8th Annual DNA Day Essay Contest Submission

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Teacher
MARIA NEDWIDEK (doctorned@d-ned.com)
Class 1: Other: Medical Human Genetics, Pd 3
Class 2: Other: Medical Human Genetics, Pd 6
Class 3: Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

School
Principal: Jie Zhang (JZhang@schools.nyc.gov)
Stuyvesant High School
345 Chambers Street
New York NY 10282
Phone: 2123124800
Fax: 2125873874

Essay 131489

Student
James Bessoir (11th grade , jbessoir@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
The world was a shockingly different place before 1953. Most people had never flown in a jet aircraft, man hadn't set foot on the moon, and the vast majority of people had no idea what DNA was. Nowadays, these things are as familiar to us as the air we breathe. If we want to go to Europe, we take a jet there. If we want to convict a criminal based on anonymous genetic material, we use DNA profiling. Watson and Crick's discovery of DNA paved the way for a shockingly large number of technological advances, but forensic DNA profiling, and genetically modified foods, have been particularly impactful on our lives.

Forensic DNA profiling has been arguably the most tangible impact of our understanding of the human genome. Since 1987, it's been used to convict

thousands of criminals and exonerate hundreds more (1). Most DNA convictions are made possible by massive databases, like the FBI's national DNA index(2). This database holds genetic information for over 11 million people, and grows every day. Many court cases long considered closed have recently been reopened, as any organic material found at a crime scene can now be analyzed, and compared with living relatives of the suspects or victims. This sort of forensic analysis isn't only limited to crimes and court cases. Archaeologists use it all the time to determine the identity of human remains. Just recently, DNA evidence was used to confirm that a skeleton found under a parking lot in Leicester, England had belonged to the king Richard III (3). Though the characteristics of the bones may have pointed archaeologists in the right direction, without DNA analysis there would have been no way to confirm this exciting discovery. Between finding criminals and long-dead kings, DNA analysis has had a huge impact of the world of forensic science, and it's all thanks to Watson and Crick.

Though the ethics of it continues to be debated, genetic modification of food has become an ordinary practice in most first-world countries. Modifying an organism's genes to produce desired traits sounds like science fiction, but is fully possible, due to our understanding of DNA as enabled by Watson and Crick. The first commercially available GM crops were created in the 1990s, by companies like Monsanto. Now, the vast majority of crops grown in the US are genetically modified. In fact, 80% of all corn, soybeans and cotton grown in the US are modified in some way (4). Though many genetic modifications are extremely beneficial, and allow for more resilient crops with higher yields and favorable qualities (without GM virus-resistant papayas, the Hawaiian papaya industry would not exist), there are still concerns over whether such science is ethical. Some argue that we shouldn't play god, or that we should leave plants and animals exactly as nature left them to us. Whichever side you take in this debate, the impact of genetic modification on modern life is undeniable.

Genetic modification of crops, and the use of DNA evidence to convict criminals are now taken for granted, but neither would have been possible without the work of Watson and Crick. Their discovery of the structure and properties of DNA has enabled countless technologies and developments, and helped advance humanity's understanding of science and the world. Next time you buy a papaya or watch "CSI," remember that without the discoveries of Watson and Crick, modern biotechnology would be nonexistent.

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Essay 131490

Student
Charles DeLisi (11th grade , delisicharles@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
The Impact of the Human Genome Project on Modern Biology

The Human Genome Project was a massive effort made in the noble pursuit of expanding our knowledge of the fundamental molecules that make us who we are. This project, completed in 2003, was set out to accomplish a considerable number of things. It aimed to identify all the genes in human DNA, to determine the sequences of the base pairs that make up the DNA, to record and store all this information, to improve tools for data analysis in the field, and to address all the social and ethical issues that the project would bring up (ornl.gov). Despite the completion of these goals, analysis of the data recorded will continue for many years. Although the Human Genome Project reached all the goals it was set out to accomplish, the project's impact is still felt ten years after its completion. One aspect of biology in particular that the Human Genome Project has had an impact on is human health and disease.

