without replication, species could not survive and individuals could not grow or reproduce. Following this information, students will complete Transparency Sheet twenty-nine, found in the Biology: The Dynamics of Life Curriculum.

Chapter Thirteen, Section Two- From DNA to Protein

In section 13.2, students will be asked, “What is the message that is contained within the DNA code?” At this point, students will be asked to read Genes and Proteins, found of page 316 if the Biology text. While reading, students will be asked to list all the functions of proteins. After the reading has been completed, students will be solicited for the functions of proteins that they have listed. This list will be placed on flip paper, labeled with a marker Genes and Proteins, and taped to the wall as a student reference during this

unit. It is hoped that the student list will include: Some proteins, called enzymes, control chemical reactions that perform key life functions (like building ATP or digesting food), proteins build and repair cell structures (like microtubules and microfilaments), and in general, proteins determine the structure and function of an organism. Students will be prompted to note that genes are somehow responsible for protein production and genes are made of DNA. The final conclusion, that answers the original question in this paragraph, is the message of the DNA code is information for building proteins.

After the students discuss the importance of proteins, they will be asked to recall the structure of proteins, amino acids, polypeptides, and peptide bond formation, from Chapter Seven of the Biology text. Students will be made to understand that most proteins require the synthesis of two or more peptide chains. After we discuss this information it will also be placed on large flip chart paper, labeled with marker Protein structure, and taped to the wall as a student reference during this unit. After this material is collected another flip chart paper will be prepared and labeled Genetic code. Students will be asked to read page 317, of the Biology text, which explains the genetic code. Hopefully, students will be able to conclude: 1) that there are over 20 different amino acids, 2) that experiments have shown that a sequence of three bases codes for the more than 20 amino acid combinations, 3) that each set of three nitrogen bases that represent an amino acid is known as a codon, 4) because of the three nitrogen bases that code for an amino acid, the DNA code is referred to as a triplet code, and 5) that the order of nitrogen bases in DNA can determine the type and order of amino acids in a protein. Students will be referred to Table 13.1 (this table can be found on page 317 of the Biology text) to examine the sixty-four different codons that make up the genetic code. Students will also place on the list that sixty-one of the codons code for amino acids, two are stops and one is a start. (Students will be made aware that there is more than one codon for the same amino acid, and that the code is the same in virtually every living organism.)

On the chalkboard a large cell with a nucleus at its center will be drawn. Student will be asked several questions regarding replication: Where does replication take place?

What is the product of replication? What are proteins made of? Where are the ribosomes? What is manufactured at the ribosomes? How does genetic material leave the nucleus to reach the ribosomes? Next, the structure of RNA will be implicated as the molecule that leaves the nucleus. The structure of RNA will be compared and contrasted to the DNA molecule. Students will observe the three chemical differences between DNA and RNA as shown on page 318, of the Biology text. (RNA is single stranded- DNA is double stranded, ribose is the sugar of RNA- deoxyribose is the sugar for DNA, RNA contains uracil- U, instead of thymine- T, found in DNA.) Students will refer back to the large cell that was drawn on the chalkboard. Now a diagram of DNA transcription into RNA will be drawn. Students will be shown how DNA strands split and how messenger RNA is formed, in the nucleus.

The next day transcription will be reviewed by completing the RNA Transcription BioLab on pages 320 and 321 of the Biology text (a student friendly, reproducible format can be found in the Biology: Dynamic of Life BioLab and Mini- Lab Workbook of the Biology Curriculum. With a reproducible copy students would not have to lug the book around). The goal of this activity is to have students determine how the order of bases in DNA, determine the order of bases in mRNA (messenger RNA, which leaves the nucleus to enter the cytoplasm to help make proteins). Students will use paper DNA and mRNA models to demonstrate the process of transcription. The reproducible masters of the DNA and RNA molecules will be copied onto white paper (these can also be found in the BioLab and Mini-lab Workbook). Students will color their models with colored pencils. Students must make sure that each nucleotide is a different color: thymine- orange, cytosine-

