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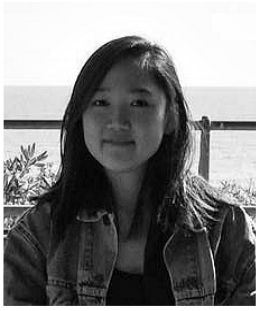

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A Message from the Chapter President...

Dear Triple Helix Readers,

In your hands is the work of a talented group of writers, editors, and designers who want to share with you their passion for the interdisciplinary study of science. Personally, I believe that science is not an exercise in intellect but an exercise in empathy. Despite the highly technical and at times brain-boggling research that is foundational to this endeavor, what we make of it is ultimately human, reflecting the hopes, dreams, and crises facing us as a species. Therefore in understanding the interdisciplinary nature of science, we understand the intersecting forces that shape our world and the people around us.

The key to using this science to change the world lies not only in knowledge and application. It also lies in the ability to cogently communicate these ideas —as well as their complex societal implications. Dialogue at the intersection of science and society has educated and empowered the public, inspired career paths, and spawned fantastically daring solutions to problems that engage the world's greatest intellects. In this tradition, your peers in The Triple Helix have documented their exploration of diverse subjects spanning law, ethics, genetics, psychology, technology, and gender.

Have a look. And remember, stay curious and never stop questioning.

Sincerely,
Amy Meng
Chapter President

A Message from the Editor-in-Chief...

Dear Readers,

The Triple Helix is a journal that explores the intersection of science and society. We examine how scientific progress may actually be implemented in real, volatile, unpredictable human populations. We probe the ethical dilemmas that exist in the gray area between research and real world application. We ask questions, we break boundaries, and we offer these mind bytes to you, dear reader. When you delve into our articles, please understand that you are only glimpsing a page of the whole story; in fact, we hope that these articles spark your curiosity and push you to dig deeper than what is encompassed here, so that what you read here remains with you long after you set this journal down.

And as for me, the editor-in-chief, what do I hope? Well, as a neurobiology major and English minor about to embark on a study abroad adventure to Australia before battling the monster that is medical school applications, I hope that you learn something new and share it, so that someone else can learn something new too. That's what I think this journal really is: a creative avenue to learn about exhilarating science from the unique perspective of your fellow students. This way of disseminating information outside of a classroom setting is, I think, pretty cool, and has the potential to be pretty powerful.

Oh, and I also hope that you enjoy reading this journal as much as I enjoyed bringing it to life, with the help of my talented writers and diligent editors.

Sincerely,
Mae Grewal
Chapter Editor-in-Chief

Cardiac Regeneration: Attacking Our Nation's #1 Killer

by Alexandra Brunjes

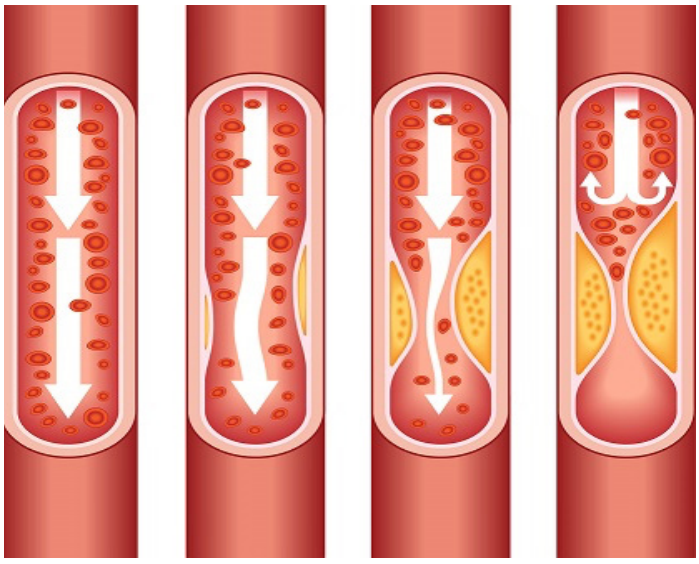
Cardiac disease is the most common cause of death in the United States, killing over 600,000 per year and accounting for approximately 25% of total recorded deaths [1]. One of the most pressing problems surrounding cardiac disease is that during heart attacks, individuals experience permanent damage to cardiac myocytes, or muscle cells of the heart [3]. When injured, these cells are unable to regenerate, leading to a weakened heart and a high chance of attack recurrence or heart failure [3]. Thus, finding a way to regenerate these cells could be extremely impactful in decreasing cardiac disease mortality. Stem cells, cells that have not yet specialized and can become any body cell, have long been thought to be a potential solution to this issue, and current research is exploring new ways to culture these cells for use in healing and regrowth.

In this article, I will discuss the current state of research surrounding cardiac regeneration, citing several studies and the potential applications of their results. Examples include implanting human stem cells into immunodeficient mice, exploring the possibility of tricking hearts into regenerating themselves, and testing regenerative therapies in large primates. I will describe the progress that has been made in some parts of this field, the ways in which this research could evolve into breakthroughs for cardiac disease and personalized treatment, and what work still needs to be done before myocardial replacement therapy can be performed using stem cells. Research surrounding cardiac regeneration and stem cells research also has many bioethical implications, which makes it an even more interesting topic to explore.

Someone in the United States has a heart attack every 34 seconds and someone in the United States dies of heart disease every 60 seconds [5]. Heart disease kills more people in the United States each year than every form of cancer combined – at an estimated cost of over $200 billion per year [1]. This problem is large- and the irreversible nature of heart damage: myocardial infarctions are caused by a blockage of blood vessels resulting in heart muscles being deprived of oxygen and nutrients, causing cells to die [3]. This cell death is irreversible and causes permanent damage, and makes future heart attacks even more dangerous [3].

One interesting avenue to explore with regards to cardiac regeneration is working to understand the mechanism that prevents cardiomyocytes from regenerating and ultimately attempt to control it. This research stems from the observation that newborn babies can repair their hearts, while adult humans cannot. Mice show a similar capacity: newborns can repair for up to a week after birth, but after that period they lose their ability to regenerate [4]. This similarity makes mice good organisms to study when exploring this subject. This loss of ability can be ascribed to the fact that cardiomyocytes lose the ability to proliferate very soon after birth [4]. This is because they leave the cell cycle, which is a process that cells continuously undergo, the most important aspect of which is cell division.

Knowing this, researchers at the Spanish National Center for Cardiovascular Research (CNIC) hypothesized



Alzheimer's Association

that these cells leave the cell cycle due to the shortening of telomeres [4]. Telomeres are the nucleotide sequences that cap the ends of chromosomes (tightly coiled DNA that carries genetic information). Telomeres protect chromosomes from deterioration, prevent chromosomes from fusing with one another, and maintain the integrity of the genetic information. This hypothesis seems logical because the enzyme that lengthens telomeres, telomerase, is only active in embryos. As you grow older, telomeres shorten and telomerase activity ceases, which results in chromosome degradation and thus aging. CNIC researchers thought that the telomeres in cardiomyocytes may have been shortening and as a result, activating a cell cycle inhibitor called p21 [4]. Cell cycle inhibitors cease a cell's progression through the cell cycle, which subsequently stops them from being able to replicate.

To test this hypothesis, these researchers observed the telomeres in cardiomyocyte cells of newborn mice. They found telomeres shorten rapidly in the week following birth [4]. This is likely the turning point that prevents mice from being able to repair their hearts after this time span. In the mice with a telomerase deficiency and thus naturally shorter telomeres, cardiomyocytes stopped proliferating only one day after birth, and hearts were unable to regenerate in response to damage [4]. Knocking out the cell cycle inhibitor p21 caused the opposite effect: the period for regenerative capacity extended [4]. Additionally, mice were able to repair their damaged hearts much more quickly [4]. These data suggest that working to maintain telomere length in adult cardiac cells could improve cardiomyocyte regenerative capability, leading to a smoother recovery after a heart attack [4].

Approaching the problem from another angle, some research surrounding heart attacks is working toward the goal of creating cardiomyocytes in the lab to replace damaged cells. These would be introduced into the hearts of heart attack or heart disease patients in an effort to replenish their injured muscle. A recent study yielded beneficial results in this exploration. In January 2017, researchers at Johns Hopkins had regenerative success after implanting immature heart cells into newborn rat hearts [2].

In this experiment, stem cells were harvested from mouse embryos and then prompted to become immagure heart cells [2]. These induced heart cells were then tagged with a fluorescent protein and injected into newborn, immunodeficient rats [2]. Immune deficiency was necessary in order to prevent the rats from rejecting the cells that were being introduced [2]. The cells did not appear changed after one week, but after one month they looked more like adult myocardial cells than neonatal myocardial cells [2].

Until this discovery, studies have historically proved unsuccessful when attempting to regenerate these cells in a lab setting; no matter how long the cells are left to mature, they never reach the stage of development seen in newborns [2]. Although there is no proof, many scientists have attributed this lack of growth to the artificial conditions of *in vitro* cultures [2].

To further support these initial findings, induced stem cells with arrhythmogenic right ventricular cardiomyopathy (ARVC) were then introduced into the rats [2]. Again, after allowing the cells to grow for a month in the newborn, immunodeficient rats, their myocardial cells began demonstrating ARVC properties [2]. This further suggested that lab-grown cardiomyocytes can be introduced to hearts and grown to maturity. Although we are still many years away from clinical application of these results, they do give researchers a confirmed means of growing cardiomyocytes [2]. This could allow doctors to grow their own patients' cardiac cells by inducing growth in their stem cells and then run tests and experiment with treatment sensitivities [2].

