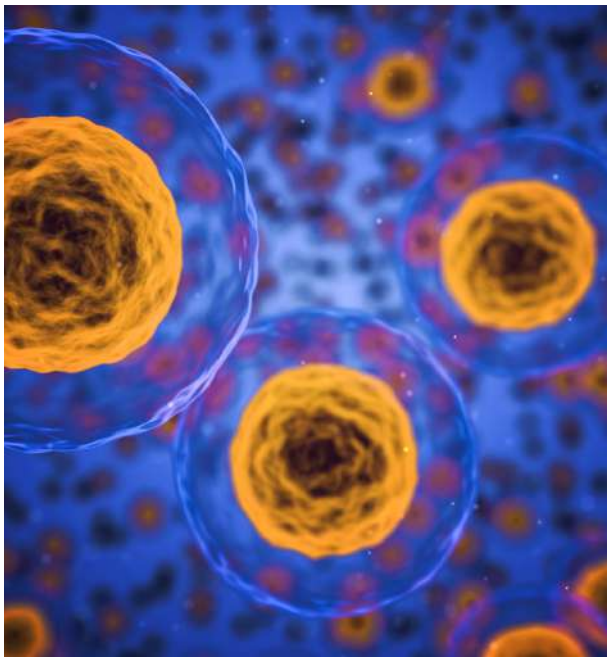
SCIENCE JOURNAL 2021

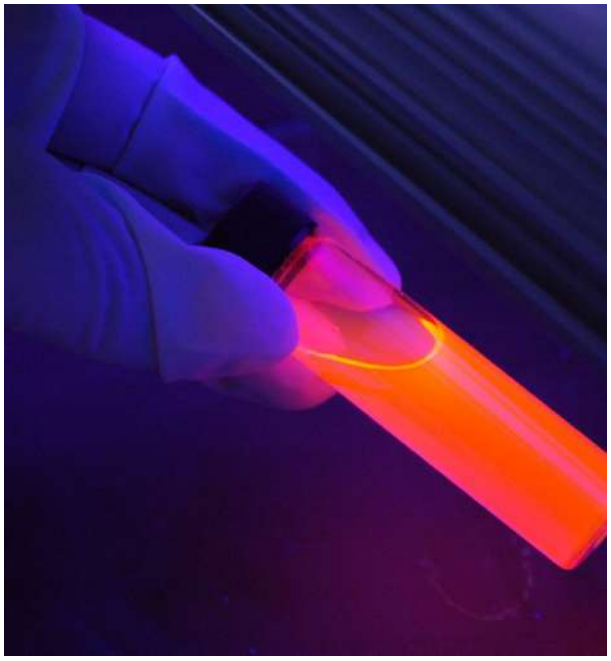
A SELECTION OF ARTICLES WRITTEN BY STUDENTS OF ISLAND SCHOOL

COMPOSED BY
RENEE WONG

EDITED BY
YU HANG HUI, SAMMI HUNG, KIMBERLEY NG, ANGUS SMEATON, ARJUN THIND, AYAHIKO USUI

SENIOR PHASE





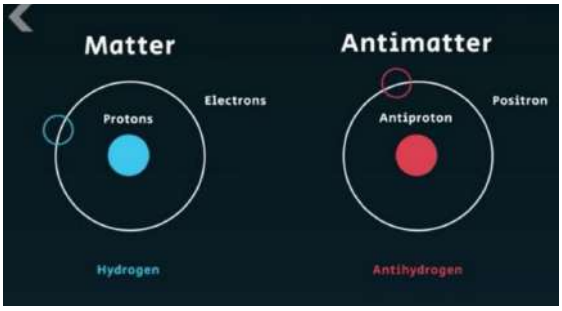
CONTENTS

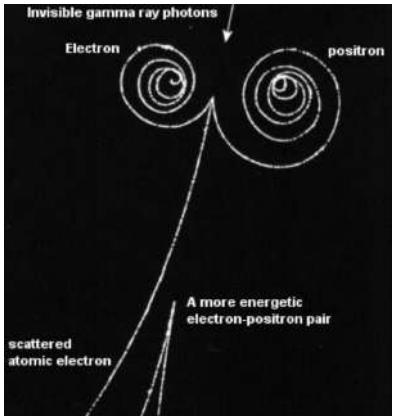
ANTIMATTER

BY AILEEN BAI YANG 12D

MYSTERIES AND POSSIBILITIES OF ANTIMATTER

Antimatter is literally the opposite to the 'normal' matter we see in everyday life, which means that for every proton, neutron, electron (etc.) there is an antiproton, antineutron and antielectron (also called positrons). So what's the difference? Well, antimatter and matter is almost exactly the same, except that antimatter has the opposite electrical charge to matter.





