Getting Real with Genetics:
Taking Genetics out of the Science Lab and into Your Life

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There is a high probability that for the Homo sapiens, the process of evolution as we currently think about it, as natural selection, is for all intents and purposes over. It is going to be replaced by our desire and capability to tinker.

~ Stuart Schreiber, Harvard Geneticist
Quoted in *The Geneticist Who Played Hoops with My DNA: And Other Masterminds from the Frontiers of Biotech by David Duncan*

INTRODUCTION

The "technology tinkering" mentioned above is a new chapter in our history, and both business and medicine are betting on it to help rid the world of such dreaded diseases as cancer, heart disease, and sickle cell anemia, while simultaneously generating huge profits. Similarly, DNA (deoxyribonucleic acid) testing is revolutionizing forensic science, but the social repercussions of establishing a DNA data bank also have to be taken into consideration. Newspapers and magazines these days are replete with articles about new discoveries and corresponding ethical concerns as the growing biotechnology industry, and special interest groups pursue their own agendas, often without regard for the rights of individuals. In an effort to control such unbridled speculation, the Senate is currently studying bills to monitor this area, and the U.S. Government Patent Office is limiting patents on genetic material to those with proven medical uses.

It will be important for today's students to understand these new issues and formulate opinions regarding the use of biotechnology. This unit traces genetics from studies of heredity pioneered by Gregor Mendel though the Human Genome Project. Since it is designed for cross-curricular implementation (not only by science teachers), it contains information on DNA, genes, and chromosomes, as well as additional information that strengthens educators' background knowledge. Legal and ethical implications of new biotechnologies are explored along with their impact on society and the individual.

Four lesson plans are provided to stimulate student interest by building on prior knowledge. These lessons appeal to multiple intelligences and learning preferences. Upon completion, students will be able to understand and visualize genetic processes and formulate opinions and debate regarding the use of biotechnology.

MY CLASS

I am writing this curriculum unit for my intermediate/advanced ESL class composed of 9th and 10th grade Spanish-speaking students. To improve their knowledge of science and social issues that will affect their futures, I have designed my lesson plans to be cross curricular. To

avoid the complaint of being "boring," I am incorporating "hands-on" activities such as art, music, and even cosmetology that appeal to different intelligences and learning styles. For dense reading with complicated theories, students, especially those at-risk, require that the subject matter be presented in a variety of formats to ensure understanding and long-term retention. As an English teacher and not a science teacher, I found it helpful to remember terminology in terms of similes and metaphors reinforced with visual images. The emphasis is on the big ideas and the implications that genetics will have on every day life.

TEACHING STRATEGIES

Activities and Their Sequence

The first lesson plan (Genes: What Are They?) will begin with a **K**now, **W**ant to know, **L**earned posted chart. The teacher will give hints about the uses of genetic material that appear on TV such as in forensic cases and paternity testing; then the students will provide ideas for the **K**now column. After the students have exhausted their knowledge, a trailer for the film *Gattaca* (PG 13) will be shown. This sci-fi movie presents a futuristic world where destiny is determined by the quality of an individual's genes. The title itself is based on the first letters in the names of the bases that make up the DNA double helix (**A**denine, **C**ytosine, **G**uanine, & **T**hymine).

Next the students will generate questions for the **W**ant to know column. They will discuss the trailer and watch the introduction to the film. The teacher will stop the DVD and ask the students to guess what material is falling. The teacher will help the students to understand that it is bodily material that contains DNA (nail clippings, skin flakes, strands of hair, etc.) magnified and with sound enhancement. This information will be added to the **L**earned column. At the teacher's discretion, more of the film (15 to 20 minutes) may be shown, stopping and advancing to touch on pertinent issues such as embryo enhancement or genetic discrimination. Students will be divided into mixed groups (intermediate/advanced) to do a web quest on DNA and genes. The groups will come together to share information. They will use their newfound knowledge to create posters, demonstrating what they have learned both through writing and drawing.

The second lesson plan (Getting DNA from an Onion) will center on a simple science experiment to extract DNA from an onion. First, the class will examine an onion peel under a microscope to identify the cells. (The students should be reminded that in the film cheek cells were used to classify a person's genes.) The teacher will proceed with the experiment to extract DNA from an onion (detailed information is included in the lesson plan). This will lead into a discussion of DNA and its role in life. An introduction and review of the relevant vocabulary that will be part of the subsequent lesson plans will also be included.

The third lesson plan (The Double Helix in Life and Art) will focus on the DNA double helix by exploring its structure and makeup. Hopefully, the DNA from the onion can be spooled in the previous class showing its linear composition. The teacher will show the double helix as it has been represented in sculptures, paintings, stamps, etc., using a computer with Internet access and an LCD projector. The teacher will also show students examples of the mutant left-handed helix that have appeared in art and print. (In nature the double helix most always winds to the right although rare exceptions do exist.) For the students to take possession of this new knowledge, hands-on activities will be completed in small groups, pairs, or individually.

