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Dr. Donna Strickland recently won the 2018 Nobel Prize in Physics for having developed chirped pulse amplification, which ultimately led to one of the most powerful ultra-short laser pulses created to date (McBride, 2018). Strickland was awarded this prize for the work she had completed in 1985, alongside Gérard Mourou, who was supervising the completion of her doctorate degree at the time. Mourou went on to join Strickland in the reception of this monumental prize. Essentially, chirped pulse amplification meant that the laser amplifier did not get destroyed in this high powered emission which was revolutionary at the time and is now consistently being used in modern medicine. Her laser technique can be found in corrective eye surgery and other medical techniques, alike (McBride, 2018).

However, what is astonishing about Donna Strickland’s win is that she is only the third woman to ever be awarded a Nobel Prize in Physics (Gibney, 2018). That said, while she is being celebrated for her groundbreaking work in this domain, she is also being recognized for not being a man. While there is no shortage of women doing monumental work in science, there sadly happens to be lack of representation and thus lack of recognition. Now, not only is Strickland getting immense recognition for her work as a physicist, she is also being recognized for the fact that she is a woman who happened to do such phenomenal work. Hence, while she is being interviewed for her Nobel Prize collection, she is also having to address her gender: an obstacle male physicists have never had to face. Strickland is consistently having to take time away from explaining all the strenuous work and dedication she put into engineering chirped pulse amplification (as would any scientist who went on to win a Nobel Prize) in order to explain her hard work from the perspective of a ‘woman in science’.

Thus, I ask that we please consider the fact that women who are recognized for their science contributions are being forced to address matters that are besides the fact. We must stop being shocked by a female scientist’s success, and start seeing it as a norm as we do for successful male scientists. Hence, Dr Donna Strickland, is a scientist, not a ‘woman in science’ and what we must address is her groundbreaking work in the field of physics, her lectures at the University of Waterloo and her Nobel Prize, not her lack of a Y chromosome.

Image Source: CBC News
The UK rock band, Arctic Monkeys, released an album in 2018 called Tranquility Base Hotel and Casino with a concept album about a hotel on the moon. A well-received album, it was hailed for its sharp social commentary and a retro-futurist sound (Monroe, 2018). While many have enjoyed listening to the album for these reasons, it also makes one think about the future of space exploration. Will we really have a hotel on the moon someday soon or is that farfetched? Perhaps a Yelp review might read: “View was excellent, but Lifetime wasn’t available on cable. 3/5 stars.” Thanks to some visionaries, namely Elon Musk, this might become a reality sooner than we might think.

Yuri Gagarin was launched into space in April 1961 becoming the first human ever to enter outer space. The completion of this revolutionary journey fascinated the general public. However, not everyone wants to complete the years of rigorous training usually required for the average astronaut. Here is where the idea of space tourism comes into play. Space tourism has existed since 2001, thanks to a company called Space Adventures. Space Adventures brokered the very first tourist trip into space in April 2001 when Dennis Tito flew to the International Space Station (ISS) with the Russian Space Agency; this was almost exactly 40 years after Yuri’s monumental first flight (“First Space Tourist Dennis Tito to Make Business Visit to Russia”, 2004). He spent seven days on the space station— all for the low price of $20 million (“Profile: Tito the Spaceman”, 2001). One would be hard pressed to find a hotel on Earth with that kind of rate. This price later ballooned to a total of $40 million in 2008 and 2009 (Schneider, 2007). To enable these missions, the Russian Space Agency had been using its Soyuz capsule to ferry tourists to the ISS with its astronaut crew. With the retirement of the Space Shuttle program in 2011, the Soyuz was now the only launch vehicle available to send a crew to the ISS. Russia could no longer accept tourists aboard the Soyuz, so the tourist visits to space were abandoned (Solovyov, 2010). But rather than reinvigorate tourism back into low earth orbit, famous entrepreneur Elon Musk has bigger plans— to send intrepid tourists all the way to the moon.

Planned for 2023, the proposed trip was announced by Elon Musk at an event at the SpaceX headquarters in California on the 18th of September, 2018. Using the SpaceX launch vehicle known as the Big Falcon Rocket (recently renamed to Starship), the travellers would be launched on a trip which would take them in a loop around the moon and back. While not quite as impressive as a moon landing, if successful, this would be the closest any human has been to the moon in 51 years. Who would this very lucky human be? The answer is Yusaku Maezawa, a Japanese billionaire, who is perhaps more wealthy than he is lucky considering the price tag that comes with being a space tourist. While no price tag has been revealed for this trip, Yusaku did spend $110.5 million at an auction for a painting in 2017. This suggests that a price tag probably does not matter much to Yusaku (“Elon Musk Unveils First Tourist for SpaceX ‘Moon loop’”, 2018). Six to eight artists are to accompany him on the trip in order to create works of art which “…will inspire the dreamer within all of us” (“Elon Musk Unveils First Tourist for SpaceX ‘Moon loop’”, 2018, para. 9)