purple, guanine- blue, adenine- red, deoxyribose and phosphoric acid- green, ribose- brown and phosphoric acid- green. Using scissors, students will carefully cut out the shapes of each nucleotide. Using any order of nucleotides that the students wish, they will construct a double stranded DNA molecule. Students will fasten the molecule together with tape, careful not to tape across the base pairs. With their DNA molecule in hand, students will demonstrate the process of transcription by first pulling the DNA molecule apart between the base pairs and then use only one strand of DNA to begin matching mRNA nucleotides with the exposed bases on the DNA model (Students must remember uracil is used in the mRNA strand instead of thymine). When completed students will tape their mRNA molecule together with scotch tape. After the entire procedure of the Biolab is completed, students will write a summary that will include answers from the following questions: 1) Does the mRNA model more closely resemble the DNA strand from which it was transcribed or the complementary strand that wasn't used? Explain your answer. *Answer: mRNA more closely resembles the complementary DNA. They have the same base sequence except that in mRNA has uracil instead of thymine.* 2) Explain how the structure of DNA enables the molecule to be easily transcribed. Why is this important for genetic information? *Answer: Because DNA is double- stranded, sections can be unzipped to allow complementary bases to hydrogen bond, while the remaining DNA stays zipped. Only the information needed is being transcribed.* 3) Why is RNA important to the cell? How does an mRNA molecule carry information from DNA? *Answer: The mRNA is formed as a complementary copy of the genetic information. The RNA copy can leave the nucleus while the "master copy"- DNA stays in the nucleus.* Students will also use Table 13.1- The DNA Code, to determine which amino acids they coded for in the BioLab. This activity may take two days.

During the next class period, students will go back to the chalkboard diagrams. I will place a sequence for one DNA strand. Students will write the corresponding sequences for mRNA. At this point students will be made aware that we have only made RNA (mRNA), but our ultimate goal is to end up with a protein. Student will be referred back to the Genes and Proteins flip chart paper on the wall to remember why we need to make proteins. Students will also examine the Protein structure flip chart paper to review how a protein is made. Students will recall the two genetic processes that we have discussed so far- replication and transcription. Students will state that DNA is the product of replication; mRNA is the product of transcription. Students will be told that there is one more process, called translation and its product is protein. It will bring to the students attention that mRNA is made in the nucleus (referring back to the large cell diagram), mRNA leaves the nucleus, through nuclear pores and enters the cytoplasm. In the cytoplasm, translation takes place. Students will be told that translation takes place on ribosomes with the help on a third type of RNA. Twenty different amino acids are dissolved in the cytoplasm. These facts will be copied onto another large flip chart paper labeled Translation. Students will also be told that the amino acids must be brought to the ribosomes. Amino acids are brought to the ribosomes by transfer RNA (tRNA), so they can be assembled or made into proteins. This information will be linked to the other information on the other large flip chart sheets, especially the Protein structure sheet. Figure 13.8 (Which provides a pictorial of translation), as well as, Transparency Sheet thirty-one will be presented to the students. The Transparency sheet can be found in the Biology: Dynamics of Life Transparency Workbook.

To review the process of translation, students will go back to the chalkboard diagram. Using the DNA strand, and the mRNA strand students will make a tRNA sequence. An illustration of the process of transcription and translation of the DNA strand will be drawn. The students will copy this illustration and label each process. The students will switch papers to do peer checking.

To begin section three, students will be reminded of their notes from the RNA to Protein section. In the second section we discussed that the order of nucleotides is what determines each organism and relate this concept to phone numbers. Students will be asked the following questions: Have you ever copied a phone number incorrectly? What are the possible consequences of changing digits in numbers? Students will relate these types of mistakes with phone numbers to the mistake in DNA. Students will be asked to describe the images that the word mutation conjures up in their minds? They will probably describe fantastic beings that they have encountered in movies, cartoons, and stories. It will be pointed out that real mutations are often much less spectacular (Biology 324).

Using the text pages 324 through 327, along with the transparency for Transparency sheet 32A and 32B, students will examine the mutations that occur in DNA. Students will observe the following mutations on overhead transparency and read about how these mutations occurs gathering the information in teacher directed notes. These notes can be found in the appendix labeled- Chapter 13.3 Genetic Changes. This information is a review of material previously covered in Chapters fourteen and fifteen. Students will complete the mini-lab that examines the effects of gene mutations on proteins which starts with a single strand of DNA.

A reproducible mini-lab worksheet can be found in the Biology: The Dynamics of Life BioLab and Minilab Workbook. To begin this mini-lab, students will copy the DNA sequence (AATGCCAGTGGTTCGCAC) from the imaginary molecule. The students will then write the complementary strand of DNA. Next students will write the base sequence that would occur on the mRNA strand after transcription. Students will use Table 13.1-DNA Code to determine the order of amino acids, in the resulting protein fragment. Students will be asked to repeat the process with the fourth base changed to cytosine-C instead of guanine G. They will repeat the process with a guanine-G added to the third base instead of thymine-T. Students must determine which is a point mutation and which is a frameshift mutation. Students will be asked to describe the effects of a point mutation and frameshift mutation on a protein. This activity will enable students to grasp a better understanding of gene mutations on proteins.

After we have discussed the different types of mutations. The students will be quizzed on the mutations using Transparency Sheet Thirty-two and the review questions. Transparency Sheet Thirty-two can be found in the Biology: The Dynamics of Life Transparency Workbook. This activity will close out Chapter Thirteen. Students will review Chapter 13, as homework, by answering the review questions one through ten, on page 330 of the Biology: Dynamics of Life text. After the review students will be tested on all three sections of Chapter Thirteen. The examination will be taken form the Biology: The Dynamic of Life Chapter Assessment Workbook, pages 73, 74, 75, and 76.