The fourth lesson plan (DNA: Who Owns Your Genetic Information?) will involve viewing genetics from an ethical and legal point of view, using newspaper and magazine articles, excerpts from books, video clips, summaries of court decisions, etc. During this lesson, students will participate in a debate about the uses and abuses of biotechnology. The central issues will be privacy, discrimination in the workplace, denial of health coverage and life insurance, etc.

Supplemental Activities

The class activities will include a web quest, discussions, and debates. Students will have the options of making a double helix as a mobile or jewelry, creating digital posters, designing a futuristic music loop that artistically interprets genetics, or fashioning a hairdo using gel, braid extensions, etc. that incorporates the double helix. Divided into groups, the students will digitally photograph these artifacts and together with the digital music and artwork produce a PowerPoint presentation to demonstrate what they have learned using technology.

Materials

To perform the onion experiment, the teacher will need to borrow equipment from the biology lab because a microscope, slides, stain, etc. are required. Another alternative would be to partner with the biology teacher for this activity.

Four classroom computers with appropriate software e.g. Microsoft Word, Paint, PhotoShop, PowerPoint, Jam Trax or Garage Band, etc., will be utilized. Internet access will be employed to do research and produce the final presentation as well as take the science quizzes available online.

The mobile or jewelry will require wire, beads of various sizes and colors, and small handicraft tools. For the hair styling, the students will need to bring their own brushes and accessories such as extensions, gel, etc. Kits can be purchased for this purpose or beads and other materials can be bought separately.

The other equipment needed for this project is a TV with DVD player and a copy of the film *Gattaca*. An LCD projector and screen will be used to show video clips from Internet sites to the whole class at once.

WHAT STUDENTS WILL LEARN ABOUT DNA, BIOTECHNOLOGY, AND BIOTECH ETHICS

Practical Applications

Students must learn about these important topics because they directly affect their lives now and will have long-range effects on their future families. This unit will help them to make real world connections, so that as voters they will be able to influence policy in these areas and make informed decisions when they cast their ballots. Genetic traits associated with certain diseases and ethnic groups will also be addressee, as well as the movement to test all newborns. The implications of genetically enhanced embryos and discrimination based on genetic profiling will be research and discussed.

Academic Skills

"Understanding science is a prerequisite for dealing with these challenging societal implications, and that understanding begins with DNA" (National Institute of Health).

This curriculum unit enhances scientific knowledge, develops higher level thinking skills, and improves reading and writing ability. The factual knowledge and skills contained in this unit are also required to pass the state science exam and the exit level exam. English language fluency and technology skills will be developed as students participate in the activities with an emphasis on developing scientific literacy.

AN OVERVIEW OF GENETICS

According to the ancient Greeks, the "vital heat" contained in the sperm was the material that determined the shape and characteristics of the baby (McGee 17). They believed that the contribution of the mother was minimal, but that experiences in the womb accounted for differences in offspring (McGee 17). It wasn't until the 1860s that Gregor Mendel, an

Augustinian monk, concocted novel experiments on pea plants to study heredity (Willett 6). Before him no one knew exactly how offspring inherited certain traits from their parents; Mendel gave the name "factors" to what we now call genes.

Mendel's theories were mostly ignored until the later part of the 19th century when improved microscope and staining methods allowed scientists to view chromosomes and their division. The word chromosome comes from the Greek "chromo" meaning color and "somo" meaning body, since chromosomes absorb the bright color from certain dyes (Willett 16). It was later confirmed that the nuclei of all plants and animals contain chromosomes, and we now know that chromosomes are made up of many genes, either only a few thousand or many thousand (See Figure 1).

In 1869 a Swiss chemist named Johann Fredrick Miescher was able to prove that cell nuclei were made up of an acid that he named it "nucelin". This discovery went against the belief that hereditary information had to be located in proteins (Willett 23). Even after the discovery that chromosomes were composed mostly of nucleic acid (DNA), scientists refused to accept this acid as the receptacle of genetic material because of its simplistic molecular composition ("Retrospect and Prospect"). The unsophisticated linear structure of DNA when compared to the complex structure of protein was judged too primitive. The fact that proteins differed from species to species and also among people reinforced this belief (AccessExcellence). The DNA molecule was treated as inferior in the scientific community, but its day was still to come. This is not to downplay the role of protein is the bases of life, but proteins take their instructions from DNA.

The acceptance of DNA as the carrier of hereditary information was proved conclusively through the work of Alfred Hershey and Martha Chase in 1952 through what is known as the "Blender Experiment" (*MedicineNet.com*). Using a kitchen blender, a virus, and a bacterium cell, they proved that DNA from one organism could invade another and take control of its cells, thereby changing its nature (Ag-West).