There are many different diseases, and several ways of contracting them, but one class of disease that the Human Genome Project has a particular impact

on is genetic diseases. We have learned a considerable amount about genetic diseases and disorders. Genetic diseases/disorders are all caused by some kind of mutation or defect in the genetic information of the organism, and the mapping of the human genome gives an extensive insight into this field. There are four different types of genetic disorders. One type is called “single-gene”, which is caused by mutations occurring in the DNA of a single gene. The second type of genetic disorder is “multifactorial”, which is caused by a combination of environmental factors and mutations across different genes. Another type is “chromosomal”, which occur from abnormalities in chromosome structure. Lastly, “mitochondrial” disorders are very rare and come from mutations that, rather than occurring in the nucleic DNA, occur in mitochondrial DNA.

The Human Genome project has increased our awareness of many specific diseases that fall under each category of genetic disease. One example of a “single-gene” genetic disorder is sickle cell anemia. This is the most common inherited blood disorder in the US, and is caused by a mutation in the

hemoglobin-Beta gene on chromosome 11. Sick cell anemia is a serious disorder where red blood cells, instead of being healthy and donut-shaped, are sickle shaped and are unable to carry oxygen as efficiently. The Human Genome Project helped discern where the mutation is that causes the disease and has also greatly helped the outlook for those with the disease; until recently, sick cell patients were not expected to live past childhood, but thanks to extensive research done on the disease infected people today generally can live past 50 years of age. An example of a “multifactorial” genetic disorder is Alzheimer’s disease. Not much is understood of Alzheimer’s, but increasing research indicates that it is caused by complex series of events affected by genetics and the environment that occur in the brain over a long period of time. Alzheimer’s disease is a form of dementia that gets progressively worse. Although there is no cure for the disease, our understanding of it continues to grow. A “chromosomal” genetic disease would be Down syndrome. Down syndrome is caused by an abnormality with chromosome 21; specifically, when a person has three copies of chromosome 21. People with down syndrome usually have poor muscle tone, sometimes have heart defects, and have a low level of intelligence. These defects can be treated through physical therapy, surgery, and speech/educational therapy.

The Human Genome Project has vastly expanded our knowledge about human health and disease. Through this project, we have discovered the causes of many genetic diseases and treatments to help those afflicted with these diseases. The Human Genome Project was undoubtedly an enormous accomplishment, and its impacts will be felt for decades to come.

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Essay 131491

Student
Brian Ge (11th grade , briange1997@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
Revolutionizing Biotechnology and Human Medicine

People have long sought to understand the basic concepts of life and discern the laws that govern our universe. Even in the 17th Century, Isaac Newton was formulating his laws concerning motion and universal gravitation, laws which have been a basis for the field of physics ever since. The disciplines of biotechnology, human health, and genetics have all been around for many years, yet modern day applications all have their foundations in one basic concept. Arguably the most important revelation of the past century, the discovery of the structure of DNA by James Watson and Francis Crick in 1953 laid the building block for many biological practices that soon developed.

Specifically, knowledge of the double helix has allowed for the field of genetics to really take off, since DNA structure is the basis for the concept of genetic code. The study of genetics with regard to genome sequencing has opened a plethora of doors in biotechnology and human health, as modern drugs are now often specifically engineered to better treat diseases, safer vaccines can be produced through genetic engineering, and an unlimited number of other fields of medicine have been discovered and explored as a result of this knowledge of DNA structure.

The study of genetics has all of its roots in the double helix structure of DNA. While earlier scientists already understood that “DNA was most likely the molecule of life,” no one knew the structure of the DNA, and as a result it wasn’t possible for anyone to generate genome sequences ("The Discovery of the Molecular Structure of DNA - The Double Helix"). However, after the discovery of the double helix and the determination of the rules of genetic coding, geneticists could decipher and analyze sequences of DNA, as well as produce their own genome sequences.