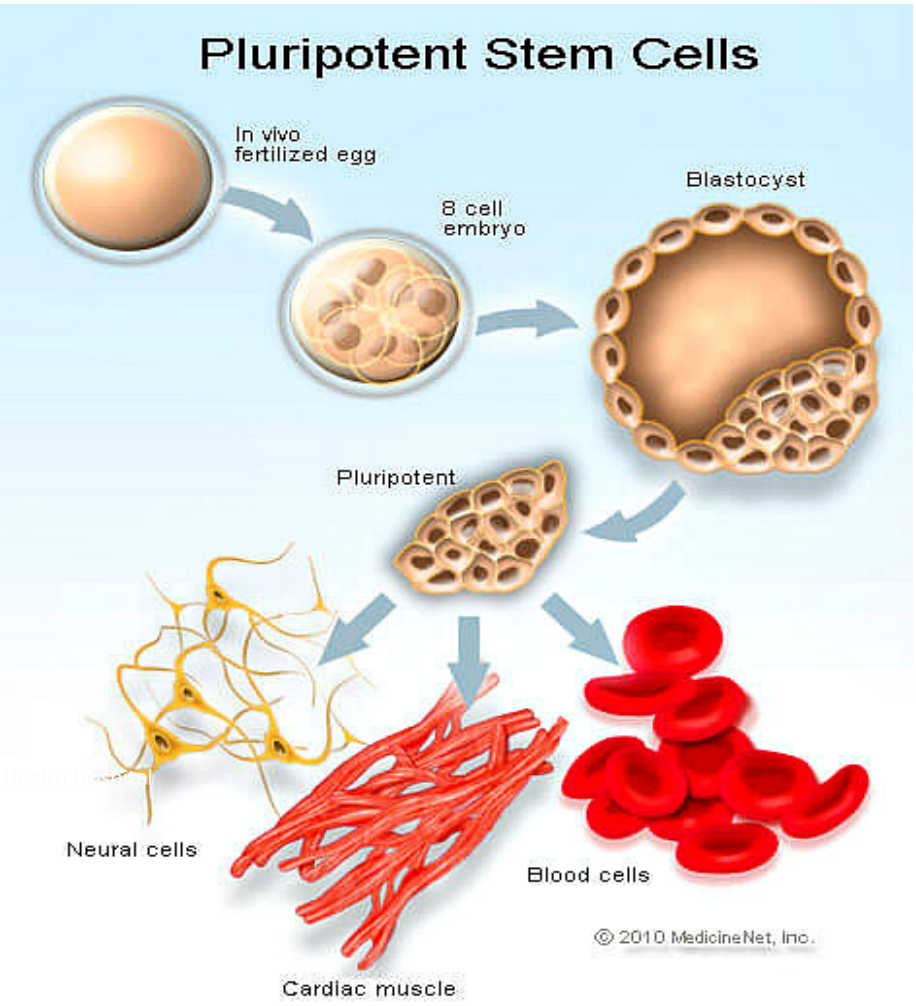
The two previously discussed studies have explained two research strategies, one that focuses on understanding what ceases proliferation, and the other that explores the possibility of lab-creating cardiomyocytes and introducing them into damaged hearts. A third method of approaching this problem is considering the signaling involved in cardiac regeneration. The protein ERBB2 is a specialized receptor that passes along growth signals to convey messages from the external environment into the cell, and it plays a large role in embryonic heart development [6]. When ERBB2 was knocked out, or made inoperative, mice had dilated cardiomyopathy, which essentially

means that their heart walls were extremely thin [6]. On the other hand, activating ERBB2 in the heart cells of adult mice dramatically increased cell proliferation, leading to an excessively large heart [6].

While this did show that too much ERBB2 could be problematic, it raised the possibility that activating the protein for just a short period of time could help with cardiomyocyte renewal following a heart attack [6]. After activating ERBB2 in mice that had recently suffered induced heart attacks, researchers saw that the hearts reverted to their original state [6]. This reversion occurs because the cardiomyocytes "dedifferentiate," or revert to an earlier form that is capable of differentiating into new cells, or regenerating [6]. Since this pathway is seen in cancer, researchers must tread lightly; they need to ensure that they boost ERBB2 levels with the correct time, place, and amount [6]. This also means that, although it could be a big step in heart disease treatment, it will likely be a long time before this can be used as a therapy in humans.

Another study looked at a different signaling pathway called the Wnt pathway. Hearts have cells called cardiac progenitor cells, which can differentiate into cells forming the three different layers of the heart. These three layers are epicardium (external, thin), myocardium (middle, thick), and endocardium (inner, thin). This process is controlled by the Wnt signaling pathway, a group of proteins that signal cell receptors. In this study, researchers discovered that if they could activate the Wnt signaling pathway, they could force cardiac progenitors to become epicardium cells instead of myocardium cells [3]. They did this by engineering cells that would express a fluorescent protein if they had differentiated into epicardium cells; once the Wnt protein was activated, the cells lit up [3]. After making this interference, researchers found that their induced epicardium cells were morphologically and functionally similar to those present in humans and grown in labs [3].

The current research surrounding cardiac regeneration is promising and exciting, but as studies continue, the more prevalent the bioethical implications of this work will become. Once studies yield more concrete and conclusive results in mice, researchers will want to shift their attention to human hearts. However, this is difficult because this research cannot be done within the confines of a lab; it requires human volunteers. This also means that there will not be a controlled environment, and unlike in drug testing, many of these therapies are irreversible and, if unsuccessful, could lead to death. The introduction of lab-created cardiomyocytes or fully grown hearts into humans will likely also give rise to objections from religious communities



rooted in the use of human stem cells-- namely the slippery slope toward the use of embryonic stem cells.

Although this work is potentially ethically controversial, it could ultimately revolutionize heart disease treatment and help overcome the problem presented by the severe organ shortage in transplantation. Heart disease is a painfully common and widespread problem that takes lives every day. The use of stem cells and regeneration is a promising and fascinating avenue to explore as a potential solution. Whether it be through cell growth, signal manipulation causing cell reversion and regeneration, or the introduction of lab-created cells, hopefully we will soon find ourselves successfully applying these techniques outside of the lab.

"Heart disease is a painfully common and widespread problem that takes lives every day. The use of stem cells and regeneration is a promising and fascinating avenue to explore as a potential solution."

Alexandra Brunjes is a freshman in Georgetown College who hails from New York City. She is currently undeclared pre-med but expects to major in Neurobiology and double minor in Creative Writing and French. She is intrigued by neurodevelopment and neurodegeneration and hopes to continue exploring these areas in the coming years. Beyond The Triple Helix, Alexandra also writes for The Guide section of The Hoya and tutors with Prison Outreach.

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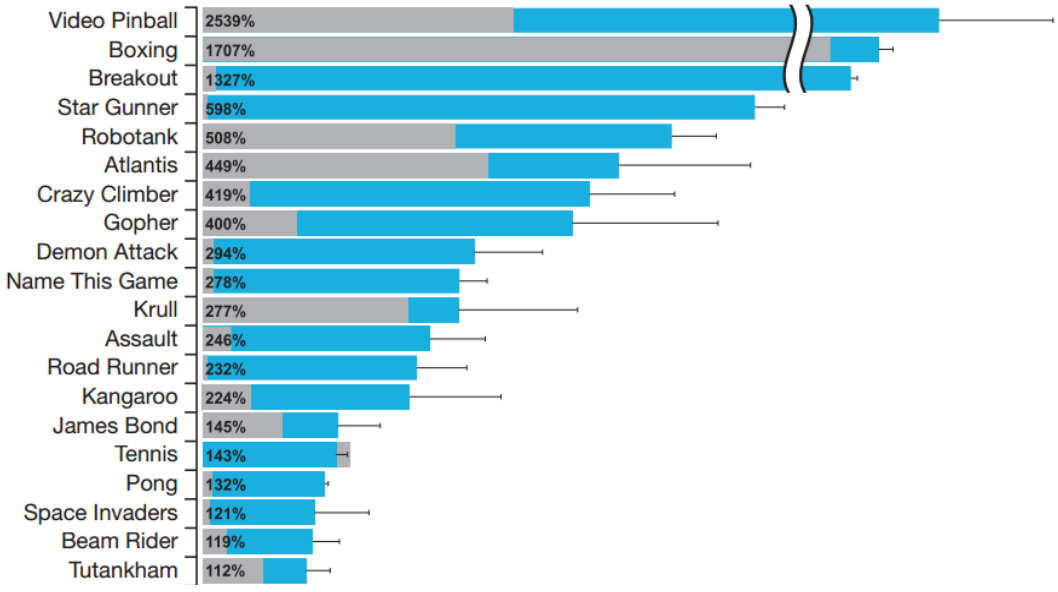
Paving the Way for a Safe Future with Artificial Intelligence

by Brendan Desimone

Artificial intelligence (AI) has drawn many computer scientists to its expanding field, but only a small sect of them have devoted their time to safety rather than technical advancement. Many in the scientific community are therefore concerned that sophisticated AI may be invented before the proper safeguards are in place to guarantee that it behaves as scientists intend, or at least in a manner that is well understood. In January 2017, notable members of this community met at the Beneficial Artificial Intelligence Conference to elaborate on what safeguards should be implemented when AI is created. The conference drafted a list of 23 principles that were determined to be integral to the safe development of AI. These 23 principles are grouped into three categories: Research Issues, Ethics and Values, and Longer-term Issues. They aim to address safety issues in crucial areas in the AI development process and guide researchers in the safest direction possible, given the possibility that AI development could lead to the creation of an entity whose intelligence vastly overshadows that of any human, a possibility of apocalyptic proportions [1].

Before discussing these principles, it is first necessary to understand the various terms surrounding the research and development of AI. Intelligence, of any sort, is a buzzword in this field. In his paper "Theory of Fluid and Crystallized Intelligence: A Critical Experiment," psychologist Raymond Cattell states that human intelligence is based on two factors: the ability to solve problems already encountered, known as crystallized intelligence, and the ability to solve problems never encountered before, which he calls fluid intelligence [2]. It must also be noted that defining and measuring intelligence are two different things. Cattell's method of defining intelligence in terms of solving different kinds of problems carries relatively well across various kinds of minds and cultures. This definition could also be applied to an artificially created program.