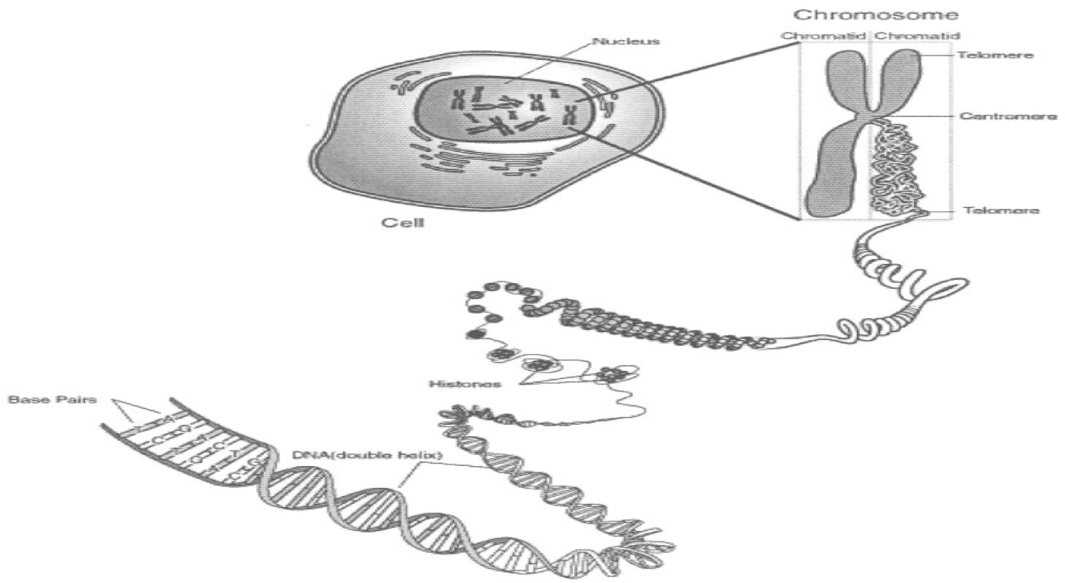

Figure 1 - The nucleus containing the capsule shaped chromosomes, an insert of a chromosome displaying the genes arranged on a wound up thread of DNA, and finally, the double helix revealing its base pairs are illustrated ("Chromosomes" NIH).

Approximately thirty billion years ago, primordial life and consequently genes appeared as a short string of molecules that could reproduce themselves (Jones 7l). They have been called "the marching order that direct our growth, what we look like and how we react to things in our world, or environment" ("You and Your Genes"). Our individual combinations of genes, approximately 35,000, have been handed down from our "ancestors who died long before our great-grandparents" (Jones 36). They make up the "blueprint" for cells in our body (Stix 76). Despite this impressive pedigree, humans have only double the amount of genetic material of a worm and even less than some other animals like the unicellular *Amoeba Dubia* that is said to have 200 times more DNA than humans (McGee 38).

Although the word genetics was first used by British zoologist William Bateson in 1906, the term "gene" wasn't coined until 1909 when Danish biologist Wilhelm Johanssen proposed that it be used instead of Mendel's "factor" (Willett 8). The word gene comes from the Greek "genesis" meaning beginning.

We inherit 46 chromosomes containing genes from our parents, half from our mother and half from our father. They determine our phenotype, physical appearance, and our genotype, our genetic makeup (genome). In total our bodies are made up of 70,000 pairs of genes in our approximately 100 trillion cells. They have been visualized as "snap-together beads on two long, connected strings of DNA" ("You and Your Genes").

Genetic Mutation: The Good, the Bad, and the Indifferent

Genes are not static; they move around energetically. They have even been described as "jumping" around on the chromosome (genome). They are constantly mutating as we age and come in contact with toxic agents in the environment, including smoke (either from pollution or tobacco), pesticides, radiation, etc. We start out as a pristine original but as time passes, this original is copied and recopied and just with like a photocopy small defects begin to show up. These defects include cancer, diabetes, etc. "The biological identity crisis which we define as old age and which is solved by death happens when the genetic message has become so degenerate that its instruction on longer make sense" (Jones 82).

More than 90 percent of genetic material is referred to as "junk" DNA because its function or functions are still unknown (*My DNA*). Surprisingly, "DNA sequencing of any two individuals is 99.9% the same, but the range of variations in the remaining 0.1% is enormous" (Arnst). This minuscule deviance is where scientists search to solve mysteries involving diseases, crimes, and paternity issues.

Currently, biotechnologists are developing microchips that can perform blood tests to identify approximately 300 mutations in one multiplex test. In the near future, the capability of the test will be expanded to 5,000 - 100,000 mutations. The new technology involves the use of microchips made of human DNA (Andrews 11).

However, not all mutation is bad. Mutation might be undesirable for the individual, but it fuels the advancement of our species (Jones 71). Some mutations such as sickle cell evolved as a defense mechanism, in this case to protect the individual from malaria. Although in the U.S. African Americans no longer need this protection, many of their offspring still carry forms of this mutation that can cause severe medical complications and even death. Mutations, or alleles, are thought to have been the beginning of evolution.