The examination includes: a fill in the blank vocabulary paragraph section, a diagram of a DNA strand to be labeled, a multiple choice section, and a critical thinking short answer section.

Chapter Sixteen, Section One- Recombinant DNA Technology

To cause a better understanding of genetic engineering, DNA technology, recombinant DNA, transgenic organisms, vectors and restriction enzymes, students will model recombinant DNA technology by completing the Biolab on pages 380 and 381 of the Biology: The Dynamics of Life text (a student friendly reproducible format of this lab can be found in the Biology: The Dynamics of Life Biolab and Minilab Workbook). The materials needed for this activity are: pink and green paper, tape, and scissors. (This activity will be teacher directed and therefore the procedure will be explained.) Students will be asked to pretend that they are scientists who are diabetes researchers. Their patients have been using the insulin from pigs to treat their condition. Almost all the patients are suffering from an allergic reaction to the pig's insulin. Ideally, the scientists would like to use human insulin, because it does not provoke the reaction that pig's insulin does. However, not enough human insulin can be made by humans fast enough or in large enough quantity to service the needs of all diabetes patients. Students will be told that one of their colleagues would like to find a way to make human insulin fast. This colleague has found the insulin gene in the human genome and wants to place this gene into another organism that: 1) reproduces fast and 2) can incorporate the insulin gene into its DNA to make large amounts of human insulin. The inquiry will be posed to the students, which asks- What organism have we studied that we know reproduces fast and would not take up a lot of space as it reproduces in our hypothetical laboratory? The hopeful conclusion is a bacterium. They reproduce quickly, have DNA (which can be manipulated), and do not take up much laboratory space. Students will be given one circular piece of DNA (this is composed of a DNA sequence of two complementary strands on pink paper- copied from the reproducible, cut out and taped by the teacher) and a small green linear piece of double stranded, complementary DNA. Students will be told that the red DNA is the bacterial DNA and the green DNA is the fragment that holds the insulin gene. At this point, students will briefly review the chemical structure of DNA, from Chapter Thirteen. Students will also discuss base pairing.

Next students will be told that the portion of the human genetic information that codes for insulin is as follows-GATCC (this is not the true gene sequence for insulin, it is only used for the purposes of this activity). They will be asked how many times does the sequence GATCC appear in the human DNA fragment. Upon observation, it is anticipated that students observe that the sequence GATCC appears twice, once forward in the top the DNA fragment and once backwards on the bottom of the DNA fragment. Students will be made aware that this phenomenon is called a palindrome (the same sequence of bases found on both DNA strands, but running in opposite directions). Next, students will be asked, how they would remove the insulin making gene GATCC from the top and the bottom of the human DNA fragment. Students should arrive at the conclusion to cut the fragment at two appropriate locations. Both strands of the human DNA fragment will be drawn on the board. With chalk the outline of how and where to cut the fragment will be drawn too. Students will then be asked how they could place the insulin-making gene into the bacterial cells. It is anticipated that students realize that they can "cut out" a portion of the bacteria's DNA and replace it with the human DNA. Students will be asked how they would decide which portion to remove from the bacteria. Their answer should involve nitrogen base sequence and base pairing. It may be difficult for them to conceptualize where the bacterial DNA needs to be cut, so I will ask them if we could cut the bacterial DNA at the same location that we cut the human DNA. The desired response is yes. Students will be asked to make the cut into the bacterial DNA. Students will then be referred to page 377 of the Biology text. We will discuss the discovery of DNA cleaving enzymes in the early 1970's, which are termed restriction enzymes. These restriction enzymes are bacterial proteins that have the ability to cut both strands of the DNA molecule at certain points. Restriction enzymes search for a particular palindrome. There are hundreds of restriction enzymes, each capable of cutting DNA at a specific nucleotide sequence. The resulting DNA fragments are of different lengths (this concept will be developed further later in the chapter). We will use figure 16.1 that shows two DNA strands cleaved/cut by ECORI as an example. Students will be asked what 'tool' did they use that would have the same function as a restriction enzyme. It is anticipated that the students recognize that the scissors act as a restriction enzyme, because it cut the DNA into fragments at a specific nucleotide sequence.