These developments have been extremely crucial in biotechnological fields such as pharmacogenomics, which studies the relationship between genetic variation and drug response in patients ("Pharmacogenomics: Medicine and the New Genetics"). This modern branch of research holds incredible promise in the development of drugs that can adapt to an individual’s genetic coding, resulting in safer and more effective therapy for diseases. Furthermore, with knowledge of a patient’s genetic makeup and the ways in which he would respond to different drugs as a result, doctors could then quickly prescribe the most effective treatment from the start based on the patient’s genome sequence without having to go through the entire trial and error process. The potential benefits in medicine that could result from this division of biotechnology would be truly revolutionary.

Also within the scope of pharmacogenomics is the research of newer and safer vaccines made out of genetic material, instead of weaker pathogens that still carry risk of infection. In fact, these vaccines promise to deliver all the advantages associated with normal vaccines while eliminating all possible drawbacks including infection, and can be engineered to deliver immunity to multiple pathogens at once. This is yet another example of how many endless new possibilities have been presented in the medicine. The entirety of this field, however, owes its existence to the discovery of the double helix structure and subsequent determination of the genetic code.

Even fields with less awareness, such as monoclonal antibody therapy, would not be possible without the ability to recreate protein surfaces by encoding genome sequences. In fact, monoclonal antibodies have a lot of potential in the treatment of cancer and other autoimmune disorders ("Monoclonal Antibody Drugs for Cancer Treatment: How They Work"). The amount of fields that all show great promise towards the bettering of worldwide human health truly demonstrates the impact that the discovery of the double helix structure has had on biotechnology.

The understanding that DNA is formed by two chains of nucleotides connected through very specific base pairings in a helix structure has opened an unlimited number of new paths have been presented to modern scientists, transforming the landscape of biotechnology. The ability to unravel and recreate genome sequences has already led to many improvements in medicine, such as drugs with higher efficacy and fewer side effects, safer and more versatile vaccines, genetic testing to discover the specific gene mutations that result in genetic disorders, and far more branches of research that all stem from the ability to understand DNA sequencing. With such a huge impact on the world, Nobel Prize winners Watson and Crick truly deserve to be recognized for their revolutionary work in discovering the double helix structure of DNA.

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Essay 131492

Student
Allyson Ho (11th grade , allyson8D@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
DNA Sequencing and Us: The Sequel

The human genome was an elusive macromolecule determined to befuddle scientists for years until 1993, when the human genome was first sequenced. This was made possible by bounding leaps in engineering and technology. Without the computer or new purification techniques, the world would have had to wait decades longer for genetically tailored medical treatments, better food, and lower mortality rates.

As the population ages and the average life span increases, more people will require medical attention and care. Instead of mass producing compounded medication, DNA sequencing allows for individualized medication that can be tweaked to target specific genes in people. It will be a groundbreaking moment when science and medicine merge together to formulate specialized medications on a massive scale. With the scandal surrounding drug compounding methods, people are seeking alternative treatments. Gene therapy is slowly gaining the approval of medical authorities with recent breakthroughs in adrenoleukodystrophy (ALD), HIV, cancer and other fatal diseases (Kolata). By finding a way to alter the DNA of people suffering from drug resistant diseases, doctors will be able to provide more personal and effective treatments.

However, the same cannot be said for the food we ingest. As I made dinner, I couldn't help but wonder what percentage of my meal was actually natural. Looking at the food labels and nutrition facts, it turns out that there are soybeans in virtually all the products I used from the chicken to the soup base. Further research revealed that eighty percent of the soybeans came from farms that grow genetically modified crops (Food Inc.). This can be traced even farther back to a test tube in a lab owned by companies. While the long term effects of GMO containing foods has yet to be studied, the truth stands that genetically modified foods make crops more viable and less susceptible to diseases such as rot (Slivka). This can be seen in tomatoes and how genetic modifications may allow growers to leave the fruit on the vine for a shorter amount of time while retaining the original vitamin capacity and flavor. In the vineyards and orchards of California, plant hormones such as gibberellin and ethylene are used to control the growth and ripening of grapes and citrus fruits. For better or worse, genetically modified foods will sustain the entire human population.