The Discovery of DNA and the Double Helix

DNA is short for deoxyribonucleic (pronounced: dee-**ahk**-see-rye-bow-noo-**klee**-ik) acid; it is found in all living creatures and plants. DNA is housed within the nucleus of all cells, except in mature red blood cells that have no nucleus, and is protected by the nuclear and cellular

membranes that are made up of lipids and proteins. "The now well-known twisting and intricate double helix" was announced in 1953 through an article published in *Nature* by scientists James Watson and Francis Crick (McGee 21). The double helix is a molecule that looks like a winding staircase with curving banisters and the cross steps that are made up of paired chemical bases. The rungs of the stairs are composed of the bases **A**denine, **C**ytosine, **G**uanine, and **T**hymine, usually just labeled A, C., G, & T. The lateral sides just add support for these four complementary bases that form the pairs G with C and A with T respectively. This has been called the four-letter language of genetics (genome). Just as the order of letters is critical to writing a word so is the particular arrangement of As, Ts, Cs, and Gs to carrying out important functions in the organism (*Human Genome Project Information*).

DNA can also be found in the mitochondria, which is located within the cell but outside the nucleus. Mitochondria DNA (mtDNA) contains its own specific set of genes. While the nuclear DNA comes equally from the mother and father, mtDNA is derived only from the mother. Another important difference is that unlike nuclear DNA, mtDNA remains unchanged unlike nuclear DNA. Since mutations in the mtDNA build up during a person's life span while nuclear DNA limits the number of mutations, the mtDNA is the source of many degenerative and fatal diseases, including some types of diabetes, deafness, and heart diseases. mtDNA is also used by evolutionists to retrace the evolution of modern man (*My DNA*).

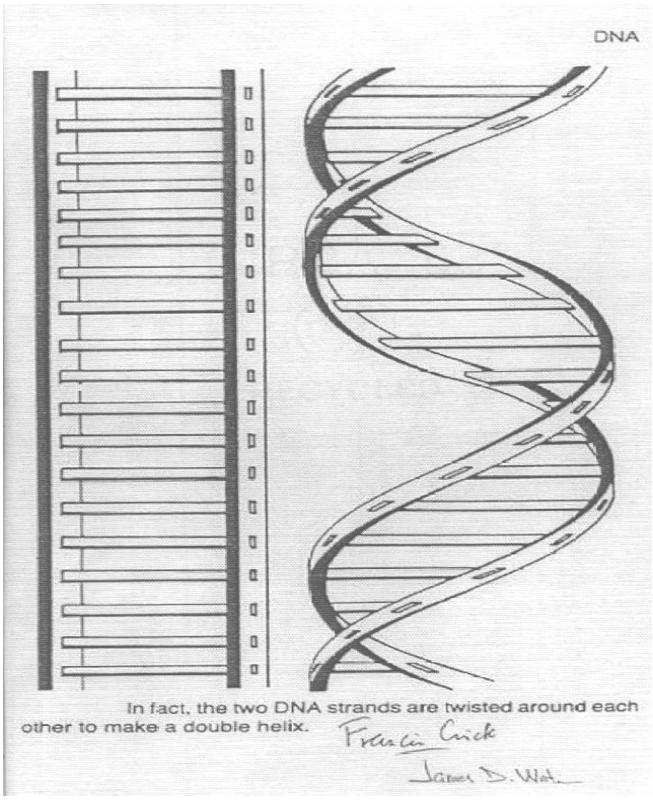

Figure 2 - Two views of the helix are signed by its discoverers Francis Crick and James Watson with the notation "In fact, the two DNA strands are twisted around each other to make a double helix." ("You and Your Genes" NIH).

Another important role of DNA is to act as a template for the making of RNA (ribonucleic aid). RNA is different from DNA because RNA has only a single strand. RNA is involved in protein assembly, splicing and editing of other types of RNA. Francis Crick explained it simply by saying, "DNA makes RNA, RNA makes protein, and proteins make us" (*My DNA*).

Representations of the double helix should show the helix twisting to the right just as a screw does, but, unfortunately, in popular media and even in scientific circles, a left-handed version has often appeared. A website entitled "The Left-Handed DNA Hall of Fame" has even been created by Dr. Thomas D. Schneider, a scientist at the National Institute of Health "in an attempt to stop this particular mutation" (Harmon). However, it has now been discovered that a rare form of the left-handed double helix does in fact exist.

On a more serious note, scientists are concerned that genetic determinism as presented in media coverage on DNA will confuse the public and propagate "a fatalistic view of genetics, rather than embracing it as a future of medicine and a font of knowledge about the past" (Harmon). While DNA/genes show a predisposition in some individuals to certain conditions such as diabetes, heart disease, cancer,

etc., there is growing evidence that environment and lifestyle also play a vital role in the development of such diseases.

Genome

The complete set of genes needed to make any animal is called its genome. This explains why dogs have puppies and cats have kittens. The human genome produces a baby, but some of these genes are common to humans and animals just as we have certain behavior in common such as digesting food ("You and Your Genes"). For this reason, scientists are studying the genome of other mammals as well as insects.