After the students have discussed restriction enzymes, they will discuss the formation of sticky ends. Students will be told that many restriction enzymes cut sequences of DNA that are palindromes. This property will be brought to the students' attention again, as being essential for engineering recombinant DNA. As a result of cuts made by restriction enzymes, single-stranded sequences of DNA are left dangling (this will be illustrated on an overhead transparency) at the ends of the fragment. These dangling ends are referred to as sticky ends that are available for pairing with their complementary bases in a plasmid or piece of viral DNA. The sticky ends usually join together with complementary single strands on other split DNA. At this point, students will be asked if they can see the sticky ends on their human and bacterial DNA fragments. The desired answer would be yes. Students will be asked to tape the insulin-making gene into the bacterial DNA. Students will be told, after taping, (it is hoped that they have already concluded), that they have just modeled the process of making recombinant DNA, and that they made a new plasmid. They will also be told that their plasmid is transgenic. A transgenic organism is an organism that has been genetically engineered to include DNA from a different organism and use them as their own. Students will wrap up the lab by completing the data table and answering the Analyze and Conclude questions in the Biolab Wrap up found in the appendix.

To end this section, the class will be broken into five equal sections. Each section will be required to research the role of transgenic organisms in one of the following categories: agriculture, industry, medicine, plants and animals. The mini-reports should include how a transgenic organism is a benefit in their area along with an example. The students will present the mini-reports as a group. Each individual in the group must share some fact regarding transgenic organism in their category in order for the entire group to receive credit for this project. Charts, diagrams, pictures, and graphs are encouraged to be a part of the mini-reports. To review section 16.1, students will complete Transparency Sheet thirty-five, which can be found in the Biology: The Dynamics of Life Transparency Workbook.

Chapter Sixteen, Section Two- The Human Genome

The last section of the unit tackles the Human Genome Project. Students will use the Internet to gather information regarding the HGP. After compiling all their information, students will use Microsoft Publisher to compose an informational brochure. This brochure would describe the HGP, mapping techniques and would be shared with someone outside the classroom, preferably a family member. The Brochure will include pictures (these can be inserted from the clip art file or copied from the Internet), and four major questions. The answers will be made up of the information collected by the students from the Internet. Students will be directed to the Department of Energy's website (<http://www.ornl.gov/hgmis/publicat/primer2001/2.html>). Students will be asked to click on the Primer link, and then begin their search at the history of the Human Genome Project. While at this site, students will answer the following questions: What is the Human Genome Project? Why map the Human Genome? How is the human genome sequenced and mapped? As chromosome maps are made, how can they be used? This information that the students will gather from the Department of Energy's website is more current than the text, but will be used in conjunction to the text, because it correlates with section 16.2. After gathering this information, students will go to Microsoft Publisher, click of Brochures, then click on informational brochures and pick one of their choosing. Students can design the brochure to their liking as long as it follows the format found in the appendix.

After students have completed their brochures and before they take them home, students will take a closer look at DNA fingerprinting through PCR. They will also examine the ethical perspective behind diagnosis of genetic disorders and gene therapy. To further examine PCR, students will perform the laboratory exercise- "Where's the CAT?" by Ellen Mayo. Students will be told that they will once again use restriction enzymes. Students will be asked to describe what restriction enzymes do. After the role of restriction enzymes has been discussed, students will each be given a Where's the CAT?-lab sheet. The class will be broken into five to eight groups. Each group will be given one DNA sample for one of the characters in the background of the lab. Students will read the background together as a class but perform the procedure with their group. After the entire procedure is completed, students will tape their character's DNA fragments to the chalkboard, where they will be compared to the other characters and the standard. This comparison will be done as a class to determine whom the father is. Students will finish the conclusion to the lab and will discuss the process. Students will then be directed to complete the homework assignment article- "A Mistaken DNA Identification? What Does It Mean?"

After the CAT lab, students will be prepared to take home their brochures. Students will be asked to allow someone from home to read their brochure. The follow up will be that students must write down every question that the person may have asked them, regarding their Human Genome Project Brochure. Students must bring the brochure and the questions back to class, where they will be discussed. Students will relate any misconceptions that they may have had concerning the HGP to the questions asked by their family member. Brochures will be collected and placed into their portfolios. Hopefully two copies of the brochure are made so that students may keep one at home for future reference.

Next students will refer back to the gene therapy aspects of the HGP. This information should have been gathered under the question- how can chromosome maps be used? Students will examine possible ethical considerations of the applications of DNA technology, particularly gene therapy. Students will watch the Lorenzo's Oil video with the viewer's guide. The viewer's guide can be found in the appendix. The viewer's guide forces students to examine several different perspectives concerning medical care and DNA technology. Students will be asked to write a viewer's response, based on the information that they have collected while watching the video. They will also use three excerpts from three different websites to complete their write up.

This will finalize the unit on DNA and DNA technology. Students will be directed to a set of review questions at the end of Chapter Sixteen in the Biology text (Understanding Concepts page 392, questions 1,2,3,4,6,7,8,11 and 12). After the review students will be tested on all both sections of Chapter Sixteen. The examination will be taken from the Biology: The Dynamic of Life Chapter Assessment Workbook, pages 89, 90, 91, and 92. The examination includes: a fill in the blank vocabulary paragraph section, a diagram of a DNA strand to be labeled, a multiple choice section, and a critical thinking short answer section.