Thanks to innovations that hastened the process of sequencing DNA, mortality rates will start to drop now that people have the means to target diseases caused by genetic mutations such as Tay Sachs and multiple sclerosis. We are no longer victims of the world because we have the ability to fight fire with fire, figuratively and literally. People who are at risk for Huntington's and Parkinson's have the choice to start treatment early to prolong their lives. Congenital diseases can be screened in fetuses; early tests can reveal whether or not a baby has Down syndrome. Even cancer is losing its death grip on the global population. Recently, three pharmaceutical companies pooled their resources to develop a drug that target a wide range of cancer. Instead of focusing on the origin of the cancer cells, this drug targets the protein p53 which signals damaged cells to self-destruct, an ability that is disabled when p53 binds to MDM2, another protein (Kolata). The drug wedges itself in between these two proteins to prevent p53 from being blocked. With the de-codification of the human genome, people will be able to prevent deaths and mitigate effects of fatal diseases.

The human genome was first sequenced a mere ten years ago but since then, we have put that information to good use through the Human Genome Project and other groups dedicated to finding cures and solutions to medical and industrial problems. This complicated macromolecule, with its twists and bends, holds the key to the answers being withheld from us. Perhaps in another couple of decades, we will be commemorating the contribution of DNA sequencing to the cure for cancer.

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Essay 131493

Student
Richard Yip (11th grade , rbyip1@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
Fixing our Food

Since the beginning of humankind, people have wondered what makes us, well, us. Yes, that sounds rather melodramatic, but it's hyperbole with a point. What intrinsic thing governs how organisms look, act, and think? The answer is simple: DNA.

Friedrich Miescher first discovered the molecule back in 1869 while examining used surgical bandages. Nikolai Koltsov was the first to propose that DNA could carry biological information and govern certain characteristics. 25 years after that, the Hershey-Chase experiment in 1952 showed that DNA is indeed genetic material, responsible for passing down inherited traits. Watson and Crick won the race to determine the structure of DNA, albeit while using some rather underhanded tactics along the way (Rosalind Franklin deserves credit for running the X-ray diffraction that showed that the correct model of DNA is a double helix). And from there, molecular biology was born.

While it's all nice and great to know that DNA takes the form of a double helix, what does it actually say? Scientists long knew of the existence of base pairs: adenine goes with thymine and guanine with cytosine. But to know what each gene in human DNA says, what it means, what it affects? That's a totally different story.

According to the official website of the National Institute of Health (NIH), the Human Genome Project was a multinational research program that aimed to fully sequence the human genome (http://www.genome.gov/12011238). This quest began in 1990. 10 years later, the first working draft of the genome was published and, three years after that, the complete sequencing was published. This project was not limited to humans, however; E. coli, lab mice, and fruit flies all also had their genetic makeup examined (http://www.genome.gov/Glossary/index.cfm?id=106). We now are able to identify what genes govern what properties of many living organisms.

Our knowledge of the genome is invaluable information. Recent years have seen the rise of bioengineered foods, with products ranging from cane sugar to bananas all being genetically modified. Naturally, this raises the concerns of many unfamiliar with genetic modification. Certain studies have been performed that appear to show that genetically modified organisms can harm existing, natural plants and animals ("Transgenic pollen harms monarch larvae", Nature, May 1999). Some people suggest that these bioengineered foods can lead to the rise of "super-diseases" that resist present-day pesticides. But while these are legitimate concerns, they do not take away from the fact that genetic engineering could usher in a "food renaissance"

capable of mitigating world hunger.

Genetically modified (GM) foods, which are foods derived from organisms that have had their DNA artificially modified, are the next frontier in food processing. Tomatoes bruise too easily? Apples don't have enough vitamin A? Just inject a gene. Scientists are doing this with foods from sweet potatoes to sugar: just add the desired genes to an organism, gather enough seeds, and presto! A new generation of riper, bigger, more nutritious foods is born.

Norman Borlaug, the "Father of the Green Revolution", won the Nobel Peace Prize in 1970 with his work in developing high-yield, disease-resistant wheat. His agricultural breakthroughs helped feed millions who otherwise had no access to healthful food. But even that is just scratching the surface of what genetics can do for humankind. If we can understand what genes say, what they do, and how they work, the potential for efficiently mass-producing healthy, nutritious foods is boundless.