Much work remains to be done before 2023. Musk has had a history of being optimistic; this is something he even admits to. However, orbital testing of the rocket is not slated to begin until 2020 (Williams, 2018). Still, tangible work is being done towards future space tourism and a return to deep space travel for humanity. If this launch is successful, billions are sure to be inspired and captivated. This mission could serve as the catalyst for an explosion of modern space tourism. Maybe a hotel on the moon is not as far off as we think.
A DISCOVERY OUT OF THIS WORLD

Emil Al-Kadi, 4th Year BIM

For centuries, physicists have been puzzled by a burning question: “What is light?” Initially, light was defined as a wave. However, recent discoveries concluded that light can also behave as a particle. This paradoxical notion led to the birth of quantum mechanics. But what exactly is quantum mechanics? In short, it is the branch of mechanics dealing with the behaviour of atoms and electrons (Coolman, 2014).

In order to further understand quantum mechanics and its contribution to a discovery of astronomical proportions, we must revisit the all-too-familiar Rutherford-Bohr atomic model. This planetary model depicts the atom as a positively-charged nucleus that is orbited by negatively-charged electrons at different distances (Helmenstein, 2018). Electrons can move from one orbit to another if enough energy is supplied to make up the difference between the two energy levels (Ghose, Milosevic-Zdjelar, & Read, 2015). One way for an atom to receive this energy is through the absorption of a photon of electromagnetic radiation. If the energy of a photon corresponds to the energy difference between two orbits, the electron will move from one energy state to the next (Drukarev, Mikhailov, Mikhaylov, & Scheid, 2007). This phenomenon is referred to as a quantum leap. Once energy is stored within an excited electron, it is almost instantly released as a photon.

To comprehend the nature of these quantum leaps, we must understand the behaviour of a photon’s interaction with an atom. First, it is important to note that the energy of a photon is dependant and inversely proportional to its wavelength. Thus, a photon consisting of a short wavelength contains relatively high energy and vice-versa. Second, each atom has its unique set of energy levels and therefore can only absorb and emit a photon of a specific wavelength (Ghose et al., 2015). Consequently, the atoms that compose a gas can be identified by analysing absorbed or emitted photons of specific wavelengths, known as spectral lines.

We can now make use of this knowledge to study the composition of any gas. First, however, we must understand how to analyze a spectrum. A continuous spectrum can be visualized through an apparatus called a spectrograph, which is attached to a telescope. As the telescope is directed towards a star emitting electromagnetic radiation photons, dark absorption lines are formed in the spectrum as gases in the atmosphere of the star take in their respective wavelengths (Ghose et al., 2015). This absorption spectrum phenomenon is described through Kirchhoff’s third law of spectroscopy. It was in this very fashion that the element of helium was identified within the Sun’s atmosphere, even before it was found on Earth. In fact, the name helium originates from the Greek word helios, meaning “sun” (Royal Society of Chemistry, 2018).

We currently know that hydrogen represents 91 percent of the Sun’s composition (NASA, 2018). However, the hydrogen lines in its spectrum appear to be only moderately strong compared to the spectral lines of numerous other elements that represent a mere 0.1 percent of the Sun’s composition. How is this possible? Is this a flaw in quantum mechanics? Not quite. According to a 2015 article by Williams for APS News, this paradox was first encountered by Dr. Cecilia Payne-Gaposchkin in 1925. Although initially doubtful of her findings, she resolved this contradiction as she was the first to understand the effects of temperature on spectral lines. She recognized that the absence of spectral lines characterizing a certain element does not indicate the absence of that very element. Instead, her observations can be attributed to the temperature of the Sun’s photosphere. Surprisingly, it turns out that the Sun’s 4500-6000 Kelvin temperature is far too cool to emit strong hydrogen lines. However, other atoms can be excited more easily at these temperatures and thus create stronger spectral lines (Ghose et al., 2015). As a result, Dr. Payne-Gaposchkin was able to demonstrate that the Sun and other stars are mostly made of hydrogen, despite their contradictory weak spectral lines. In fact, her 1925 Ph.D. thesis entitled “Stellar Atmospheres” has been called, in the words of astronomer Otto Struve, the “most brilliant […] in the history of astronomy” (Williams, 2015, para. 1).
This holiday season, give the gift of self-discovery! AncestryDNA, 23andMe, and FamilyTree DNA are all companies that have based their success off helping you find out more about who you are. Considering that more than 12 million people have purchased a direct-to-consumer (DTC) genetic testing kit since 2013 (Regalado, 2018), the human genome has never been more marketable than it is now. But what happens after you have found out that your family hails from some distant part of the world or that you are not who you thought you were? All of that information is still kept somewhere, within databases that store genetic data on millions and millions of people. This begs the question of privacy. Sure, that string of nucleotide bases might not mean anything to you, but with just a little bit of analysis, it could mean a lot to someone else. Third-party websites, such as GEDmatch, have made it extremely easy for participants to upload their indecipherable genetic data and use it to find relatives or shared ancestors. Now, not only do you know a lot more about yourself, but you have access to deeply personal information about someone else.