DNA is certainly the technology of the future. It is essential that we equip our students with a basic knowledge of this technology. When students catch the nightly news, read an article on stem cells or cloning, it will not fly over their heads. They will have an awareness and sensitivity that will allow them to connect and

make an informed decision. They will see the light behind DNA technology instead of stigma that blinds so many others.

Supplemental Assignments

For students who have missed class periods, class activities, and/or laboratory exercises, following along with the pace of instruction may be difficult for them to accomplish. To better support these individuals, they will be given the study guide sheets-(Study guides 13.1, 13.2, 13.3, 16.1, and 16.2). This will force these students to read the material that has been covered, even though they may not have the same understanding as a student that attends on a regular basis. Students that have missed class periods can also read and answer the question for the articles- “A Mistaken DNA Identification” or “This Monkey’s Part Jelly Fish”. Website to download the actual article can be found in the Annotated Bibliography. The question sheets can be found in the Appendix. There is also a video sheet activity for “The Real Eve”, a video representation of mitochondrial DNA technology and the tracing of the origins of human kind. This video illustrates cutting edge DNA technology and human genome research. The video can be order through the Discovery Channel.com. There are also articles and interactivities that surround the topics of: human migrations, human origins, and mitochondrial DNA.

Annotated Bibliography/Resources

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Teacher Resources

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Learning Center. <http://gslc.genetics.utah.edu/basic/wheatgerm/>. Laboratory protocol that directs the extraction of DNA from wheat germ.

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Health Museum. 1995. http://www.accessexcellence.org/AE/AEC/AEF/1995/mayo_dna.html. Takes students through the basic steps in the DNA profiling, commonly known as DNA fingerprinting.

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Appendices

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The following section includes the Appendices. The Appendices contain all the assignments and standards that are listed throughout the “A New Way- Through DNA” Unit. The Biology: The Dynamic of Life curriculum includes assignments not included in this unit that may be helpful when presenting this unit to students. The Biology: The Dynamics of Life curriculum includes: Chapter assessments, study guides, bio labs, laboratory exercises, lesson plans, rubrics, alternative assessment aids, and other activities.

Appendix A- Assignments

13.1 DNA: FACT NOT FICTION

I. Structure and Function of DNA

A. DNA a molecule:

1. DNA is a complex biological polymer called a nucleic acid.
2. Nucleic acids are made up of smaller subunits, called nucleotides.
3. Composition of nucleotides are:
 - a. deoxyribose
 - b. a phosphate group
 - c. a nitrogen base

B. Nitrogen Base

1. A nitrogen base is an organic ring structure that contains one or more atoms of nitrogen.
2. There are four possible nitrogen bases:
 - a. Adenine (A)
 - b. Guanine (G)
 - c. Cytosine (C)
 - d. Thymine (T)
3. There are four possible nucleotides (See figure 13.1)

C. Chains of nucleotides

1. In nucleic acids, nucleotides do not exist as individual molecules.
2. Nucleotides combine by condensation (Reaction that removes a hydrogen ion and a hydroxide ion- removal of water.) to form two long chains.
3. The two long chains produce one large molecule.

4. Each chain of nucleotides contains single nucleotides connected to each other.
5. The two chains are joined by weak hydrogen bonds between the bases.
 - a. Adenine will always bond with thymine, and vice-versa
 - b. Cytosine will always bond with guanine and vice-versa
6. The structure looks like a twisted ladder and is called a double helix.

D. The Importance of DNA

1. The genetic material that makes up ALL living things is DNA.
2. Two different organisms will have the same DNA made up of the nucleotides adenine, thymine, guanine, and cytosine.
3. The order of nucleotides in the two different organisms is different.

(Example: Change 911 to 191, will you still reach the emergency services if you call 191 instead of 911?)

4. The more closely related two organisms are, the more alike the order of nucleotides in their DNA will be.
5. The Human Genome Project is determining the sequence of the human species.

REPLICATION ACTIVITY

1. Randomly pick eight students.
2. Give two students an A, two a G, two a C, and two a T (These can be prepared before class by the teacher on colored construction paper.)
3. Ask four of the eight students that you have just given letters, to come to the center of the room and form a straight line. (Students should be in a single file line)
4. Ask the seated students, if this were a DNA strand, what bases would we need to complement or complete this molecule? (Solicit answers from the seated students)
5. Using the remaining four students, tell them to find their position next to their complementary base. At this point there should be two single file lines at the center of the class.