In the past, computer scientists developed a technique called machine learning, during which a computer program runs a type of optimization function–a program that is given a variable to maximize and the means to control inputs that affect the variable in question. Google's DeepMind DQN project, led by Volodymyr Mnih, published "Playing Atari with Deep Reinforcement Learning" (2013), which outlined how computer scientists, by simply supplying the screen view of common Atari games and scores, developed a program which was able to learn to play Atari games and was able to surpass even an expert human player [3]. The program was not told the rules of the game,



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but could only view the game's screen, the current score, and the controls. After being told to optimize the score, the machine mastered several Atari games without the intervention of programmers. Note that in the figure to the left, the games that AIs (in grey) and DQN (bue) in general performed better than humans tended to be more action oriented and lacked exploration or experimentation elements. The percentage denotes how much better the AI performed than a human.

More recently, Google's Translate team leveraged machine learning to vastly increase the effectiveness of language translations [4]. Google had employed linguists and multi-lingual dictionaries to associate words in different languages. With the help of automation and machine learning, Google was able to use the concept of neural networks to achieve a boost in quality equal to all prior updates on its Google Translate software.

The principle of neural networks relies on a large amount of interconnected programs that look for patterns in data. Machine learning allows for the neural network to learn how to detect patterns without significant intervention. This innovation is significant because, for example, finding a way for a computer to identify if a photo were of a leopard or of a lion would involve a relatively complex design. But using machine learning, we can allow a neural network to rapidly test a number of ways to differentiate leopards from lions and determine what is reliable. Fleshing those intuitions out in a program would prove technically challenging, so letting a computer do the job of detecting patterns is a necessary step in the road to AI. Detecting and organizing the world is crucial for any entity to effectively interact with the world in a way in which interactions have predictable effects.

A program that makes use of machine learning and neural networks' capabilities fulfills part of Cattell's definition of intelligence, in that it is able to solve new problems and employ its acquired knowledge to solve problems related to ones it has already solved. Crucially though, this program could not optimize wealth, even if it were given access to stock market data, a stockbroker, and a bank. This program has no self-concept, sentience, or consciousness, yet it is able to learn about a limited kind of environment and eventually control it. Keep in mind that playing arcade video games using a joystick does not compare to interacting in the many ways that humans do, but DeepMind's Atari program demonstrates a level of sophistication and flexibility that appears to be moving towards what computer scientists refer to as a general artificial intelligence.

This leads us to the "Research Issues" principles that the Beneficial AI Conference proceedings categorized in an attempt to reconcile concerns of developing AI, which could become malevolent, with the complex research process. Computer scientists want to avoid creating AI which could make the world worse off economically, legally, or socially. Hence, the first principle is: "The goal of AI research should be to create not undirected intelligence, but beneficial intelligence" [1]. This means that the base programming of an artificial intelligence must incorporate a need or desire to make the world a better place for humans.

Related to this principle are extensions pertaining to preventing outcomes that could foster the creation of a non-benevolent intelligence.

If an AI were created, the limits of its capabilities-- including its actual intelligence-- would not be easily ascertainable or controllable, unless it was designed with such a need in mind. This in an example of one of the many uncertainties which entail AI research. The most imminent danger in AI research is that the inventor does not pause to ensure that his or her concoction of code does not permit any negative societal outcomes. Scientists are trying to avoid a "Terminator" scenario where an AI may become a dangerous enemy of society. The Beneficial AI conference hopes that AI researchers develop the protocols for safely introducing AI into society before anybody gets close to solving the challenge of creating AI. AI's effects on society will depend on whether it is fundamentally benevolent or malevolent; there are legitimate economic, philosophical, and social concerns in both cases, but benevolent AI garner substantially fewer and less severe ones.

Brendan hails from Beverly, MA and intends to major in Science, Technology, and International Affairs. He is also a freestyle skiing coach.

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The Unscientific Method of Forensic Science

by Clare Foley

In an episode of CSI, forensic science is presented as simple and infallible. Viewers watch as a detective races to the laboratory with a lock of hair or smudged fingerprint found at the crime scene. After the commercial break, the white-coated hero scientist stands over a microscope, or a computer, and voila! "It's a match," the scientist declares. And with that, the bad guy is arrested, the episode ends, and the audience switches channels, confidently believing that justice has been done.


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Unfortunately, the CSI model has led the public to wrongly equate forensic science with more rigorous scientific disciplines, like medicine and chemistry. For this error, the public can be forgiven, given that the name for the application of science to civil and criminal laws —forensic science— certainly implies that the rigor of the scientific method has been used in forensic disciplines in the same way that it is used in other scientific fields. In fact, however, the adoption of the adage "science" to forensic disciplines has disguised for decades the lack of analytical foundation underlying forensic testing. This deficiency is not without serious real world consequences; according to the Innocence Project, the misapplication of forensic science is the second leading cause of wrongful convictions [1].

Forensic evidence encompasses many disparate types of examinations—fingerprints, hair, DNA, ballistics (the testing of guns and bullets), arson, and others. With the exception of DNA analysis, which was developed for and by laboratory scientists before being adopted by law enforcement agencies, most forensic disciplines were creatd by most forensic disciplines were created by police investigators and are used almost exclusively in the criminal justice system. Because of this, the methodology used by forensic scientists to reach conclusions has not been subjected to the analytical rigor required for scientific conclusions in other fields, even though forensic evidence is used to make life and death decisions. Despite this problem, judges and juries rarely question either the methods used or the conclusions reached by forensic scientists—even when the testing fails to meet widely accepted scientific standards.

Recent reports by distinguished scientific associations, such as the National Research Council of the National Academies, have at long last focused attention on the many problems inherent in forensic science. Among the many criticisms leveled at forensic disciplines, the National Research Council pointed to the use of flawed methodologies, insufficient research, unsupported conclusions, and examiner bias as major issues.

The investigation of the 2004 terrorist attack on the Madrid commuter railway system serves as a case study of the many deficiencies in forensic science that have for too long gone unnoticed. After the bombing, the Spanish police recovered fingerprints from a bag of detonators and enlisted the FBI's help to find the bomber. Using its fingerprint database, the FBI identified 20 potential matches, including the fingerprints of Brandon Mayfield, an Oregon lawyer. After a comparison and analysis by an FBI examiner, Mayfield was positively identified as the Madrid terrorist; the match was

confirmed by a second FBI examiner and a supervisor. Despite Mayfield's insistence that he was innocent, and the lack of any evidence other than the fingerprint to connect him to the Spanish bombing, he was detained and jailed as a "material witness" while the investigation continued. An independent fingerprint examiner appointed by the court also confirmed that the print belonged to Mayfield. A latent fingerprint like the one on the previous page was used to arrest Brandon Mayfield for a crime he did not commit. The Spanish police, however, announced that they had made an arrest based on their own fingerprint analysis—but their suspect was a completely different man. After reviewing the other suspect's fingerprint sample, the FBI withdrew its identification of Mayfield, and the proceedings against him were dismissed [1].

The Mayfield case clearly highlights the problems that cause analytical errors in forensic examinations, errors that often result in the wrongful convictions of innocent people. Examiner bias is one such common problem. When performing a review of the Mayfield case, the FBI found that the second examiner had been informed before his examination about the conclusion from the first test [1]. The FBI had failed to meet one of science's basic rules about the necessity of blind testing during peer review. Unfortunately, this basic flaw in scientific methodology is particularly common in forensic science because crime laboratories are usually operated and financed by police departments. Too often, examiners consider themselves to be police officers rather than independent scientists. Examiners often know incriminating facts about the suspect before the examination is completed, such as his criminal record or that a witness has made an identification of the individual whose fingerprint is being examined. Such information can easily influence testing results that are inherently subjective to begin with.

Forensic labs violate scientific standards in other ways. A core principle of scientific methodology is that the results of an experiment must be reproducible. But forensic examiners' conclusions are too often based on their own subjective judgment, and are therefore not reproducible, because the discipline has no applicable standards. This is the case with fingerprint examinations. Examiners determine a match by comparing an exemplar from a suspect with a crime scene sample, which often is only a smudged or partial print. The examiner looks for "points of agreement" between the suspect's print and the crime scene print [1]. If the examiner concludes that the two prints contain sufficient points of agreement, he declares the prints to be a match. The prints are then turned over to another examiner, who repeats the process. If that examiner also finds a match, then the match is confirmed.

But the problem with this methodology is that it is wholly dependent on the subjective judgment of each individual fingerprint examiner. American fingerprint examiners have rejected the creation of a universal standard requiring a set number of points of agreement. Rather, each examiner is left to reach a conclusion based on his own subjective confidence level. According to the National Research Council, fingerprint analysis outcomes "are not necessarily repeatable from examiner to examiner," since any one examiner can set his own definition of what constitutes a match. Thus, fingerprint testing fails any measure of scientific objectivity [1]. The lack of a standardized methodology is common to many forensic disciplines, including shoeprint analysis and ballistics

In addition to examiner bias and subjectivity, too many forensic disciplines lack even basic research supporting the fundamental premise underlying the discipline. Examiners of shoeprints, for example, claim that the prints contain individual and unique patterns that examiners can use to make scientific comparisons, similar to fingerprints. As with fingerprint testing, this method is highly dependent on the "expertise" of the examiner. Moreover, the National Research Council report was unable to find any scientific study that had proven the uniqueness of shoeprints, meaning that the entire discipline lacks a scientific basis for its fundamental claim [2].

The same problem can also be found with forensic odontology (the study of bite marks); despite the fact that experts claim that no two jaw or teeth alignments are the same, no scientific study of the population has been undertaken to prove the claim [2]. Arson testing has demonstrated the critical need for basic research into the claims made by forensic examiners. Until 1990, it was

Improvements in arson technology have led to old arson cases, like the Graf house fire pictured above, being reopened for investigation.

assumed that certain characteristics found at the scene of burned buildings—cracking of glass, certain charring patterns in wood—demonstrated that an accelerant had been used to start a fire and constituted crucial evidence in arson cases [1]. But when scientific experiments were finally conducted on the subject, the tests demonstrated that these characteristics were simply evidence of extremely hot fires. People had been imprisoned based on expert testimony that relied on unsupported and unscientific claims. Improvements in arson technology have led to old arson cases, like the Graf house fire pictured below, being reopened for investigation.