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Essay 131494

Student

Edward Zilberbrand (11th grade , zilberbrand28@gmail.com)
from class 3 - Other: Junior Level Biology (LE and Molecular), Periods 8-9-10

Essay
Everything in nature from the largest whale to the smallest bacterium is composed of the same thing- DNA. The building block of life, DNA, scientifically named Deoxyribonucleic acid, provides us with the ability to live. Through the various processes that stem from gene expression we are able to communicate, consume, and coexist with the environment and stimuli that surround us. How we are able to do all of this is derived from the study of this amazing molecule and years of hard work. Discovered by James Watson and Francis Crick in 1953, the study of DNA has allowed us to make drastic innovations in the fields of biochemistry and genetic engineering. Now, sixty years after the discovery that revolutionized science, we are further advancing in the aforementioned fields. From a tiny double stranded helix we have been able to uncover nature's secrets- all from that seemingly meaningless discovery in 1953.

Before Watson and Crick's discovery, DNA was assumed to follow the same rules as Mendel's rules of heredity (Source 1), which explained how traits were passed down throughout species. However, this didn't give scientists the entire story, instead providing a limited scope for things such as hereditary diseases and mutations. In addition, scientists in the 1940's knew that DNA had four nucleotide bases: adenine, thymine, guanine, and cytosine, but had no idea that these bases conglomerated together and what shape was created when they were combined (Source 2). This issue perplexed scientists for years until Watson and Crick expanded on the ideas of other scientists to come up with their conclusion that DNA was a double helix model. The two DNA pioneers utilized X-ray photographs produced by Rosalind Franklin throughout 1951 to 1953 that showed not just the quantity of water molecules in DNA but also a rough outline of its structure (Source 3). In 1953, just months before Watson and Crick announced their discovery, another scientist named Linus Pauling announced that he had discovered the shape of DNA—a triple helix with a sugar-phosphate backbone at its center (Source 4). However, Watson and Crick realized that this couldn't be the structure since it had a neutral charge, meaning it couldn't behave as the acid DNA is. Utilizing both of these prior discoveries Watson and Crick inferred and later proved that the DNA molecule was a double helix with the adenine and thymine bases and the guanine and cytosine bases matching respectively. For their discovery both Watson and Crick received the Nobel Prize for Chemistry in 1962, a fitting end for a discovery as immense as the structure of DNA.

Furthermore, research into the structure of DNA and gene expression has altered the way we as animals in our most primal form view the world. Through Watson and Crick's discovery the Human Genome Project was spawned, a mission to identify all 100,000 genes and 3 billion base pairs of DNA molecules

(Source 5). Completed in 2003, this study had massive consequences in the field of medicine. Through the Human Genome Project scientists have institutionalized the practice of gene therapy, which some day would allow the treatment of some diseases that had been thought to be untreatable. We have also been able to utilize the information DNA provides in order to formulate the process of cloning. From our knowledge on Dolly, the first ever mammal cloned in 1996, we have been able to expand our knowledge of stem cells, or more importantly the usage of stem cells as a means of replacing the sick or dead organs (Source 6). Scientists are particularly interested in a process called cell fusion, in which stem cells from bone marrow in a body spontaneously fuse with the host's hepatocytes, thus allowing their recovery. This could save lives in the future, showing how powerful such a small molecule like DNA can be.

Looking into a microscope today, identifying the double helix of DNA is nothing special. However sixty years ago the discovery that DNA was a double helix by James Watson and Francis Crick revolutionized science and our understanding of the world around us. The combination of DNA's structure and its base pairing rules have led us to where we are today: utilizing gene therapy and stem cells to save lives. The year 1953 marked a turning point in science: after Watson and Crick's discovery the field of biology would never be the same. Only through their effortful labors are we able to claim to understand what life really means.

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The American Society of Human Genetics, Incorporated
9650 Rockville Pike • Bethesda, Maryland 20814
society@ashg.org • 1-866-HUM-GENE • (301) 634-7300
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