6. Next, students should lock arms inside arms with the person next to them (their complement base). Afterward, students should place the outside arm on the shoulder of the person in front of them.
7. At this point in the activity, it will be explained that the students at the center of the class represent the hydrogen bonds that hold the base pairs together. The arm to the shoulder connection represents the covalent bond between the sugar and phosphate. Each person represents a nucleotide (Head-deoxyribose, shoulder-phosphoric acid, stomach-nitrogen bases.)
8. Another eight students (two A's, two G's, two C's, and two T's) will be given construction paper cards that represent the nitrogen bases.
9. Next, two students will be picked randomly to be the DNA separator and the DNA bonder. (They represent the enzymes involved in replication.)
10. The DNA separator will be asked to unhook the students at their hydrogen bond one pair at a time. (Purpose is to clarify where the hydrogen bond is and how DNA replicates.)
11. The DNA bonder will pick two students (not from the line) to complement the nucleotides just separated.
12. This will continue until there are two new DNA molecules at the center of the room. (There should be sixteen students in the center of the room.)
13. Tell the students that they have just modeled replication.
14. Have students write summaries of the process of DNA replication. (Students should read pages 313, 314, and 315 and incorporate what they read into their summary of replication.)
15. Choose several students to write their summaries on the chalkboard.

The Human Genome Project

Brochure Format

You will be designing a brochure that tells all the details of the Human Genome Project. You will use the Department of Energy's Website-<http://www.ornl.gov/hgmis/publicat/primer2001/2.html> and your text.

The Human Genome Project brochure is due _____.

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WHAT TO INCLUDE

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In your brochure you should answer the following questions...

What is the Human Genome Project?

- a. Present basic facts about DNA, chromosomes and genes.*
- b. Define the Human Genome Project.*
- c. Describe the goal of the Human Genome Project.*
- d. Explain how long it will take to complete the HGP.*

Why map the Human Genome?

- a. Define a chromosome map.*
- b. Explain the use of different chromosome maps (physical maps and linkage maps).*

How is the Human Genome mapped?

- a. Describe the use of restriction enzymes.*
- b. Define PCR, electrophoresis and various labeling techniques.*

As chromosome maps are made, how can they be used?

- a. Relate the question to diagnosis of genetic disorders.*
- b. Relate the question to gene therapy?*
- c. Relate the question to DNA fingerprinting.*

FORMAT

Your brochure should be designed to attract a teenage reader but, it may take any format that you choose. You have seen examples in class and you may use any of these formats OR if you're creative enough, design your own.

You must include at least two (2) sources of information (the text book and the website).

GRADING

This brochure will count for a 100 point test grade.

It will be graded on

1. organization
2. Whether the reader can develop a clear understanding of the Human Genome Project after reading your Brochure.
3. If the brochure is appropriate for the audience
4. Whether there are sufficient facts and details included
5. Whether there is a good explanation of
 - a. The Human Genome Project
 - b. Why the Human Genome is mapped
 - c. How the Human Genome is mapped
 - d. How chromosome maps can be used

Chapter 13.3 Genetic Changes

Mutations

I. DNA Mutations

(See figure 13.9, on page 325.)

A. Point mutations: a change in a single base pair in DNA

1. A point mutation can change the entire structure of a protein, if it causes the amino acid to change.
2. A point mutation such as AAA to AAG still code for the same amino acid, even though the last A in the sequence is change to a G.

B. Frameshift mutation: A mutation where a single base is added or deleted from DNA.

1. If a single base were lost during transcription into mRNA, the mRNA would be out of position by one base.
2. As a result every codon after that base would be different.

II. Chromosomal Mutations

(Changes can occur in chromosomes, as well as, in genes. During cell division a chromosome can break incorrectly. See figure13.10 on page 326.)

- A. Deletion: part of the chromosome is left out.
- B. Insertion: occurs when a part of a chromatid breaks off and attaches to its sister chromatid. The is a duplication of genes on the same chromosome.
- C. Inversion: occurs when parts of a chromosome breaks out and is reinserted backwards.
- D. Translocation: occurs when part of one chromosome breaks off and is added to a different chromosome.

III. Danger of Chromosomal Mutations

- A. Chromosomal mutations can be very serious because they affect the distribution of genes to gametes during meiosis.
- B. Gametes that have a complete set of genes may end up with extra copies of some genes or a complete lack of certain genes.

- C. Few chromosome mutations are passed on to the next generation because the zygote usually dies.
- D. In cases where the zygote develops, the mature organism is usually sterile and cannot reproduce.

IV. Nondisjunction

(the failure of homologous chromosome to separate properly during meiosis.)