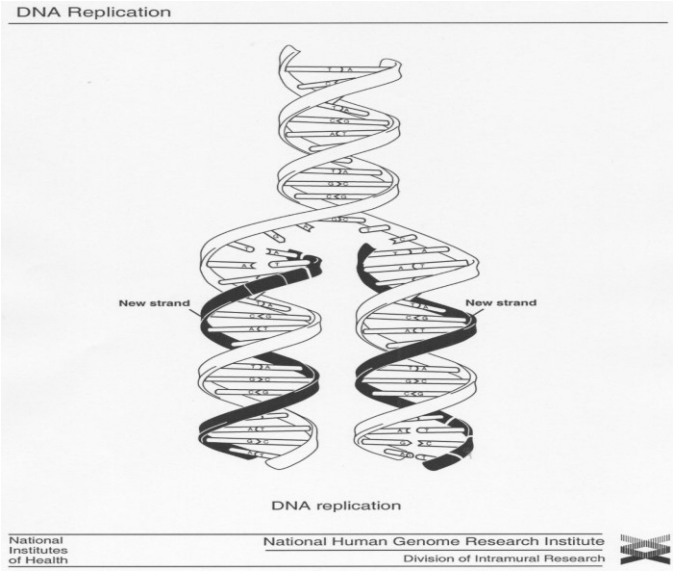

Figure 3 - The replication, or the copying process, in the illustration shows how the double helix unzips, and then the two sides zip up with new strands of DNA ("DNA Replication" NIH)

The genome has been likened to a book with the 23 paired chromosomes making up the chapters, and the genes representing several thousand stories in the book of life (Riddle 7). Or perhaps you prefer to conceptualize the genome as the plans for a house, with the house being the human body. The genes direct, or code, for the production of different proteins, and the proteins are the construction materials but also the construction workers in the organism ("You and Your Genes").

THE HUMAN GENOME PROJECT AND OTHER GENETIC RESEARCH

The Human Genome Project began in 1999 under the sponsorship of the U.S. Department of Energy and the National Institutes of Health, with the aim of studying an entire set of human genes. Although it began as a government initiative, there was a gradually shift to the private sector (*Human Genome Project Information*). As the genes were listed, their locations were also noted. Using new computer technology, the task was completed in record time in 2003 with 99.9% accuracy of the genome sequencing.

In addition to this project, the government of Iceland embarked on a program to the map the genes of its citizens. Since Iceland has a homogeneous population with little immigration, it was the ideal scenario. They also had extensive genealogical records. An Icelandic scientist originally began this project; however, due to financially problems, it was taken over by an international pharmaceutical corporation.

The University of Utah is also actively involved in genetics as the Mormon population is very homogeneous and maintains careful family records. The university also has a website to disseminate information concerning genetics and genetic diseases.

LEGAL IMPLICATIONS

What give genes their power, then, are the values or ethics used to apply them: the decision made by individuals and society about how genes fit in the desire to live a good life" (McGee).

A discovery in the field of genetics begins a quest on the part of physicians, lawyers, health care services, scientific organizations, social institutions, insurance companies, legislatures, courts, and ordinary people to develop the appropriate policy about its implementation and social impact (Andrews 2). Some of the dilemmas posed are:

- Who should have access to genetic information that could affect employment and insurability?
- Should gene therapy be used to correct genetic afflictions in embryos?
- Should genetic enhancements for height, intelligence, etc. be permitted to create "designer babies?"

These questions and more are debated in *Future Perfect* by Lori Andrews, a law professor who specializes in science, technology, and medical ethics. Interventions involving the germ line (the sperm cell, ova, and embryos) will affect the genetic makeup of future generations. As she points out, "Genetic technologies could be applied in attempts to create 'perfect' people. But moving in that direction entails such high psychological and social costs that the society we would be creating would be far from perfect" (2). The creation of such an artificial society could inadvertently happen today as only the rich will have access to the latest genetic technology that will provide their progeny (children, grandchildren, ad infinitum) with advantages that are not affordable for the poorer segment of the population. Genes to improve health, appearance, intelligence, etc. will create a veritable caste system from which there will be no escape.

There is also the problem of the "therapeutic gap" when diseases can be identified by genetic testing but cannot be cure (Andrews 5). The knowledge of a genetic risk in one individual will have an impact on his/her whole biological family. The word "gen-etiquette" was coined to refer to such a situation and the moral/legal obligation of the individual to share this knowledge with a wide range of blood relatives. (Andrews 7).

Biotechnology

While other countries such as Canada and Great Britain have appointed nonbiased commissions to develop coherent policies to regulate genetic technologies, "the United States notably lacks an adequate structural mechanism for analyzing controversial new medical technologies" (Andrews 15). Canadian Minister of Health David Dingwall is quoted as saying, "New technologies concern the future of our society. How we manage them will be no less than a statement of who we are and what we value" (Andrews 22).

At the same time in the United States, the social value of biotechnology is overlooked in favor of its commercialization (Andrews 16). The approach to regulating such new biotechnology is labeled "bioethics fire drill" as policy is written in panic as a response to a new genetic advancement (Andrews 21).

In 1980 the U.S. Supreme Court ruled that a patent be granted on bacteria. This inclusion of a life-form was the beginning of patents on human genes. A patent gives its holder exclusive rights for 20 years. This landmark decision reversed the previous opinion that only inventions could be patented, therefore eliminating "products of nature." The U.S. Patent and Trademark Office issued a growing number of patents on human genes by the middle of the 1980s. These patents permitted researchers to earn royalties on gene therapy or tests based on the gene they identified. In the 1980s a series of federal laws caused more radical changes in research, permitting university and government researchers to profit from discoveries that were financed by the tax paying public (Andrews 8).