The branches of family trees often intertwine. This linking of branches means that even if you yourself have not submitted DNA for DTC genetic testing, chances are someone related to you has. In a study published in Science, Yaniv Erlich and his team at Columbia University estimate that roughly 60% of Americans with European backgrounds can be identified through a third-cousin or closer match using these consumer genomics databases (2018). “The takeaway is it doesn’t matter if you’ve been tested or not tested. You can be identified because the databases already cover such large fractions of the US, at least for European ancestry,” says Erlich (Molteni, 2018, para. 4).

On the one hand, this wide reach could have important implications for law enforcement. The database used in forensics testing analyzes a genetic feature known as variable number tandem repeats (VNTR), which act as genetic fingerprints (Nature Education, n.d.), while consumer recreational testing sequences the person’s entire genetic code (Molteni, 2018). This alternative has already proven its merit this year by identifying the Golden State Killer, who had evaded authorities since 1974 (Jouvenal, 2018). Furthermore, the makeup of these recreational genetic databases is much more skewed towards white individuals of European descent, in stark contrast to the racial disparity observed in criminal forensic databases (Erlich, Shor, Pe’er, & Carmi, 2018).

On the other hand, computational biologists such as Yaniv Erlich have already shown how easy it is to identify people based on DNA they contributed anonymously to a study. According to Erlich, a genetic database only needs to have DNA for two percent of an ethnic population to be able to identify anybody within that population. Once a DNA match is made between a sample and some of their closest relatives listed in the database, public records, sex, and year of birth can narrow that search down to just one or two individuals (Erlich, 2018). The privacy of a person’s genetic information used for research, despite the safeguards put up by researchers, can be invaded using easily accessible programs.

Of course, like many arguments concerning privacy, if you have nothing to hide, you have nothing to fear, as they say. But what about the genetic basis of certain diseases? Insurance companies have long fought for access to that information, citing those who might try to deceive insurers as a valid concern (Pearson, 2016). In the face of this dispute, Canada passed a law in 2017 making it illegal for companies to require the results of a genetic test, titled the Genetic Non-Discrimination Act (Weikle, 2018). As for the safeguarding of genetic information obtained by DTC kits, according to Hank Greely, a law professor specializing in the legal implications of biotechnology, that is a caveat we have to be willing to accept if we want to participate. “Anonymity is a myth if you’ve got richly detailed genetic information and access to a variety of databases,” says Greenly (Miller, 2013, para. 9).

Ultimately, it is up to us to determine how much we want to know about ourselves, and how much we want others to know about us.
Investigating the Connections Between the CCR5-delta 32 Mutation and Historical Outbreaks of Disease

Hailey McTaggart, 3rd Year BPS

One of the most fascinating powers the study of genetics has allowed scientists to harness is the ability to trace how traumatic outbreaks of illnesses experienced by our ancestors have contributed to our genetic make-up and the unique ways our bodies manage disease in modern times. Several of the genetic mutations that can be found in populations around the world today serve as both defenders of our health and as relics of events that changed genetic history forever. Among these is the CCR5-delta 32 genetic mutation. Discovered in the mid-1990’s (Cohn & Weaver, 2006), the CCR5-delta 32 allele allows its homozygous possessors virtually complete resistance to HIV, while heterozygous individuals infected with HIV experience a delayed onset of AIDS (Stephens et al., 1998). The origins of this extraordinary gene have been of interest to the scientific community for decades. Scientists’ investigations into what triggered its presence in certain populations are models through which the important role past outbreaks play on our modern genetic makeup may be demonstrated.

Shortly after its discovery, researchers used coalescence theory to determine that CCR5-delta 32 appeared 700 years ago, around the time that the Black Death devastated European populations (Nicholson, 2001). This detail became more intriguing as subsequent studies on the modern geographic distribution of the gene were performed. A review published in 2006 by Cohn and Weaver states that the allele “shows strong geographical traits” (p.497). They estimate that as much as 14% to 18% of northern populations of Eurasia are carriers of the mutation, while the frequency of the allele in non-Eurasian populations are comparatively very low. Findings such as these encouraged theories that the mutation became comparably prominent in European populations as a result of the Black Death (Nicholson, 2001).