- A. In gametes formed as a result of nondisjunction, one has an extra chromosome, and the other is missing a chromosome. The effects are often seen when gametes fuse in fertilization.
- B. Trisomy: gamete with an extra chromosome fuses with a normal gamete. (Example: Down Syndrome three chromosome #21 instead of a pair.)
- C. Triploidy: a gamete inherits a complete diploid set of chromosomes. When this gamete is fertilized by a normal haploid gamete, the offspring has three sets of chromosomes instead two sets. This condition is rare in animals but occurs frequently in plants. (Example: Banana plant are increased in size)
- D. Monosomy: organisms that lack one or more chromosomes. This occurs when a gamete with a missing chromosome is fertilized by a normal gamete. (Example: Females with one X chromosome)

V. Causes of Mutations

- A. Spontaneous Mutation: Errors in DNA provide the variation that enables species to evolve. These are mutations that occur randomly.
- B. Exposure to X-rays, ultraviolet light, radioactive substances, or certain chemicals can cause changes in DNA.

(Mutations often result in sterility or lack of normal development in an organism. If these mutations occur in human gametes, they can cause birth defects. If they occur in body cells, the mutations can lead to cancer.)

Name _____ Date _____ Period _____

3. Some restriction enzymes cut DNA at particular places but do not leave sticky ends. These enzymes cannot be used to engineer recombinant DNA. Explain why. What function might they serve in a cell?

Name _____ Period _____ Group _____

Where's the CAT?

Goal of this activity: This simulation activity will work through the theory of DNA profiling, to teach the principles of restriction enzyme digestion, gel electrophoresis, and probe hybridization. *(Don't let the big words scare you. Some of them you already know.)*

Background Information:

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- A woman has been cheating on her husband and several weeks' later finds herself pregnant. She wants to know whether the baby is her husband's or the child of her lover. In this activity we will 'simulate' gene testing to determine the true biological father.
- Simulated gene testing (gene testing is also known as DNA fingerprinting) compares the DNA fragments from the known samples to those of the suspected fathers. EVERY cell in the body contains a copy of DNA. While the majority of DNA does not differ from human to human, some three million base pairs of DNA (about .10 percent of your entire genome) vary from person to person. The key to DNA evidence lies in comparing the DNA of the child to that of the suspected fathers, in the chromosomal regions that show high diversity among people. *(There are two kinds of diverse regions, also known as polymorphic regions: 1) length polymorphism, VNTRs- variable number tandem repeats and 2) sequence polymorphism, RFLPs- restriction fragment length polymorphism)*

Materials:

-

1. Highlighters 2 different colors
2. Colored copier paper (white, and two colors hopefully different from highlighter colors)
3. Scotch tape
4. Scissors (One per group)
5. Photocopies of the DNA sequences
6. Paper labeled- Agarose gel (made with one of the colored copier papers)
7. Glue sticks

Procedure:

-

Part One

1. First we had to find and isolate the highly diverse area of DNA (a diverse locus or gene portion from a chromosome), for ALL the parties involved. *This procedure is not included in this lab.*
2. To simulate the restriction digest (digest or cut up DNA with one or more restriction enzymes- endonuclease) each group will be given a strip of DNA in a sequence to cut up. (One group will have mom, one husband etc...)
3. Tape your sequence together- this represents one sample of DNA. (Match the subscripted numbers 1 and 2. Be sure to cover them up when you tape the pieces together)
4. Scan the sample strip for the probe sites: CAT. Wherever the sequence CAT appears, mark it with your highlighter.
5. Next, mark the sample strip at the recognition sites for the restriction enzyme Hae III (GGCC) with your other highlighter.
6. Then cut the strip all the way across between the center G and C of each restriction site. (*This will yield your RFLPs. Within the human genome this particular sequence GGCC will reappear at many points. Because each person inherits a unique combination of sequences, the number and size of fragments created from each person's DNA should be as individualistic as a fingerprint.*)
7. Place your DNA fragments into the envelope marked well. (Look at the board to see what a well in the agarose gel looks like.)



- To wrap up this portion of the activity use the lab background, lab procedure, and your text to define the underlined words, from part one of the procedure. Write them in your own words, in the lab Follow Up-Data & Terms section.

Part Two

1. Get the blue paper marked agarose gel matrix. (This is the paper that you will tape your RFLPs on) Place your character – standard, mom, husband, or lover in the space provided at the top of the graph.
2. Count the number of bases in each of your fragments (A's, G's, C's, and T's). The larger fragments- ones with the most bases, will be closest to the well and the smaller fragments- ones with the least bases will be further from the well. Line your bases up with the graph on the side. A twenty base fragment should be on the twenty base fragment line and so on. The fragments will be distributed down the column. This process simulates gel electrophoresis.
3. Tape the fragments in place.
4. Cut out your DNA probes- GTA sequence. (Pink paper)
5. Using a glue stick, place some glue on the back of the GTA sequence. The probe sequence GTA is complementary to the CAT sequence that you highlighted earlier. (The sequence CAT represents the VNTRs- that can help distinguish one person from another. Children inherit these from their parents, one from each parent)
6. Scan your fragments and wherever you see the highlighted CAT glue a GTA probe on top of it.
7. Any fragment that does not have a GTA probe in it, remove it (untape it from your column). When looking at a real autoradiograph- agarose gel only those bands with the probe are visible.
8. Place your column on the chalkboard, with tape, next to the others. WE will compare the columns as we complete the follow activities.