In 1988 the "Harvard Oncomouse," a mouse engineered for genetic susceptibility to cancer, was the first animal to be patented as an invention by the U.S. Patent & Trademark Office. In the realm of plants, strains that do not produce seeds are being developed and patented by transnational corporations. Poor farmers must buy seeds each new growing season. In effect, subsistent farmers are held ransom by big business. This trend will worsen poverty in the developing world as a type of "biocolonialism" develops (Council for Responsible Genetics).

For Our Global Society

There are three predominant approaches regulating health care: the medical model, the public health model, and the fundamental rights model.

Currently, in the United States the majority of genetic services come under the *medical model,* which means that the public's access to health care is only limited by their financial situation (Andrews 22). This policy suffered modification in 1957 when a California court included the requirement of informed consent in the medical model (23). However, the legal concept of informed consent is rarely implemented in real life due, in part, to the physician's "profound misunderstanding of what patients actually want to know? (23).

The *public health model* strives to protect the public from diseases through educational programs, required testing, and mandated vaccination (Andrews 25). With regard to genetics, this model has required that new technologies to test for spina bifida and neural tube defects be brought to the attention of pregnant women. State laws require blood tests known as "heelstick" in newborns for genetic disorders such as congenital hypothyroidism, phenylketonuria (PKU), sickle cell disease, etc. Congenital hypothyroidism, which occurs in 1 of 5,000 U.S. births, is due to an underactive thyroid and can lead to mental retardation. PKU also causes mental retardation but is due to the buildup of amino acid; this condition is found in 1 out of every U.S. 14,000 births. One in every 500 births among African Americans and one in every 1,000- 4,000 births among Hispanic Americans have the disease or trait for sickle cell disease in the United States (*Talk Medical*). The condition causes an abnormal form of hemoglobin and can cause infant death. The sickle cell trait is predominant among African Americans but it also appears in Latin Americans, Arabs, Greeks, Italians, and Indians. PKU is predominant among Northern European descendants, and hypothyroidism shows no ethnic distinction. The March of Dimes recommends that newborns be screened for 29 conditions, which includes a hearing test (March of Dimes).

The *fundamental rights model* involves issues of reproduction and requires that "a health care service takes place only voluntarily, with extensive information provided in advance," but how much information is to be considered sufficient? The physician is only required to supply as much information as the 'normal' person would require, thereby making it a subjective decision. Of course, the more educated and wealthy will demand more explanations and documentation and will have the wherewithal to search for them in libraries and on the Internet.

As I write this unit, Canadian, British, and American public health officials are meeting at the 4th International DNA Sampling Conference in Montreal to debate the ethical, legal, and social issues of human genetics (HumGen). Many other international conferences dedicated to genetics are taking place throughout the world. Genetics is going global. All the new discoveries no longer make the headlines, which have left the public in the dark about the rapid pace at which biotechnology is changing the world we live in.

FOR THE INDIVIDUAL

Health

Day in and day out articles appear in newspapers, magazines, and on the Internet announcing the genetic connections for various diseases and also for behavioral addictions to food, sex, and violence, etc. In response, science is researching gene therapy to correct or disable the "bad" gene termed a mutation. This therapy is done by inserting a working gene to substitute a nonfunctional gene.

Unfortunately, the process is not simple since diseases usually involve multiple genes, and a safe bacterial vector to carry the new gene must be developed. Furthermore, scientists are still not able to insert a gene with full confidence that it will be installed in the correct location on the

gene sequence. Several children with Severe Immunodeficiency Disease (SCID), commonly known as the "bubble boy" disease, received gene therapy and were cured only to later develop leukemia. The same gene therapy that cures can also kill. Jesse Gelsinger, a teenager with a rare liver disease, received gene therapy but died shortly thereafter as his vital organs shut down in response to the treatment. His death in 1999 brought gene therapy to a temporary halt (*Learn.Genetics*). An even newer therapy called RNAi (RNA interference). Gene Therapy inserts DNA that produces a molecule to shut off an overactive gene. This therapy has the potential to cure hepatitis, HIV, and cancer, but for now the researchers need to solve the problem of high toxicity ("RNA Interference").

Identity Theft

Just as there is identity theft today, the writer Randall Parker warns of the threat of identity theft based on a DNA sample. While charges to a credit card can be detected because they generate a bill for a service or a product not requested, DNA theft could be hard to detect because the sample could be submitted with anyone's name. Nowadays there are companies that do DNA testing by mail. "The incentive to get another person's DNA tested is still very low and will remain low until a lot more information about a person can be gleaned from testing their DNA" (Hood). As new gene markers are identified for obesity, alcoholism, violence, etc. a DNA profile will become a valuable asset, especially to employers, insurance companies, and health service providers.

Health Insurance

An article in *Business Week* entitled "How Likely Are You to Get Sick?" expounds the supposedly good news that with regards to genetic advancements, "the goal will be to counter the risk of disease, not pigeonhole the person." It is within this 0.1% of the genes that predispositions to diseases can be located (Arnst).