The National Research Council report defines the scientific method as a method where "hypotheses are developed, are measured against the data, and are either supported or refuted," while scientists understand the "limits of [their] knowledge" [2]. In science, weaknesses in experiments must be acknowledged and included in reports. But many forensic science disciplines do not admit the possibility of erroneous testing or conclusions. Despite being presented with the evidence of their mistake, the examiners in the Mayfield case continued to assert that their conclusions were correct and indeed tried to convince their Spanish counterparts that it was they who made the error. And even more problematically, the court system allows forensic examiners to testify as though their disciplines are infallible. Fingerprint examiners have repeatedly testified that their discipline has a zero error rate, a claim that most scientists would find incredible. DNA testing is actually one of the few branches of forensic science that was developed by scientists using the scientific method.

The lack of scrutiny of forensic science is in part caused by the fact that judges act as "gatekeepers" [2] to determine what forensic methods are sufficiently reliable to be used as evidence in court. But because judges, lawyers, and many times the expert witnesses themselves do not have scientific backgrounds, the ability of judges to accurately evaluate forensic evidence is limited.

DNA testing is one of the few branches of forensic science that was developed by scientists using the scientific method.

Many flawed disciplines, such as fingerprint analysis, are admitted as evidence in court simply because such evidence has historically always been admitted. Despite the flaws in fingerprint analysis, only one court case, Maryland v. Rose, has ever disallowed the presentation of fingerprint evidence as a scientific conclusion [3]. In that case, the court based its decision to exclude the evidence on the fact that the fingerprint examiner "was not a scientist and had no scientific training," and declared latent fingerprint testing to be a "subjective, untested, unverifiable identification procedure that purports to be infallible" [3].

The court's decision in the Rose case demonstrates the real problem with forensic science; it is afforded the credibility of science without meeting the rigorous standards of science. Without strict controls, the elimination of subjective testing, and the scientific training of all forensic examiners, forensic science is assuming a scientific reputation that is simply unearned.

Clare Foley is a sophomore in the College majoring in English.

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Running Out of Data Storage: Is DNA the Solution?

by Patrick Lim

As far as global catastrophes are concerned, the greatest threats to humanity often fly under the radar. Rather than an asteroid impact, a nuclear war, or some other cinematic apocalyptic event, the true harbingers of doom are likely already among us. Most of us are aware of global warming and climate change; the insidious increase in bacterial and viral antibiotic resistance is becoming a hot topic; even the extinction of honeybees has made its way into headlines once or twice. Even if we miraculously starve off these imminent threats, there is still a problem facing humanity in the not-so-distant future: we are running out of (digital) storage space.

Every day in 2016, Youtube published 4 million hours of video content, Twitter users posted 500 million tweets, and 6 billion searches were made on Google. As technology improves and more of the world gains access to the internet, these numbers will continue to increase at an exponential rate. Though it can be a powerful predictor of the affordability of computer technology and advancement, Moore's law (the observation that the number of transistors in a microchip doubles every two years) fails to account for the fact that there is a hard limit to the physical properties of silicon, which is used to make computer chips. Chip scientists are already toying with semi-conductors on the molecular scale, and, within the next five years, it is likely that it will be the laws of physics, not technology, that will constrain how small these chips can become [1]. In addition to the material limitation of silicon chips, manufacture will also be unable to keep up with demand. By 2040, the global requirement for memory will exceed 3 x 1024 bits (3 million, billion, billion bits). This is equivalent to 10 billion kilograms of silicon wafers, which is 100 times more than the total projected supply [2]. If we still want to use Facebook, or Youtube, or continue making Instagram posts of our food, it is vital that we explore more unconventional means to storing digital data.


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Perhaps the most intriguing of novel data storage mediums is DNA. Tried and tested through millions of years of evolution, DNA is life's information storage mechanism, and has several innate qualities that make it an ideal candidate: firstly, it is extremely dense; if we could pack information as dense as an E. coli's genome, we would need just 1kg of DNA to store all the world's data [3]. Secondly, it is more eco-friendly and efficient to store information in DNA than in traditional digital methods —computing with DNA consumes a billion times less energy than electronic computers [4]. This is particularly important as data centres currently use 1.5-2% of the global energy supply, which is estimated to grow by 12% every year [5]. Thirdly, DNA is extremely stable; under sterile, experimentally ideal conditions, DNA can potentially survive for around a million years, as researchers from ETH Zurich have established —compare that to hard drives, which routinely fail after just 50

years [6]. Furthermore, there are four possible states that a nucleotide base of DNA may take —A, T, C, and G—, allowing for two 'bits' of storage, compared with traditional binary code, written in ones and zeros, encoding a single 'bit'. This means that the theoretical maximum amount of information that can be stored in DNA is twice that of conventional methods (in reality this limit is lower, at around 1.8 bits per nucleotide due to biochemical and other practical constraints) [7].

Nevertheless, despite being an ostensibly perfect solution to the problem of data storage, it may be quite some time before we can start converting our Facebook posts and family photos into DNA. Though the cost of synthesis (writing) and sequencing (reading) of DNA has come a long way, (from more than $10 million dollars in 2008 to just $1400 in 2015 to sequence the human genome) it still may be another 50 years before DNA becomes a commercially viable alternative to silicon [8]. Moreover, storing information in DNA requires synthesis and sequencing to both encode and retrieve data, effectively meaning that data stored in DNA cannot be edited (though some researchers are working on a solution) [9]. The most recent effort to encode information into DNA was published in March 2017 by scientists at Columbia University and the New York Genome Center, who managed to store 215 petabytes (215 million gigabytes) of data into a single gram of DNA [10]—a very impressive feat compared to previous attempts. However, if we take into account synthesis and sequencing costs, it still averages to around $9000 for a measly 2 megabytes of data —hardly practical for large-scale adoption.

At least for the time being, it seems DNA would be more suitable for archival purposes, long-term storage of data that does not require frequent access or revision, like government documents, bank records, or library archives —not to mention the difficulty of transitioning to an entirely new medium of information storage. Unsurprisingly, biologists are not the only ones trying to address the data problem; engineers have proposed other promising methods, including 3D optical data storage [11], carbon nanotubes [12], and forays have even been made into storing data as quantum memory [13]. That being said, whatever ends up replacing our computer chips and hard drives in the coming decades, we can rest assured that at least our genetic information is safe from obsolescence.

Patrick is a 3rd Year Exchange student from The University of Edinburgh studying molecular genetics. He competed with his university in the 2016 iGEM (International Genetically Modified Machine) competition, developing a modular method to store information as DNA. In his spare time, Patrick enjoys singing folk songs in the shower.

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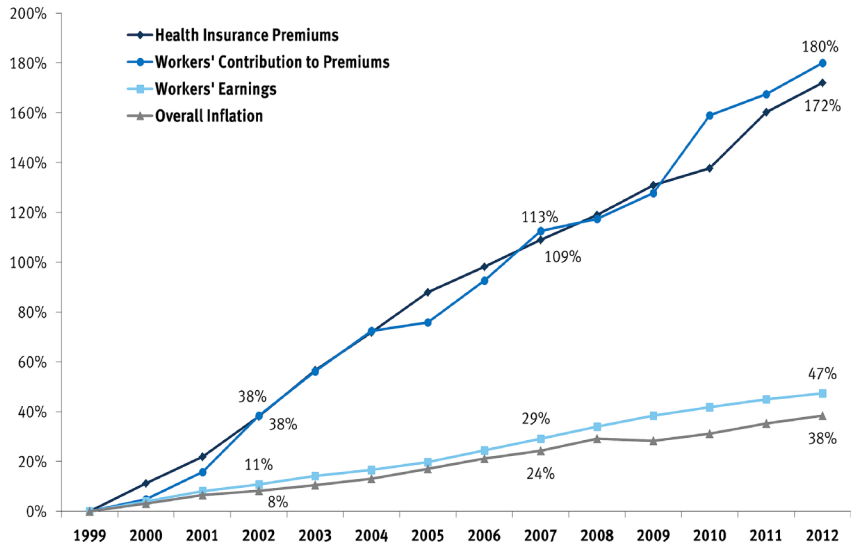
U.S. Healthcare and its Fragments

by Angela Lu

When asked about their understanding of their own health insurance, many people give vague and uncertain answers. It is widely accepted that most people are not very health literate; they do not understand their healthcare and how to make the best possible decisions when the time comes. The first basic misunderstanding to address is the nature of health "insurance." Before any government healthcare acts kicked in, health insurance stayed true to its name and only provided coverage for catastrophic incidents just like an automobile insurance would for car accidents. Other expenses were paid for by the patients as out of pocket costs, with their own money. Yet nowadays many of us have come to expect and hope that our health insurance can provide us affordable access to a variety of healthcare resources. Most importantly, the healthcare industry itself has become greatly impacted by stakeholders from various professions, making it difficult for improvements or changes to be beneficial to all the sectors involved.

Employers-sponsored insurance is common across the country and most employees share the financial burden with their employers. The employers essentially can buy health insurance plans in bulk with a negotiated (lower) price than if the employees were to buy their plans on their own individually. The reality is that the employees bare unforeseen consequences that help employers compensate for this extra cost. The chart below compares the increases in worker's contributions to employer-sponsored insurance premiums and their earnings along with the actual increases in premiums and inflation. At its core, the chart explains how the employees are indirectly baring cost through retarded wage increase. In addition, they are paying co-pays, payroll tax for Medicare, and state tax for Medicaid all out of their own pockets. As to do with American political sentiments, major tax raise is unlikely to reimburse cost – although many other developed countries charge much more tax to operate their single tax-payer or nationalized healthcare and save cost quite successfully without sacrificing care.