2. What if the samples represented the lover only instead of the husband and the lover, and a sample of the mother's DNA instead of the child's? Would this be sufficient evidence to determine paternity?
3. What limitations can be seen in these procedures?

HOMEWORK!!!:

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Read the article "A Mistaken DNA Identification? What Does It Mean?"

After reading the article answer the following questions:

1. What is a locus (plural- loci)?
2. Based on the information given in paragraph one, would you have found the man guilty? Explain.
3. Explain what occurred when they retested the gentlemen's DNA. How was the second test different from the first?
4. List two benefits of a DNA database and two consequences of a DNA database. (One consequence should be obvious after reading this article)
5. Do you completely trust DNA identification methods after reading this article? Why or Why not?

Name _____ Date _____ Period _____

This Monkey's Part Jellyfish

After reading the article, answer the following questions.

1. What does ANDi stand for? _____

2. What is a transgenic monkey? _____

3. What kind of gene was placed in ANDi? _____

4. What does the jellyfish gene produce? Is it important to monkeys? _____

5. Why is it considered an advance that the jellyfish DNA is found in every cell of ANDi's body?

6. Transgenic lab mice have been used for years, but why are transgenic monkeys valuable?

7. What insights could a transgenic monkey with human genes that promote cancer provide?

8. Not everyone approves of using monkeys to test human diseases. How do scientists justify the use of transgenic monkeys to study human diseases? _____

9. Why has the development of transgenic monkeys lagged behind other transgenic species?

10. The jellyfish DNA was packaged inside a viral vector. What is a viral vector?

11. What does the analysis of the gene show? _____

12. Ronald Cole-Turner states that many moral and ethical questions remain to be answered before

Name _____ Date _____ Period _____

The Real Eve

1. How many years ago did "Eve" live? _____
2. True or False: The humans during "Eve's" time were just like we are today.
3. Fifteen thousand years ago _____ was vital to human survival.
4. Eve _____ were successful and the only ones to survive.
5. Gene Markers are like _____.
6. _____ is the birthplace of the human.
7. The first _____ of humans took place in Africa.
8. As Africa dried up, so did the _____.
9. Our entire survival has always been at the mercy of _____.
10. Humans were just, as much as an Endangered Species as _____.
11. Our ancestors came out of Africa through a _____.
12. The process of the reduction of lines is called _____.
13. Its not until we reach _____ that new evidence begins to fill in gaps.
14. One hundred miles of _____ sea separated them from the New Land.
15. Tortoises in Australia, at that time, were as big as, _____.
16. Mungo man three's bones, based on the earth surrounding them, was found to be about _____ years old.
17. Based on scientist's research, the lack of U.V. rays, pigmentation, and melanin (our natural sunscreen), the time to go from black to white is _____.
18. The burial of a 12 year-old modern child has been found, dated _____ years ago.
19. The Neanderthal's nose were mechanisms for breathing Neanderthals _____ and _____ air.
20. Neanderthals are _____ times closer to us than chimpanzees.
21. Modern humans use their _____ to mediate with nature.
22. The fragile strip of land joining Asia with America is called the _____.
23. There is evidence, on the Ohio River in Pennsylvania, of a rock shelter called _____.
24. Scientists found a spare in the Kennewick man's _____.
25. There was a connection found between a _____ and a _____.

Appendix B- Content Standards

The Pittsburgh Public Schools has adopted, in accordance with the State of Pennsylvania Department of Education, Content Standards for each subject area taught with in the District. The following standards are related to the DNA unit.

Science and Technology Standards

1. All students explain how scientific principles of chemical, physical, and biological phenomena have developed and relate them to real world situations.
2. All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological, and earth sciences.
3. All students' use and master materials, tools, and processes of major technologies, which are applied in economic and civic life.
4. All students explain relationships among science, technology, and society.
5. All students construct and evaluate scientific and technological systems using models to explain or predict results.
6. All students develop and apply skills of observation, data collection, analysis, pattern recognition, prediction, and scientific reasoning in designing and conducting experiments and solving technological problems.

7. All students evaluate advantages, disadvantages, and ethical implications associated with the impact of science and technology on current and future life.

8. All students evaluate the impact on current and future life of the development and use of varied energy forms, natural and synthetic materials, and production and processing of food and other agricultural products.

9. All students demonstrate basic computer literacy, including word-processing, software applications, and the ability to access the global information infrastructure, using current technology.