However, doubt surrounding this theory soon arose. Stephens et al. (1998), prominent researchers behind this theory, believed that the bacillus of the Black Plague was Yersinia pestis. Cohn and Weaver (2006) would later argue that plagues that matched the symptoms of Yersinia pestis also wreaked havoc during the fourteenth, nineteenth, and twentieth centuries in India. In addition, doctors reported plagues spreading from rats to humans in China during the eighteenth and early nineteenth centuries. However, as Cohn and Weaver point out, the modern-day populations inhabiting Asian regions show extremely low frequencies for the mutation’s allele. For example, 0% of Chinese descendants proved to be carriers (Cohn & Weaver, 2006).

Other theories focus less on pandemics and more on recurring epidemics throughout time. In a study that compares the episodic selection associated with the Black Plague to the continuous selection caused by several smallpox epidemics, Galvani and Slatkin (2003) propose a model that indicates that the Black Death (also referred to as bubonic plague by the authors) could not have provided the adequate selective pressures that would have been required to produce the allele frequencies seen in modern times. They argue that not enough Europeans of high reproductive potential were killed by this plague and that their “results suggest that plague could not even have driven the resistance allele to 1% during the period that it existed in Europe” (Galvani & Slatkin, 2003, p.15277). Alternately, Galvani and Slatkin have proposed that smallpox has claimed the lives of more people over time than bubonic plague, and that the majority of the victims were young, removing greater reproductive potential. In addition, they explain that the frequency of the allele is most prevalent in Scandinavian countries, which have a history of suffering several intense smallpox epidemics. Finally, Galvani and Slatkin assert that, unlike with Yersinia pestis, HIV shares similarities with poxviruses such as the entrance of leukocytes through chemokine receptors and the association of virally infected leukocytes with defective cellular immunity. Therefore, it is possible that the allele has allowed carriers to resist smallpox and HIV (Galvani & Slatkin, 2003).

Research done into the identity of the CCR5 delta-32 mutation is as valuable today as it was when it was first performed. Scientists are now in the process of using this knowledge to revolutionize gene therapy in relation to HIV (Cornu, Mussolino, Bloom, & Cathomen, 2015). Indeed, examining past epidemics and pandemics may prove to help patients in the future.
A prehistoric rainbow of possibilities

Alysha Riquier, 2nd Year BIO

Bird eggs come in so much variety. You can find different sized eggs and colorful ones. From the tiny, pale hummingbird eggs, to the large, deep green-black emu eggs, eggs have fascinated scientists for years. Yet, birds do not lay colored eggs for looks only. Egg colour serves many ecological purposes, such as post-mating signaling and camouflage (Wiemann et al., 2017). This makes egg colour a much more interesting object of research. A study has shown that colours and markings might have been an evolution trait present 150 million years ago, when dinosaurs walked on Earth. Until this finding, experts thought colored eggs evolved more recently and that the earliest birds laid white eggs in the same way crocodiles do (Pickrell, 2018).

To begin, it is the study of molecular biologist Jasmina Wiemann that showed evidence of dinosaur egg coloration of an oviraptorosaur dating 70 million years ago called Heyuannia. Two pigments were detected using a chemical analysis: biliverdin, the pigment responsible for blue-green eggs, and protoporphyrin, the pigment responsible for red-brown eggs (Pickrell, 2018). Using another method called Raman microspectroscopy, a method which does not require destruction of fossils, the "team found fossil eggs of many colors and speckling patterns" (Pickrell, 2018, para. 5). They discovered that a relative of the Velociraptor, Deinonychus, laid blue-green colored eggs. They also discovered that Troodontids, a carnivore, had eggshells of the colors blue-green, beige or white and the eggshells of Heyuannia were found to be deep blue-green (Pickrell, 2018).

The fact that these pigments were found in many close relatives to birds, colored eggs evolved long before modern birds, which means more than 150 million years ago (Pickrell, 2018). Wiemann says that tinted eggshells probably helped with egg camouflage from predators, as seen in modern birds. Therefore, it is possible that eggs got their pigments from when dinosaurs switched from burying their eggs to building open nests. Speckled eggshells might have been useful for parents to distinguish their own eggs from other nest parasite dinosaurs. As for species that lay white eggs today, such as ostriches, parrots, and some domestic chickens, it is possible they lost the trait of getting colored eggs through evolution. For these different reasons, Wiemann and her team were able to give evidence that dinosaurs were not the "reptilian-style breeders that dumped their eggs and left" (Pickrell, 2018, para. 8). Some possibly gave advanced parental care. This can be supported by the fact that egg coloring in modern birds is associated with complex nesting behavior.