Cumulative Increases in Health Insurance Premiums, Workers' Contributions to Premiums, Inflation, and Workers' Earnings, 1999-2012



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The reality is that many qualities of a typical free market do not apply in the healthcare industry. First of all, supply drives demand in this industry. The more treatments, testing, and drugs that are available, the more people want and will use them. Consequently, competition does not help lower price since some people are willing to pay more to get better care. The consumers also do not have real free choices because doctors decide what we buy through prescriptions and insurers negotiate prices. In addition, with managed care, consumers are often limited in a network of doctors and providers to choose from. We end up unable to know in advance what we are paying and how much everything actually costs:

very different from regular markets. Other healthcare economics issues include: patients with low-premium high-deductible plans potentially forgoing care, loosely regulated pricing system for health resources, and older and sicker risk-pools suffering from expensive insurance rates.

In addition, we often consume unnecessary resources, such as by over-testing. For example, if a CAT scan finds a tiny cancerous tissue in someone's thyroid tissue, it is likely that he or she will seek treatment to take the tissue out just in case. Yet statistically such a procedure doesn't save as many lives as imagined: over the past two decades, the number of thyroid cancers detected and removed in the United States tripled but death rate did not reduce. Scientifically speaking those small tissues are very unlikely to evolve into real "cancer." So would the testing and the treatment just be a waste of medical resources? No one can be sure when looking at individual cases and respecting that most people want to be healthier at any given time, and that's the tough part of the debate.

Waste of over-testing can also originate from the providers in addition to the patients requesting unnecessary treatments. Many doctors perform aggressive diagnostic testing to protect themselves from potential lawsuits – so called defensive medicine. The primary challenge is that defensive medicine is difficult to define mostly because it is tough to tell if doctors are ordering tests to consciously avoid legal responsibility or to be extra careful. Other challenges including measuring the benefit or rather damage that patients receive when subjected to defensive medicine. All these uncertain factors make not just defensive medicine but also medical liability cost as a whole hard to estimate, but the chart below attempts to extrapolate the 2008 cost. The medical liability system does incur a considerable amount of cost but this cost problem is largely unbeknownst to the consumers because not everyone is impacted by a specific medical legal issue. Reform of the both cost system as well as the legal system need to happen in order to tackle this problem – an example of how the healthcare industry involves stakeholders of other professions.

Another issue of the industry is the incredibly high cost. Monopolies are becoming increasingly common as hospitals undergo both vertical and horizontal integrations. With no regulations in the private market, these big coalitions can easily raise prices to increase profits. Hospitals are incentivized to release patients sooner as the payment system pays them the same whether a Medicare patient stays five or four days, with that extra day adding costs to the hospital's bottom line. Hospitals

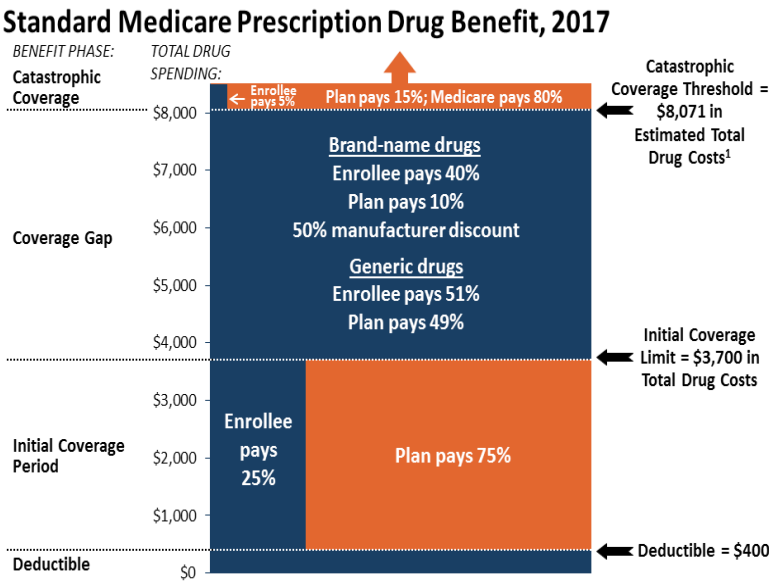

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EXHIBIT 1

Estimates Of National Costs Of The Medical Liability System

Component	Estimated cost (billions of 2008 dollars)	Quality of evidence supporting cost estimate
Indemnity payments	$5.72	Good as to the total; moderate as to the precision
Economic damages	$3.15	of the split among the components
Noneconomic damages	$2.40	
Punitive damages	$0.17	
Administrative expenses	$4.13[a]	Moderate
Plaintiff legal expenses	$2.00[a]	Good
Defendant legal expenses	$1.09	Moderate
Other overhead expenses	$3.04	Good
Defensive medicine costs	$45.59	Low
Hospital services	$38.79	
Physician/clinical services	$6.80	
Other costs		
Lost clinician work time	$0.20	Moderate
Price effects	–[b]	Low
Reputational/emotional harm	–[b]	No evidence
Total	$55.64	

Mello, *Health Affairs*

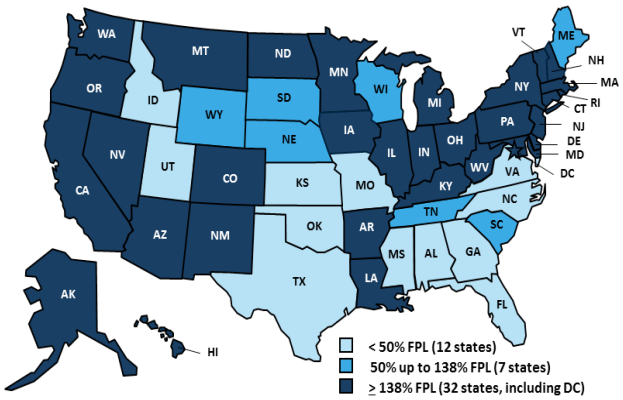
can also bill literally everything. For example, California Pacific Medical Center charges "$20 for a codeine pill (50 cents at Rite-Aid or Walgreens), $543 for a breast-pump kit ($25 online), $4,495 for a CT scan of the abdomen (about $400 at an outpatient facility nearby)."

Pharmaceutical companies, on the other hand, are heavily dependent on patents. One important factor is that the drug industry is essentially regulation-free unlike other developed countries where the government caps drug prices. The patents essentially make drug companies government-sponsored monopolies and in pressure of patent expiration they put out skyrocket high prices. Once the patents expire, generics drugs come swarming in and the financial benefit of the drug they invested millions into research and development (R&D) are now worth nothing. So to compensate for the cost of their failed drugs and keep supporting future R&Ds, prices are raised even higher. Another concerning factor is that in order to enter the market, new drugs just have to be better than placebos: positive improvement is not required. Other developed nations again do not allow sales of drugs without evidence that they provide value corresponding to their costs. As a result, many drug companies renew their drugs with expired patents with a few tweaks or different target symptoms. These drugs are either almost the same as the olds ones or just treat symptoms that clinically do not need serious medication. But they are surely potential money makers: perhaps that is why US is the one of the very few developed countries with DCT (Direct-to-Consumer) drug advertising.

"The healthcare industry itself has become greatly impacted by stakeholders from various professions, making improvements or changes difficult to be beneficial to all the

Another reason why healthcare cost is increasing is simply because the population is aging and life-expectancy years increasing. With preventive and wellness care being emphasized and practiced, people's lives are prolonged and more people are facing illnesses that are

Medicaid Income Eligibility Levels for Parents of Dependent Children, January 2017



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costlier to deal with such as chronic diseases or cancer. Long-term care for older population takes up almost one third of Medicaid expenditures. Yet the debate is ethically sensitive because the purpose of healthcare is to keep people healthy and alive. It is then difficult for lawmakers and health economists to judge how much weight cost saving should have in this conversation.

As prices for healthcare will continue to increase, health insurance models should constantly be improved and updated to help alleviate financial burden for patients. However, many fiscal obstacles still stand in the way for those insured. The coverage gap created by high deductibles for drugs especially continues to be a major problem. Many people fall in the coverage gap and most likely will not reach the coverage threshold to have insurance for most of their cost, again leading to potential bankruptcy in the worst case. It was predicted that, by 2015, almost a third of large employers will only offer high-deductible plans, up from 10 percent in 2010. There is even the risk of people forgoing care when they really need it simply because they cannot afford it.

Another important aspect to consider is the dramatic differences between all states. For example, Medicaid income eligibility varies a lot across state borders, with some higher and some lower than the Federal Poverty Line. Every state has a different condition, whether it be political, financial, or just based on population size. This results in the fifty or more individual state healthcare systems of this country. The mere demographic differences make it difficult to create large-scale reforms or monitor overall healthcare delivery. The power balance between state and federal governments continues to be the core debate

of healthcare reform (for example, the block grant component of the recently proposed American Health Care Act) and struggles to find the optimal bal ance to provide maximized care model for all citizens. No healthcare model is perfect; eventually improvements, restructuring, and reforms are needed to accommodate changes in society and science. Looking ahead, if the US government were to set its main goal as insuring the remaining uninsured, they have to understand that the process is going to be costly. The rising cost of healthcare will translate into more financial burden on the Congressional Budget, perhaps requiring the cutting of funds for other public products such as education. Cost containment from within, payment method reform, reform of providers and insurers structures, and most importantly political consensus on future progress of the US healthcare system must be addressed in order to work towards the goal of expanded coverage. US healthcare system must be addressed in order to work towards the goal of expanded coverage.

Angela Lu is a freshman in the School of Nursing and Health Studies navigating major options of Global Health and Healthcare Management and Policy and minor options of Public Health and Health Promotion and Disease Prevention. She is from Taipei, Taiwan. And when she isn't missing everything about Asia she enjoys running, cooking, and wasting hours on Youtube!