This scenario would be the ideal; however, people are in danger of losing their health insurance if their predisposition to a disease is known even though legislation has been passed to prevent it. Sandra Thomas who has *just* "the gene for the blood disease hemochromatosis" already lost her health insurance. According to an article by CBS News, testing can lead the way to treatment and cure, but it can also put employment and health insurance in jeopardy. ("Brave new World?").

Genetic Discrimination

Genetic discrimination can also negatively impact employment and career opportunities since privacy of medical information is just an illusion. If a person wants treatment, he/she is required to sign a mountain of paperwork in the doctor's office. New legislation was enacted to facilitate the flow of information and treatment, but it has allowed many third parties access to medical records as well (Andrews 28-29). Employers will be reticent to hire people with late-onset diseases and predispositions to maladies.

GENETICS ON THE BIG SCREEN

"There is no gene for the human spirit." (tagline from the film *Gattaca)*

When Professor Scott, the seminar leader, recommended this film, I was initially uninterested in watching a sci-fi flick, but his enthusiasm convinced me to view it. It is an extremely well done presentation of how life may be if society is dominated by biotechnology. Although it was produced in 1997, it has accurately foreseen situations that we are now facing or contemplating in the near future.

Gattaca follows the life of a man who has been labeled as genetically inferior because he was conceived without prior genetic planning and has a predisposition to die of a heart condition

before the age of 30. In this dystopian vision of the future, embryos are examined to eliminate genetic defects of all types ranging from serious birth defects to future conditions such as myopia, baldness, sexual orientation, etc. For $5,000 more, embryos can be enhanced with special talents for music and math. Upon birth, the babies' DNA is examined to determine its "quality," and the genetic information is entered into a central database. This predetermines careers and opportunities in life. Thus this society creates a "genetic caste" where "invalids" are reduced to serving the "valids."

By purchasing the DNA of a "specimen of genetic perfection" and assuming his genetic profile, the hero is able to escape his genetic fate and pursue his dream. The movie is reminiscent of novels such as *Brave New World* and *1984*, and the theories of heredity and genetics that justified white supremacy and racism in the 19th century (McGee 20; *Spiced Wire*). However, the completion of the Human Genome Project and the ongoing International HapMap Project (a study of common patterns of genetic variations in human populations) make it seem uncomfortably close to reality (*Orange Hedgehog*).

REFLECTIONS

If you really want to learn more about the real future of science, the best way is just stay alive as long as you can and see what happens (Dyson).

While researching this curriculum unit, I discovered how fast new biotechnologies are advancing without public notice in many cases. It is alarming that a person's genetic material can be withdrawn from his/her body and used, without informed consent, by researchers and universities for financial gain. This happened to Henrietta Lacks, a poor African American, who was undergoing cancer treatment in 1951. A biopsy from her tumor was sent to George Gey at John Hopkins who discovered that her cancer cells were unique. They continued to reproduce as long as they were cared for, and this indefinite reproduction is contrary to the limit of 50 cell divisions for humans (Weil 11). Gey named these cells HeLa cells and announced his discovery on the same day that Mrs. Lacks died, without acknowledging her contribution. Her cells are now in laboratories throughout the world and have aided in the development of the polio vaccine and other treatments. The Lacks family only learned about what had happened, by accident, twenty-four years later (13).

This is not an isolated case as laboratories are commercializing blood and tissue samples that are left over from lab tests. One Internet company even included patients' medical records for buyers to have full information about the origin of the cells.

It will be a two-edged sword that must be managed carefully to protect and not slay its handler. Genetic testing will enable parents to avoid giving birth to severely impaired children, but the question will eventually come down to what is "an acceptable genetic human being" and who will make this decision.

LESSON PLANS

Lesson 1 (Intermediate & Advanced ESL) - Genes: What Are They?

Class: 9th & 10th grade ESL students (intermediate & advanced)

Timeframe: Two 90-minute classes

Objectives

To develop listening, speaking, reading, and writing skills and learn about genetics.

Materials

- KWL chart (large poster chart and individual charts for students)
- Bilingual dictionaries (Spanish/English)
- DVD *Gattaca* (PG 13)
- TV with DVD player
- Individual computer stations with Internet access
- Handouts of the Web Quest in Appendix A

Warm-up

A KWL poster chart will be placed on the board with the title genes. The teacher will review the strategy for filling out this type of chart. The teacher will give a brief explanation of what genes are and hints about the uses of genetic material (DNA) that appear on TV such as in forensic cases and paternity testing. She will model how to fill in the poster chart with input from the student. Students will then receive individual copies of the KWL chart to fill in. The class will suggest and discuss ideas for the Know column and questions for the Want to know column.

After the students have run out of ideas, the teacher will show the trailer for the film *Gattaca*. The class will discuss what they think the film is about. The teacher will help in the discussion as needed. The students will fill in questions for the Want to know column.