As for several herbivorous, such as long-necked sauropods and the Maiasaura, no hint of pigment was detected in their eggshells. This suggests that these species, which are on more distant branches of the dinosaur family tree, laid white eggs and they were most likely buried in the ground in the same way modern turtles bury theirs. Another paleobiologist, David Varrichio, states that others will most likely want to investigate this test's veracity since it is a new method, but that does not take away his awe in the subject. Wiemann has planned to increase the dinosaur sample size in future studies, having as a goal to discover where and when colored eggshells first evolved within the carnivorous theropod group of dinosaurs and what color came first (Pickrell, 2018).

The advances being made in the field of paleontology is unbelievable. Not only can we produce models demonstrating what dinosaurs possibly looked like, but we can now learn what nesting habits they might have had thanks to eggshell color. What will be discovered next? For all future paleontologists, with scientific methods getting even more sophisticated and advanced, Wiemann says that "it’s an amazing time to be a paleontologist" (Pickrell, 2018, para. 11)!
Cure for Sickle-Cell Anemia

This year, a woman in Alberta is among the first in Canada to be cured of sickle-cell anemia as an adult. Revée Agyepong was born with sickle-cell anemia, a genetic disease that alters the shape of red blood cells. 2 Years ago, Alberta Children’s Hospital started treating pediatric patients with stem cell transplants. Recently, they started expanding treatments to adults. The procedure requires the patient to undergo a dose of radiation to eliminate their native blood-producing stem cells in bone marrow. They will then receive a bone marrow transplant from a healthy donor. The donor and patient must be matched based on their human leukocyte antigen tissue type. Luckily for Revée, her sister was a 100% match. Her sister’s bone marrow has taken over production of red blood cells and now Revée has almost zero sickle cell hemoglobin.

Generative Adversarial Networks (GAN): NVIDIA’s hyper-realistic face generator

GANs are derived from unsupervised machine learning algorithms and can be used to generate novel images by casting two deep learning networks against each other. The first network - the generator - attempts to produce counterfeit copies of real human-created images, and the second network - the discriminator - attempts to distinguish these forgeries. Both networks are stressed against each other over time, with the generator producing higher quality counterfeits to outplay the always-improving performance of the discriminator.

Nvidia proposes the “style transfer technique”, which is a system that can learn and classify different aspects of an image: resulting in better control over facial features, as previous efforts in GANs often produced unpredictable outcomes.
On August 22, the discovery of the 90,000 year old remains of a half-Denisovan, half-Neanderthal woman was published in *Nature* magazine. The bone fragment of “Denny”, as researchers have nicknamed her, was found in a Siberian cave and subjected to genome sequencing. By comparing its DNA to that of a modern-day human, a Neanderthal, and a Denisovan, scientists were able to determine that the specimen contained an equal amount of both Neanderthal and Denisovan DNA. As the first specimen to be found of a first-generation progeny from two different human groups, this finding is significant to our understanding of ancient humans and how they have contributed to our genetic make-up.

Archaeologists find the world’s oldest drawing
A stone has been discovered in South Africa by an international team of archaeologists and they’re claiming that it could be the earliest known drawing in history. The archaeologists found a smooth flake of silcrete that is covered in scratch-like markings made with ochre. It seems like seventy-three thousand years ago, an early Homo sapiens picked up a piece of ochre and used it to scratch a hashtag-like mark onto a piece of stone. Lots of questions emerge from the symbol whether it was deliberate or meant to portray something particular but without a time machine, we’ll never know according to Conkey.

Our solar system may be special!
Dr. Lauren Weiss and her California Kepler Survey team use the W. M. Keck Observatory to analyze 909 planets belonging to 355 multi-planet systems, located 1000 to 4000 light-years away from Earth. They find that planets orbiting the same star have similar sizes and orbital spacing, just like peas in a pod. Planets of our solar system, however, are of diverse sizes and have surprisingly large spacing. These findings suggest that our solar system could have a distinct formation history.

Discovery of the Hiawatha crater
In November, aircraft radar revealed the Hiawatha crater in northwestern Greenland that was hidden under a kilometer thick ice sheet. It is thought that the crater is the site of impact of an asteroid that slammed into the Earth 13,000 years ago, instantly vaporizing rock and sending shock waves across the arctic. The Hiawatha impact likely had a powerful effect on the global climate as meltwater from the impact could have caused plummeting temperatures by halting currents that bring warmth to northwest Europe. Further carbon testing is still required to tie the impact to the Younger Dryas, a thousand-year global cooling event that began just as the world was exiting the last ice age.