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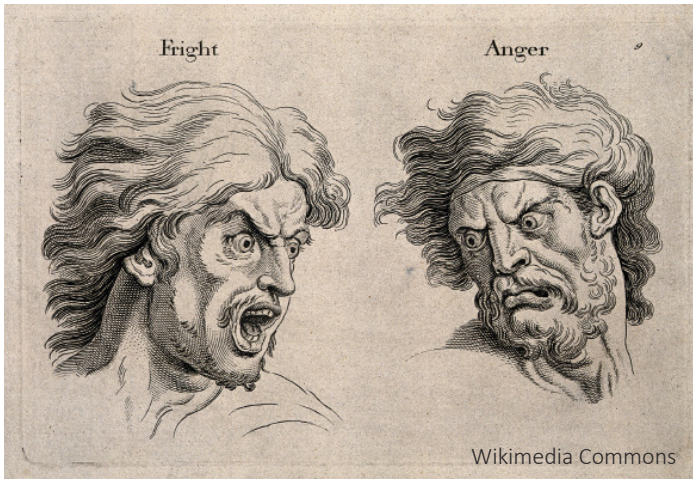
A Study in Violence: Behavioral Genetics and the New *Mens Rea*

by Amy Meng

Shortly after midnight on February 17, 1991, a young man named Stephen Mobley walked into a Domino's Pizza delivery store near Gainesville, Georgia. After robbing the store, he fatally shot the working night manager, a student from a nearby college. Found guilty of armed robbery, manslaughter, and possession of a firearm while committing a crime, Mobley was sentenced to death on February 21, 1994, as per Georgia law [1].

But there was something peculiar about this case—something that to this day continues to befuddle the world's leading geneticists and behavioral scientists. In their search for mitigating evidence, Mobley's attorneys failed to come upon any "traditional" indications; he came from a white, affluent family and had no history of abuse or trauma. Nor did he suffer from any mental disorders, his childhood psychologists confirmed. A deeper profile, however, revealed a family history blighted by generations of serious behavioral issues. Suspecting a genetic link, his legal team requested that he be permitted to undergo testing in an attempt to argue that the motive for his crime lay in his genes [1].

The Georgia Supreme Court took their request in stride — that is, denied it altogether— with the reasoning that the genetic theory involved would "not have reached a scientific state of verifiable certainty in the near future." Despite a volley of subsequent appeals, Mobley was executed by lethal injection in 2005 [1].



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The genetic link that Mobley's attorneys had sought was a mutation of the monoamine oxidase A (MAOA) gene, which encodes enzymes that break down mood-regulating neurotransmitters. One in particular is serotonin. Despite its reputation as "the happiness hormone," serotonin unfortunately does not always live up to its innocent nickname. In high levels, as experienced by people with low-functioning MAOA variants (MAOA-L), serotonin hyper-stimulates the amygdala, the brain region that regulates intense emotions of fear and aggression. MAOA-L carriers therefore have been found to have a harder time controlling anger and violent reactions -- hence MAOA's popular title, "the warrior gene"[2].

One year after Mobley v. State, the legal validity of the MAOA gene was tested again in Tennessee after a man named Bradley Waldroup shot and killed a family friend before attacking his wife with a machete. "Come tell your mama goodbye," he had told his children after dragging her into a barn. Waldroup later confessed that he had snapped in the middle of an argument and was permitted to undergo genetic testing. Sure enough, he was a MAOA-L carrier. After his legal team explained how his genes had predisposed him to violent behavior using newly published research, the jury made the landmark decision to revoke Waldroup's death penalty in favor of a 32 year prison sentence [3].

Since then, law enforcement officials have turned increasingly to geneticists to find internal triggers for violence [2]. Can a genetic catalyst explain the senseless violence of killers like Barry Kirk, who abruptly gunned down four of his neighbors one sunny afternoon, and mass shooters like Uber driver Jason Dalton, who killed six people in a roadside rampage last year? More importantly, can we prevent people from getting

hurt by identifying those prone to criminal tendencies?

The answer, of course, is much more complex than the presence of a genetic variant. As any geneticist is quick to point out, gene expression is determined by both nature and nurture— or in this case, a lack of nurture, researchers at Yale University found in a 2006 study. After following the cognitive development of 975 seven-year-old boys, they discovered that childhood maltreatment—especially physical abuse—greatly compounded the effects of MAOA-L on behavior [4]. This was true for Waldroup, who had endured a childhood of abuse and neglect [3].

"If [the brain] sees a hostile world, the only way to survive is to be hostile. If it sees a normal world, it will be normal," says James Fallon, a neuroscientist at the UC Irvine School of Medicine and himself a MAOA-L carrier. Fallon, along with other MAOA researchers, are currently working

"MAOA researchers are currently working to flesh out a more complex model of moral responsibility shaped by genetics."

to flesh out a more complex model of moral responsibility shaped by genetics. The result: a fairer and more nuanced definition of mens rea. Integrating this genetic evidence into the penal system, however, poses formidable obstacles.

One concern is that MAOA-L carriers may experience varying severities of MAOA-deficiency. "We don't know how the whole genome functions and the possible protective effects of other genes," Giuseppe Novelli, a forensic scientist and geneticist at the University Tor Vergata in Rome, told Nature News [5].

What's more, the same gene could have different effects in people of different ethnicities. Researchers at New Jersey Medical School have found that abused children without the MAOA-L variant were less likely to commit violent crimes, but only if they were white. Numerous similar studies have since shown that while tempting in its simplicity, genetic determinism broad-brushes complex interactions between genes and the environment [4].

Societal concerns also question the place of behavioral genetic evidence in the courtroom. Experts predict that an emphasis on genetic predisposition could dampen societal responsibility to solve other drivers of crime rates such as poverty, lack of education, and drug abuse [6]. Legitimizing behavioral genetic evidence would also forever transform free will as we know it, not to mention that screening individuals to separate them based on stigmatized genetic characteristics conjures not-so-subtly the ghost of eugenics.

The latter revealed itself in a 2014 study conducted at Columbia University, where participants were asked to evaluate and decide appropriate sentences for defendants whose violent crimes were the result of either impulsivity, childhood abuse, genetic predisposition, or abuse + genetic predisposition. The bewildered research team described their findings as "paradoxical"; they found that conditions of genetic predisposition and abuse + genetic predisposition resulted in the greatest fear of the defendant and led participants to impose the longest sentences. Rather than being grounds for leniency, genetic information was instead "stigmatizing" and led people to "desire a greater social distance" [7]. Judges, however, took an entirely opposite approach to the scenario. A 2012 survey of state trial court judges revealed that the vast majority believed MAOA-L to be a mitigating factor in sentencing and were willing to reduce average sentences by approximately one year [8].

This marked gap between the judiciary and the pub-

"As with the disability community, we as a society need to better understand that some people are born with the cards stacked against them in terms of adhering to social norms."

lic is, to say the least, disturbing. Whether out of self-consolation or stigma (or both), it represents our eagerness as a society to distance ourselves from criminal behavior-- so much so that we often dehumanize those most in need of empathy. Mirroring our progress with disability, we need to better understand that some people are born with the cards stacked against them in terms of adhering to behavioral norms. As neuroscientist James Fallon and many others have shown, MAOA-L carriers raised in a supportive environment are perfectly capable of living healthy, productive lives.Therefore while it is our duty as jurors to uphold the justice of our legal system, we must also build a more com

passionate community to help prevent those with genetic disadvantages from standing trial in the first place.

The question of how behavioral genetics can take root in the landscape of justice is in desperate need of an answer. We need to separate the people who must be held accountable for their crimes from those who are victims of their genes, while accounting for the social implications of this distinction. Furthermore, the challenges of linking genetic propensities to specific actions and determining the extent to which genetic predispositions form legitimate excuses remain topics of continuing (and perhaps insoluble) debate. However, the research so far has been promising. Behavioral genetics has opened a much-needed dialogue on the revision of an out-dated *mens rea*, one that will help reorient the penal system from punishment to rehabilitation- while underscoring the importance of mental health.

Amy Meng is a rising Junior in the College majoring in Biology of Global Health. She is always looking for new horror movie recommendations.

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Hope for Patients with Multiple Sclerosis

by Patrick Mulcahey

An article published in Scientific Reports in February 2017 reported on the discovery of the first blood biomarker for Multiple Sclerosis (MS). Researchers suggested that abnormalities in the kynurenine pathway (KP) of tryptophan metabolism may be associated with forms of progressive MS[1]. Accordingly, the KP metabolic signatures may be employed as effective MS subtype blood biomarkers for diagnosis, and the study reported successful MS subtype detection at sensitivities of 85 and 91%. These results may allow for the development of cost-effective, highly-accurate blood tests for MS subtype detection and diagnosis [2].

Multiple Sclerosis (MS) is a condition marked by an abnormal immune system response that attacks the body's central nervous system, comprised of the brain and spinal cord [3]. While researchers do not know the exact antigen, or biological entity, that motivates the immune response, they have described the course of the disease. After the immune response is triggered, the immune system attacks the myelin of nerve fibers. Myelin is a fatty substance that surrounds the nerve fibers and allows for nerve impulses to propagate more quickly across the neuron. Scar tissue, called sclerosis, then forms around the damaged myelin. However, because the myelin has been damaged by the body's immune system, the nervous system cannot regularly transmit impulses without distorting or interrupting them. This produces a wide variety of symptoms that affect both physical movement and cognitive ability. Currently, there are over 400,000 cases of MS in the United States and 2.5 million cases across the world[4]

> *" Currently, there are over 400,000 cases of MS in the United States and 2.5 million cases across the world."*

Additionally, it is the most widespread neurological condition in the young adult population aged 20-40.