They will proceed to watch the introduction to the film. The teacher will stop the DVD and ask them to guess what material is falling. She will help them understand that it is bodily material that contains DNA (nail clippings, skin flakes, strands of hair, etc.) magnified and with sound enhancement. This information will be added to the Know column.

More of the film will be shown (15 or more minutes at the teacher's discretion), stopping and advancing to touch on pertinent issues such as embryo enhancement or genetic discrimination.

Activity One

Students will be divided into mixed (intermediate & advanced) groups/pairs to do a web quest on genes and DNA.

Activity Two

Students will use their newfound knowledge to create posters, demonstrating what they have learned both through writing and drawing. They will also finish their KWL charts.

Evaluation

The completed products will be presented to the class by the individual groups/pairs. Later posters will be displayed in the classroom or in the hall outside the classroom.

Homework

Students will look for articles and commentaries on genetics in the media and share their findings during the next class.

Lesson 2 (Intermediate & Advanced ESL) - Making DNA from an Onion

You can extract DNA from all living things. For an experiment, spinach, bananas, chicken liver, strawberries, broccoli, etc., can be used. I chose an onion because the students can easily see the cells under a microscope before extracting the DNA.

If you prefer not to use an onion, you can find exact instructions with pictures (in only four steps) for split peas on the University of Utah Genetic Science Learning Center website www.learn.genetics.utah.edu.

Class: 9th & 10th grade ESL students (intermediate & advanced)

Timeframe: One to two 90-minute classes

Objectives

- To develop English language skills and learn about DNA by observing the extraction of DNA.
- To become familiar with measurements (cm, ml, teaspoon, cup, Fahrenheit, centigrade, etc.).

Preparation

Make friends with the biology teacher and borrow one of her microscopes and some test tubes.

Warm-up

Students will share the information on genetics that they found in the media. Then they will look up the following words in a bilingual dictionary.

chop (verb)	stain (noun)	precipitate
measure (verb)	pour (verb)	tilt (verb)
slide (noun)	test tube	lipid (verb)
float (verb)		

Activity One

The teacher will show some examples of the DNA double helix using the LCD projector and the Internet. Websites are listed in the Bibliography.

Activity Two

Students will find other examples of the double helix on the Internet. They will divide into groups to make representations of the double helix according to their preferences.

They can create jewelry such as earrings or a keychain. Instructions are on the website DNA Jewelry Models on the Access Excellence @ the National Health Museum <www.accessexcellence.org>.

Students can also create hairstyles to resemble the double helix using hair extension, beads, wires, etc. Other students can create music loops using the appropriate software such as Garage Band or Jam Trax.

Evaluation

The products and artifacts will be videotaped for a PowerPoint presentation that will be presented in class and also shown to a biology class. Digital photos will be posted on the ESL web page.

Lesson Plan 4 - DNA: Who Owns Your Genetic Information?

Class: 9th & 10th grade ESL students (intermediate & advanced)

Timeframe: One 90-minute class

Objectives

To develop English language skills and higher level thinking skills while examining the issue of DNA ownership, gene patenting, privacy, etc.

Materials

"Who Owns Your DNA?" (www.salon.com) is an interesting article that the teacher could use (the first few pages) or the story of Henrietta Lacks that is mentioned in Reflections.

Warm-up

Students will look up the following words in a bilingual dictionary:

biotechnology	ownership
commercialization	patent (noun)

The teacher will read the text aloud to the class, stopping to check on comprehension and understanding or she will explain the case of Henrietta Lacks and the HeLa cells.

Activity

The student will be divided into groups/pairs to develop opinions in favor or against patenting cells, genes, and other parts of a human organism.

The points for debate are:

- Does patenting stimulate research and promote cures?
- Does patenting limit access and discourage research and ultimately delay cures?
- Is it ethical for a company to patent a person's genes without his/her permission?
- Will biotechnology improve or destroy our society by causing genetic inequality between the rich and the poor?

Students will compose slogans to express their opinions.

The teacher will circulate around the room to monitor the activity and help as need.

Evaluation

The groups/pairs will post the results of their studies about genetics and their slogans on the ESL web page.

Homework

Students will discuss this topic with their parents and poll their opinions. The results will be compared during the next class.

APPENDIX A

Web Quest on Genetics and DNA for Lesson Plan 1

For this web quest you will be searching for answers to questions about genetics and DNA. Be sure to write your answers in complete sentences.

The following websites will help you in your search:

- <http://learn.genetics.utah.edu/units/basics/tour/>
- <http//:www.pbs.org.html> (See the scientific sidebar for definitions.)
- <http:www.ekac.org>
- <http://www.marchofdimes.com>

1. What does DNA mean?
2. Which relatives have the same DNA?
3. What bodily material can be used to test DNA? (name four)
4. Where is DNA found in the cell?
5. What shape is DNA?
6. How many chromosomes does a human being have?
7. Who does a baby get its chromosomes from?
8. What is a gene?
9. What does HGP stand for? What is a genome?
10. What is the purpose of HGP?
11. Write the names of three genetic diseases.
12. How many genes does a human being have? (approximately)
13. Who is known as the pioneer of genetics?
14. What is a clone?
15. What is a transgenic creation?

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