Image Source: *Insito Blog*

Image Source: *Science*

Image Source: *Live Science*
Painkillers are a class of pharmacological products that occupy an important place in today’s healthcare environment by meeting patients’ needs for long-term relief from pain and suffering brought on by chronic diseases with no cure. Morphine was a key discovery at the centre of many challenges in biopharmaceutical science, wherein different strategies and approaches were employed to try to optimise the product to meet the requirements and deliver the desired benefits, while avoiding unwanted side effects.

The first challenge was to determine how to dose a drug that would suppress pain without inciting a neurological state of physical and psychological dependence that might eventually lead to deterioration and the death of the patient (Schwarcz, 2016). Opium products were among the first medicines used by ancient Roman and Greek doctors to relieve various pathologies such as pain and coughing, as they seemed to provide relief to the individual. The dose of opium, however, becomes a crucial measurement since it can quickly become a poison to the system if taken in excess (Schwarcz, 2016).

In addition, opium had unique physical properties, as it was more soluble in alcohol than water. Determining the dosage to be used on a patient that provided an overall beneficial effect was complicated, since the different varieties used varied greatly in the concentration of active ingredients and were not homogenous, a crucial factor of modern organic synthesis. The doctors who advanced the project also had to overcome another complicated element: ceasing the administration of the drug after long-term use inevitably lead to anxiety and depression in the patient. Thus, an alternative to pure opium rose in popularity during the Victorian era: laudanum. Laudanum was embraced swiftly by the public as a new pain-reliever. However, its euphoric effects were also attractive to a number of people.

Eventually, a German pharmacist by the name of Friedrich Wilhelm Serturner succeeded in isolating and purifying the active ingredient of the poppy, a medicinal plant. He named the product morphine, inspired by Morpheus, the god of dreams in Greek mythology (Schwarcz, 2016). Serturner developed safety trials in the early preparatory stage by performing various experiments on mice and dogs. These trials didn’t lead to any especially meaningful conclusions, but they suggested a possible track towards the desired product from the crude chemical (Schwarcz, 2016).

He undertook a risky and unethical approach to further research, using his close friend group as test subjects for the substance to determine the minimal effective dosage in humans (Schwarcz, 2016). He observed that a dose of 30mg brought feelings of joy to the subject, while a different second dose brought fatigue, and a third dose had considerable effect in inducing deep sleep. Shortly after these discoveries, however, he had to stop this experimental approach as the risk had surpassed the potential benefits of the method (Schwarcz, 2016).

The development of the hypodermic syringe facilitates the administration of the correct dosage of morphine. The civil war was the cause of various wounds in soldiers which called for morphine, but which also created dependence to the drug in survivors.

As early as the 1970s, the mechanism of morphine’s biological activity on the body was well-established and documented. The chemical in question binds to the specific receptors of the central nervous system that interfere with transmission of pain signals from nociceptors that usually pass through “the great door”, a commonly-used term in functional anatomy (Schwarcz, 2016).

The organic synthesis techniques for morphine remain elusive even today, as research has not yet established an effective method of large-scale production (Schwarcz, 2016). In conclusion, the general public need to be aware about the potential risk associated with the drugs, especially since the prescription has been trivialized over the years (Gagnon, 2014).
Measuring Electrical Activity in Fetal Hearts

Dominique Yelle, 4th Year HSS

The heart is a rhythmic electromechanical pump responsible for supplying the body with oxygen and nutrients. Its functioning depends on action potential generation and propagation (Nerbonne & Kass, 2005). Cardiac issues occur regularly, especially in North America where cardiovascular diseases are among the leading causes of death. Some cardiovascular diseases affect the heart's electrical activity, which in turn can become very problematic. For most patients, electrocardiography (ECG) is used to record the patient's cardiac electrical activity. Using ECG, physicians can determine the exact cause of the abnormal electrical activity in the heart (e.g., tachycardia, bradycardia, etc.) by placing electrodes on their patient's chest (Jensen et al., 2018). ECG is a good and effective method for those who are already in this world. For fetuses, ultrasound scans are mainly used to determine if abnormal cardiac electrical activity is present, but these do not convey exactly what is wrong with the fetal heart. Until recently, there was no way of specifically determining the exact type of cardiac electrical activity abnormality.