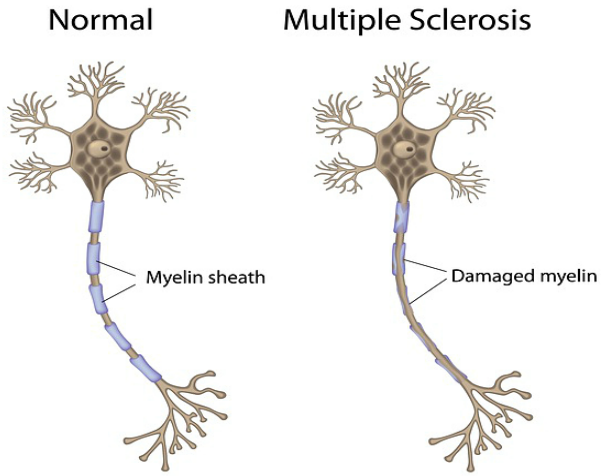
There are four primary subtypes of MS that a patient may be diagnosed with [5]. Clinically Isolated Syndrome (CIS) is a first episode of symptoms that may be caused by inflammation and demyelination of the nervous system. CIS must last for at least 24 hours, but the patient does not qualify for the diagnosis of MS because the episode is typically isolated. Relapsing-remitting MS (RRMS) is the most common course of the disease marked by distinct attacks of symptoms of MS. The attacks, called relapses, are followed by periods of apparent recovery (remission). Primary progressive MS (PPMS) is characterized by initial worsening of symptoms after initial diagnosis without any remission or recovery period. Secondary progressive MS (SPMS) initially follow the course of relapsing-remitting MS, but at some point in the course of the disease transitions to progressive MS without any periods of remission observed.

Currently, the most typical tools for MS diagnosis are medical histories, neurological exams, and blood tests [6]. When a doctor performs a medical history, she carefully gathers all information about past medical experiences that may have been caused by MS. Additionally, she may gather information about birthplace and risk factors for developing the condition, including family history of the disease. The neurological exam consists of a variety of tests examining a subject's men-

tal, emotional, and linguistic functions as well as motor functions such as sensory perception, movement, and strength. Blood tests, as they are currently used in the clinic, do not necessarily confirm a diagnosis of MS. Instead, they rule out other conditions that may cause the symptoms observed. However, after a diagnosis of MS, patients face a long wait before the subtype of the disease is determined [2]. During this period, a patient may receive ineffective medication or experience significant anxiety over his future quality of life. As reported in Scientific Reports, the recently discovered biomarker promises a relatively quick and accurate description of the MS subtype that can be applied during clinical diagnosis of subtype identity in patients of MS.

Aside from the scientific consequences of this study, this work could have significant economic repercussions for MS patients. In May 2013, a study in Medical Economics found that the cost of MS treatment ranged from approximately $8,500 to $50,000 dollars per year [7]. This cost comes primarily from expensive prescription medications. As mentioned previously, patients who are waiting for a subtype diagnosis may receive ineffective medication and squander thousands of dollars in the meantime. The identification of a blood biomarker of MS subtype offers the opportunity to eliminate the financial waste that waiting may incur, all while working to maintain the patient's quality of life.

"The identification of a blood biomarker of MS subtype offers the opportunity to eliminate the financial waste that waiting may incur, all while working to maintain the patient's quality of life."



NLM- NIH

In February 2017, the Trump Administration and the House Republicans introduced a bill that intended to repeal and replace the Affordable Care Act. While Trump's first major legislative effort failed, the actions of the administration indicate that healthcare access is vulnerable under the Republican-led government. However, the blood biomarker study presented here demonstrates an important point about federal monetary allocation. This scientific advancement will relieve some financial burden incurred due to MS treatment. Accordingly, as the government allocates money to health research, more cost-effective options for disease diagnosis and treatment will develop, driving federal healthcare costs down, all while increasing the quality of life for Americans who have medical conditions.

In short, researchers have identified a blood biomarker for subtypes of MS. This research may cut down on spending and psychological stress that a patient may experience while waiting for a subtype diagnosis. Therefore, as the Trump administration threatens to dismantle accessible healthcare for Americans, the results of this study demonstrate the utility of continual funding for scientific research, as this can lead to improved and more cost-effective approaches to treating disease.

Patrick Mulcahey is a sophomore from Newtown, Pennsylvania studying biochemistry with minors in physics and philosophy. In his spare time, he enjoys playing guitar, reading, and exploring Washington.

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"Organ"-ic Market

by Timothy Ring

If you know much about movie or television tropes, you've probably encountered this story somewhere before. A young man or woman spends a night drinking or partying and gets involved with a shady crowd. This person is then drugged, or blacks out from too much alcohol, and wakes up the next morning in a bathtub full of ice with a surgical scar on their abdomen. A kidney has been stolen from this unsuspecting individual and is now being sold on the black market for thousands of dollars. This process, known as organ trafficking, although not as cliched as the story suggests, is a thriving industry. [1] According to the United Nations Global Initiative to Fight Human Trafficking, the process of illegally selling these vital body parts often involves underpaying and exploiting impoverished people in what are known as "organ-exporting countries." These include developing countries such as Pakistan, the Philippines, and India. These harvested organs, almost always kidneys, are then sent to "organ-importing" countries such as Australia, Israel, Japan, Saudi Arabia, and the USA. [2]

Organ donation, collection, and transplantation (especially in involuntary circumstances) are processes invariably accompanied by ethical questions. Although there seem to be very few reservations with the process of transferring organs from willing donors, living or deceased, there are still plenty of controversial topics within the system itself. For instance, in China, some donated organs come from executed prisoners [3]. There are also discussions of legal organ selling on a regulated market, an ethically controversial proposition with both proponents and critics. Before the morality of organ transplant can be further discussed, the purpose and frequency of transplantation as well as the problems with the current process must be understood.

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Despite a demand for just about every part of the human body, kidneys are the most transplanted organ [4]. Each person has two kidneys, located on each side of the waist just at the bottom of the rib cage. These serve as hormone and urine producers, mineral absorbers, and blood filters that remove waste from the circulatory system [5]. Although the function of these organs is much more complex, their role in the body is not the primary concern. Rather, their availability is. While everyone possesses two kidneys, a healthy individual can live with just one. This makes them popular candidates for donation, which is fortunate as kidney failure is strikingly common. There are currently over 98,000 people on the United Network for Organ Sharing kidney transplant waitlist as of March 2017, which makes up 83% of all patients currently awaiting a transplant [6].

These statistics highlight the dreaded "waiting list" that many regard as the most daunting obstacle in organ transplantation – the average waiting period for anyone on the list is about six years [7], but can reach up to ten years [8]. The number of successful transplants is increasing every year, but it simply cannot keep pace with demand. Only 17,878 kidney and 30,969 organ transplants were completed in 2015 despite there being more than 118,000 patients still on the waiting list. While people are willing to help, the results fail to reflect public sentiment. 80% of people surveyed by the Living Kidney Donor Network responded in favor of being organ and tissue donors, but only an estimated 30-40% of Americans are designated donors in the DMV registry [8], leaving

an unsustainably wide gap between supply and demand.

The demand for donations cannot be met solely through car accidents or homicides, however. There are tens of thousands of people in need and millions of healthy kidneys eligible for donation in the U.S. alone. To serve the largest number of people, some argue that the health care system must consider alternative options that are better equipped to deal with the mounting cases. The most popular and obvious substitute for the current system is the legalization of organ trade and sale. This plan proposes that instead of having patients with time-sensitive illnesses placed on multi-year waitlists or turn to the black market and "transplant tourism," the legal donation of organs must be incentivized by payment.

Despite the organ trade being illegal in most parts of the world, some countries have instituted a legal system of trade to combat the estimated 660,000 patients in need of transplants globally [10]. The model for this system is Iran. In 1988, the country legalized living non-related donation (LNRD) of kidneys in exchange for payment from the government and free health insurance. In the first year of its establishment the number of transplants almost doubled. Since then, the promises of payment and insurance have continued to entice donors. There are still regulations in place, however. For instance, it is illegal for the medical and surgical teams involved or any 'middleman' to receive payment for a transplant [10]. Potential donors are also barred from communicating with anyone on the waitlist, preventing unethical deals or favoritism.

The success of this system is well documented. The waitlist for kidney transplants was eliminated in 1999 and has since succeeded in meeting the needs of all patients. In 2005, over 19,600 kidney transplants were performed annually in Iran – thousands more than the number of transplants completed in the US in 2015 [11]. Through payment, a country with a quarter of the population of the United States has performed more kidney transplants and eradicated waitlists. The benefits of the system are undeniable. So the question is, why aren't we doing this?


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Besides the challenges that come with overhauling the American healthcare system, the proposition of selling one's body parts raises numerous ethical questions, leaving many divided on the topic. Some argue that any change that saves lives is worth making, especially if it can benefit citizens as well as cut down on black market organ trade. Others claim that a market might jeopardize people's health and safety and only exacerbate the problem. To be fully informed on this policy, however, it is crucial that both arguments are studied.

Advocates for a legal organ market such as Sally Satel, a psychiatrist and resident scholar at the American Enterprise Institute who received a kidney, argue that "altruism is just not enough. Many people need an incentive to give" [12]. Others, such as Amy Friedman, the director of transplantation at SUNY Medical University, compare it to other existing institutions. She claims: "Compensation for the organ donor's time and risks, by providing life insurance, lifelong health insurance and even a direct monetary fee, is more appropriate than for the donation of an egg, the rental of a uterus for a surrogate pregnancy, or the participation in clinical experimentation, all of which are legal." [12] This juxtaposition between legal donation markets and the alleged illegal nature of an organ market is a compelling point. All proponents of legal trade endorse a third-party system, not a commercial marketplace such as Amazon, eBay, or even Walmart. There is no buying and selling in terms of the highest bidder receiving the prized kidney or a donor naming the price. The intended system design is one in which a person signs up to donate just as they do now, only they receive money instead of leaving empty-handed and with one less kidney.

Those against the legalization of payment for organs argue that the system is

already undermined by illegal trade, and could diminish the supply and cause safety concerns. One critic of this legal organ market is Francis Delmonico, Professor of Surgery at Harvard Medical School and an advisor on transplantation for the World Health Organization. Well versed in the surgical process as well as the current underground systems attuned to meeting organ demand, Delmonico argues that the system will do nothing to stifle the black market trade. He presents the hypothetical, although perhaps all too real scenario, "If there's a market legalized in the United States, in the global context of medical tourism, do you think that the 72-year-old patient in the list would wait for a kidney here, versus going to buy a 20-year-old kidney in Manila?" [12] He essentially frames the situation as: why buy into a new but still unpredictable organ donation system, if the fastest and most efficient way to obtain a kidney continues to be through illicit means? Delmonico presents an all or nothing approach: either make the new payment institution immediately productive so that it can outpace the black market, or don't bother with it at all. This may be a bit of an exaggeration, but given the results of the Iranian experiment, this system could potentially eradicate the waitlist and meet all immediate needs within a decade. Although most people would take professional surgery over unlicensed operations, rapid availability and time are the most alluring aspects of the black market. A new payment institution would render tourism transplantation irrelevant in only a few years.

Other doubters of payment for organs bring up economic reasons for decreasing the number of organs available. David Rothman, Professor of Social Medicine at Columbia University, asks, "If I can buy it, why should I give it?" He invokes the principles of a free, unregulated market, much like a supermarket selling organs. This freedom of purchase however, could very well lead to stockpiling and reselling organs [12]. Although the proposed organ market is designed to prevent middlemen from profiting and illicit reselling, without implementation we cannot be certain the problem will not arise. James Childress, Professor of Ethics at the University of Virginia and Chairman of the Institute of Medicine, also opposes the motion. He imagines the legal trade as a futures market, where people can sell their organs after death in exchange for a down payment. Thus, when a person dies, their organs belong to whomever supplied them the funds. He mentions his concern that the current mistrust within the donor system (there are some claims that signing a donor card means doctors don't try as hard to save your life in the event of an accident) could be amplified as people essentially have monetary values associated with their deaths [12]. This could produce a new black market, one of cashing in futures investments early.

"*Although most people would take professional surgery over unlicensed operations, rapid availability and time are the most alluring aspects of the black market.*"

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Regardless of what critics or adherents say of this proposition, the fact remains that something must be done. Organ donations do not meet the current demands and as a result, people die waiting for the chance at surgery. The legalization of a controlled organ market presents the possibility to eliminate illicit organ trade and harvesting, reduce wait times, and benefit donors in a way not currently seen. Personally, I believe the system of payment for organs has real positive potential, but could easily be mismanaged and lead down a slippery ethical slope. There is promise in this "organ-ic" market, but will the United States and countries around the world capitalize on the opportunity it presents?

Timothy Ring is a freshman in Georgetown College majoring in Biology on a pre-med track. Hailing from New Jersey, his interests have long included topics in biology ranging from anatomy to the implementation of health care and scientific policy.

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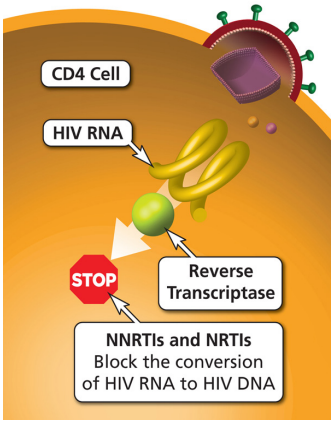
DC or Diseased: HIV in the U.S. Capital

by Jinia Sarkar

As the capital of a major world power, Washington, D.C serves as the national and global center for policy creation. One would reasonably assume that the President's home is the cross-section of American patriotism and international influence. With this arrives the natural inclination for the United States' capital to represent the best of the nation with a location that is filled with safe, happy, and healthy citizens. Below the surface, however, lies an epidemic that sweeps across the region.

According to the World Health Organization, any disease that affects over 1% of the population is considered an epidemic. Approximately 3% of D.C's population is affected by HIV, a percentage that is close to entire nations with fewer resources and fully developed infrastructure. Policymakers must take action in order to end the HIV epidemic throughout the world.

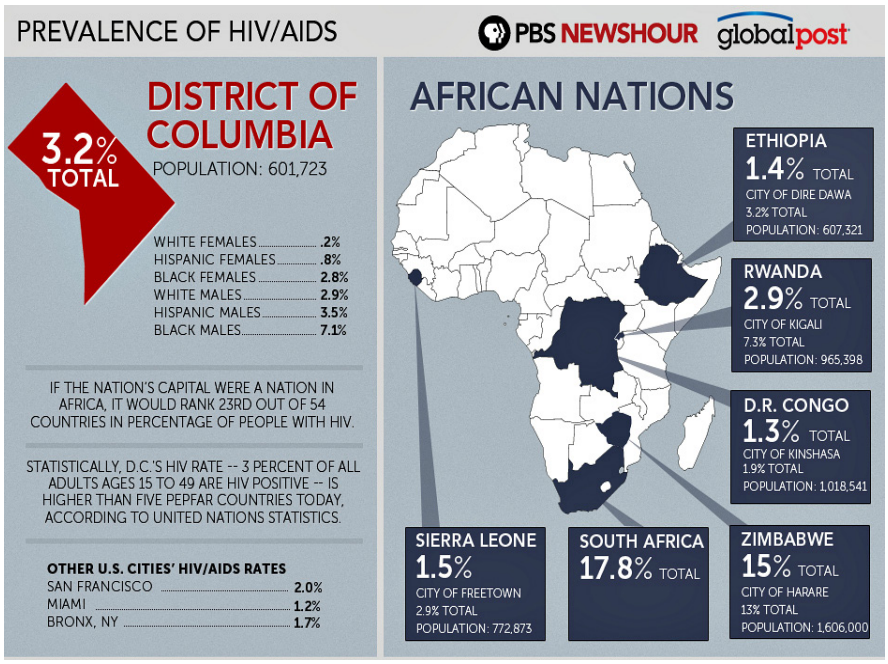
D.C's recorded rate of HIV can be attributed to two main factors: the data set present and the high proportion of residents at risk. The total population of D.C citizens is less than 700,000, leading to a sample size smaller than that of other prominent cities and skewing the data values received [1]. Further, D.C is known to have a large population living in poverty. Coupled with homosexual and heterosexual relationships, as well as drug user injection, an environment of decreased prevention and health care providers arises [2].



AIDSInfo - NIH

The District of Columbia has a specific plan, dubbed "90-90-90-50". By the year 2020, the goal is to decrease new diagnoses by 50%, while 90% of the individuals who are living with the virus will both know their status and receive appropriate treatment to reach viral load suppression [3]. Such a plan requires uniting community healthcare providers as well as promoting peer education. Some believe that Pre-Exposure Propylaxis (PrEP) could play a vital role in achieving this overall mission. PrEP is a daily medication that reduces the risk of contracting HIV up to 90% by acting as an inhibitor for HIV-1 reverse transcriptase. In order to properly utilize PrEP, we must understand the epidemic through a biological and public health lens.

Needle sharing and lack of condom usage contribute to the rates of HIV seen in D.C. The virus spreads via contact of bodily fluids, then decreases the number of CD4 cells, which are lymphocytes that activate a body's immune response, present in an individual's immune system. When HIV enters the bloodstream, the virus binds to two cell surface receptors. This causes a release of viral components into the cell, making the virus easily replicable via conversion of RNA into DNA, a process otherwise known as re-



PBS Newshour

verse transcription [4]. The completion of a viral DNA strand causes the DNA to enter into the nucleus of the cell, where proteins of the cell act to follow the instructions of DNA. The cell releases more viral components to other immune cells, increasing the body's vulnerability to other diseases.

Nowadays, HIV may be treated through antiretroviral therapies, such as PrEP for individuals who are HIV negative and at risk as well as Post-Exposure Propylaxis for individuals who are HIV positive [5]. The drugs either stop the virus from entering the body cells or contain non-nucleotide reverse transcriptase inhibitors that block HIV from reverse transcription. Some concern has arisen regarding HIV resistance to these drugs, but this may be tracked through genetic testing or HIV RNA levels [6]. The therapy itself has been proven to work in almost all cases, even if medication dosage may need to be altered to suit each individual. The main problem lies in the general stigma around medication and prevention.

Research focusing on the willingness of injecting drug usersto take PrEP consistently has found that most individuals would be willing to use PrEP if it were available to them easily without cost. 13% of individuals sampled agreed to use condoms during sex or clean injection equipment after understanding the potential for the spread of HIV, implying further education is necessary in the DC general public. Further dissemination of knowledge and access to PrEP can reap public health benefits in high-risk populations [7]. Further, in a gender study, women were found to be at greater risk for contracting HIV through sexual partners and needle sharing. Needle exchange programs are an important method in HIV prevention catered towards younger drug users. Injection and intimate behaviors, amongst other psychosocial issues, differed significantly between the two genders, calling for the presence of specific prevention strategies depending on the subset of the population [8]. In order for D.C to conquer the epidemic, more research must be conducted concerning at-risk individuals.

Many studies have documented the decline of HIV incidence in patients with access to antiretroviral therapies. Most of the problem lies in the individuals who are unaware of their HIV status and are uneducated about risky behavior [9]. As the scientific community uncovers more information, it is crucial for DC legislators to take action on this community health issue.

The 90-90-90-50 shows that DC is moving forward. This is in conjunction to the National HIV Strategy, which strives to continue widespread HIV testing, end stigma against HIV, strengthen each stage of the HIV care continuum, and expand prevention and treatment services. Major milestones have been reached in federal actionables, even if the White House has not addressed this prevalent issue in its own neighbourhood. The U.S President's Emergency Plan for AIDS Relief (PEPFAR) was a historic agreement to alleviate suffering of HIV/AIDS around the world through partnership of donor and sponsor nations [10]. Although this has proven to be successful, many of these policies and strategies must work in tandem in order to handle the epidemic. in the best way possible Until then, HIV will continue to be one of the world's most serious health challenges.

Jinia Sarkar is a freshman Human Science major at Georgetown's School of Nursing and Health Studies. She is from Ellicott City, Maryland. Aside from exploring her interest in HIV/AIDS research and policy creation, she enjoys tutoring local high school students and learning about international relations.

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