In 2018, a paper published by Scientific Reports proposed a way to potentially measure electrical activity in a fetal heart (Jensen et al., 2018). Prior to this publication, the main technique used to measure electrical activity in a fetus was magnetocardiography (MCG) (Wacker-Gussmann, Strasburger, Cuneo, & Wakai, 2014). This technique detects the magnetic fields generated by the heart's electrical signal by using extremely sensitive devices. A major drawback of these devices is the need of either cryogenic cooling or heating at several hundred degrees Celsius (Jensen et al., 2018). Optically pumped magnetometers (OPMs) are some of the already existing sensitive devices and are usually based on absorption of light. The original method contains some disadvantages, which do not make them the most suitable to measure fetal electrical heart activity (Jensen et al., 2018).

Two scientific teams at the University of Copenhagen have instead developed an OPM that is based on cesium atomic vapour (Jensen et al., 2018). The locked-up cesium atoms can detect very small magnetic fields and allow precise observations and measurements at the quantum level (Jensen et al., 2018). This OPM can be placed in contact with or at mm-distance from biological tissue and is operated at room or human body temperature (Jensen et al., 2018).

To discover this, the teams used an isolated guinea pig heart (Jensen et al., 2018). The animal's heart is the approximate size of that of a human fetus at a gestational age of 18 to 22 weeks (Jensen et al., 2018). It also has electrical properties similar to that of a human fetus (Farraj, Hazari, & Cascio, 2011). They placed the guinea pig hearts in a plastic chamber with a constant supply of oxygen and saline water to make them beat for a few hours (Jensen et al., 2018). In one experiment, they used a potent ion channel blocker named E-4031 to mimic inherited long QT syndrome (LQTS) (Jensen et al., 2018), a common fetal arrhythmia that causes fetal morbidity (Cuneo & Strasburger, 2015). Their OPM was able to fully detect the mimicked LQTS in the electrical signals of the hearts with E-4031.

Diagnosing cardiac electrical activity problems and intervening as early as possible could be lifesaving. Fetal MCG can provide an understanding of the electrical mechanism underlying fetal arrhythmias, such as tachycardia, bradycardia, LQTS, and atrio-ventricular block, as well as other cardiac conduction abnormalities (Jensen et al., 2018). In a foreseeable future, there could be a decrease in fetal mortality thanks to the two scientific teams at the University of Copenhagen.
Do you remember what you packed for lunch last Tuesday? For many, chances are they may not remember. Remembering experiences for repetitive events such as meals can appear trivial, but these events still contribute to an entire life journey. As individuals age, these experiences can accumulate just as easily as they are lost, particularly at an older age due to a certain disease: Alzheimer’s disease (AD). Of all the different cases of dementia that exist, AD contributes to the deterioration of cognitive function at a level of 60-70% incidence (World Health Organization, 2019).

AD takes over many lives in a progressive, chronic neurodegeneration, when compared to normal aging symptoms for differential diagnosis. AD onset is typically in those over 65 years of age (Makin, 2018). Early AD patients tend to have episodes of forgetfulness, such as forgetting the names of family and friends. Going beyond the familiar can start to pose more issues (World Health Organization, 2019). At a middle AD stage, difficulties can arise with sleep, newly learned concepts, and their location to altogether create deeper confusion. Finally, late-stage AD results in apparent speech problems with poor thinking ability for repetition in conversation, in addition to increased abusive personality (World Health Organization, 2019). AD affects society as a whole, and in turn, causes a surge in development for research in AD theories.

One of the oldest theories, which has been rebutted, includes the acetylcholine (ACh) basis. ACh synthesis is theoretically reduced, but drug therapies to restore ACh levels have not appeared effective for AD (Martorana, Esposito, & Koch, 2010). Other theories are related to the blood-brain barrier, smoking, and other lifestyle/environmental factors that may affect the brain over time (Deane & Zlokovic, 2007; World Health Organization, 2019).

The variety of theories contributing to AD, however, are only second to the more popular and well-established theory on amyloid. Two of the main symptoms found when observing an AD brain are extracellular plaques and intracellular tangles (Makin, 2018). Beta amyloid protein is thought to result from cutting amyloid precursor protein (APP), which spans across the cell membrane, at a variety of cleavage sites by y-secretase (Stetka, 2018). Longer pieces of beta amyloid released extracellularly are thought to aggregate more easily. Continuous aggregation eventually forms oligomers, fibrils, and finally dense and largely insoluble plaques. The location y-secretase cuts to produce more or less plaque appears to originate from mutation. Beta amyloid aggregation is then thought to cascade into inflammation and tangling of tau (Stetka, 2018). These tau proteins normally support structural units called microtubules in neurons. The destruction of tau leads to the collapse of the neuron cytoskeleton, structure, failed biochemical communication between neurons, and cell death. This amyloid theory with plaques and tangles appears promising.

The amyloid theory was first mentioned over a century ago, with beta amyloid only being isolated in 1984. Its credibility, however, remains in question due to a weak correlation between plaque presence and AD: plaques are found in the brain of the normal functioning elderly as well (Makin, 2018).

To make a counterargument, more recent 2016 research from Moir and Tanzi at Harvard Medical School explores the nature of AD related to infections while attaching more reason to amyloid’s presence. Their research on mice and worm models show that amyloid is lethal to pathogens including bacteria and viruses (Kumar et al., 2016). Therefore, the accumulation of amyloid plaques may be an artifact of the body’s own immune system. Rather than simply aggregating, amyloid production and aggregation may be driven in the presence of pathogens. Amyloid would bind to these pathogens to trap them from harming the brain further. Accumulation of these pathogen-trapped plaques is, in turn, thought to be toxic for the brain following tau tangling and neurodegeneration characteristic of AD (World Health Organization, 2019).

The implications of these findings from Moir and Tanzi provide extensive insight into those with and without AD. A prime concern arises for transmission from long-term pathogen contraction from others, with AD symptoms only truly appearing in its late onset (Kumar et al., 2016). This time lag is possible when considering syphilis, a sexually transmitted infection which may only manifest as a rash at first. Gradual inflammation in areas such as the brain can take up to 30 years before resulting in late-stage neurosyphilis. Inflammation over time may be similar in AD with pathogen-driven amyloid activity.

While research at this point has not provided definitive conclusions for AD, any research is valuable to first discover trends. An investigation into HPV may shed light on many cancers, while gastrics ulcers were found to largely originate from H. pylori bacteria (Kumar et al., 2016). Further research into AD is equally invaluable. Will you join the research on AD?
It is that time of year again. The blankets are out, the tea is steeping, and the Kleenex boxes are ready. Why does this have to happen: the coughs, muscle aches, headaches, weakness, and fever? Well, forgetting to get a flu shot has its consequences!

This is what a virus can do. It is as simple as a small bubble of protein with genetic information inside, either DNA or RNA, that dictates how it will use your body to spread and reproduce. A virus is essentially just a code of information that eloquently explains to your cells how to make more virus until the cell dies. Viruses are not alive, so you cannot kill a virus. With time, your body finds a way to stop it from spreading and damaging your tissues.

Now how could we possibly use these pestering infective agents to cure cancer?

Since there are so many viruses that target many specific hosts, why not find a virus that specifically targets cancer cells? This was the reasoning behind the development of oncolytic viruses (OVs), “a promising treatment modality that offers unique opportunities for tumour targeting” (Singh, Doley, Kumar, Sahoo, & Tiwari, 2012, p.571). Onco refers to tumors, and lytic refers to the causing of lysis, or cell rupture. So how do OVs treat cancer without also giving patients a dose of the flu?

OVs distinguish between normal and cancerous cells based on their physiologies. For example, OVs can be designed to target the translation of proteins. If a virus forces a cell to translate proteins, the cell, cancerous or not, will continue to make protein for the virus capsid until eventual lysis. In specifically modified viruses for cancer treatment, the gene that forces a cell to manufacture viral protein is knocked out. As a result, normal and healthy infected cells can use cellular mechanisms to stop producing viral proteins while cancerous cells, who’s physiology is broken, will continue, ultimately leading to cell death (Sarinella, Calistri, Sette, Palu, & Parolin, 2006).

Another method may be to transfer the tumor suppressor gene, p53, to cancerous cells, which will then recognize their broken state and undergo apoptosis, or controlled cell suicide (Gomez-Manzano et al., 1996). Voilà, two mechanisms for OVs, amongst others.

However, viruses cannot get all the credit for their therapeutic properties. Not only can viruses kill tumors, but the release of antigenic molecules from within lysed tumor cells cause the immune system to mediate further cancer cell destruction (Filley & Dey, 2017). The perfect recipe to help the immune system recognize tumors, provided by a successful OV.

Excellent, but has there been proof of concept? Designing new viral strains to administer patients may seem like a risk to their safety since it is not always known how the body can respond to a virus. However, unfavorable symptoms can be minimized by removing specific pathogenic genes in the virus. Fortunately, when adverse events do present, they resemble symptoms of the average flu with fatigue, chills, fever, and nausea, all of which were very manageable in clinical trials (Matsuda, Karube, & Aruga, 2018).

What has happened is that hundreds, if not
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John Evans, Physics ‘18

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A Prehistoric Rainbow of Possibilities


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April


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Measuring Electrical Activity in Fetal Hearts


Research Spreads: The Infectious Nature of Alzheimer’s


The Flu That Cured Cancer