Antimatter was first predicted by Paul Dirac in 1928, and was later proven experimentally by Carl Anderson in 1932. Anderson had been looking at positrons (which was from atmospheric showers of subatomic particles caused by the interaction between high energy cosmic rays and Earth's atoms) through a cloud machine. Particles passing through cloud machines would leave a trail behind it, and a particle would curve a certain way based on its charge when a known magnetic field is applied. Anderson found that the positrons share the same curve as electrons, just in the opposite direction, confirming Dirac's theory.

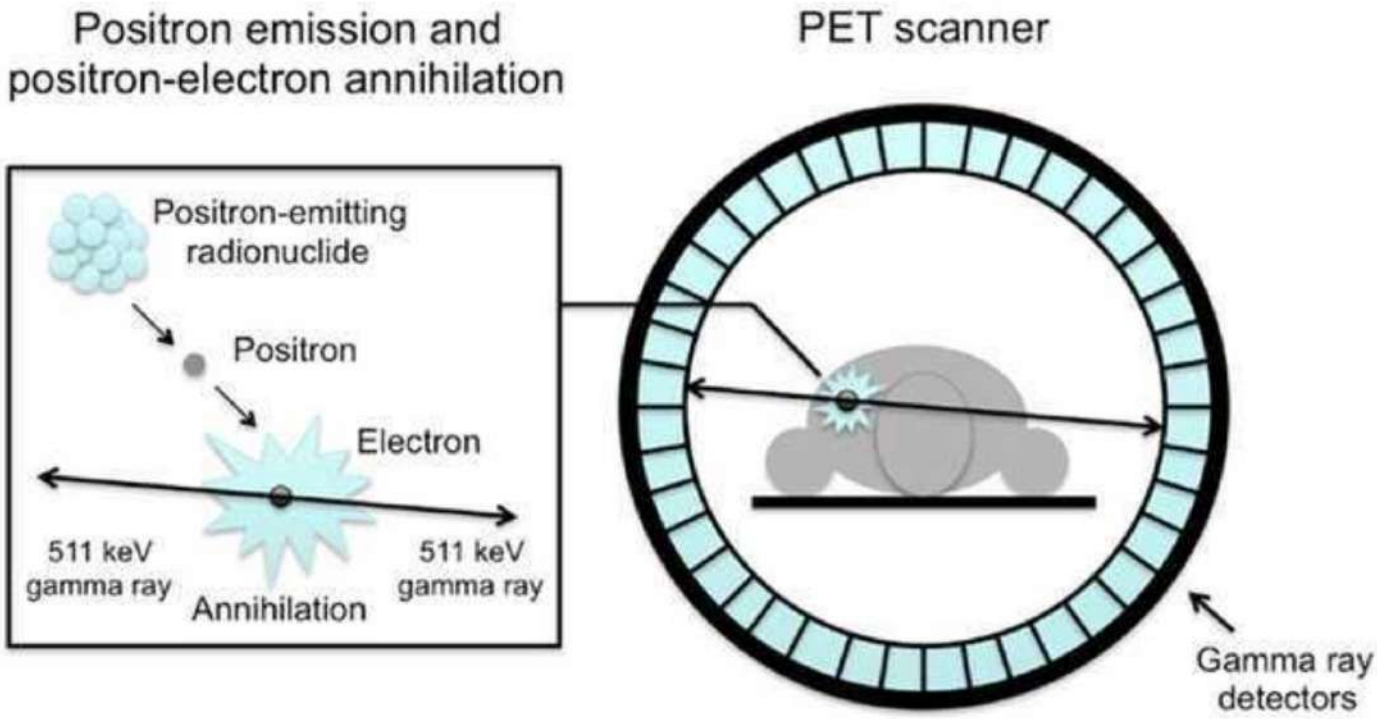
THE MATTER-ANTIMATTER ASYMMETRY MYSTERY

So if for every matter, there is an antimatter, then theoretically, our universe should consist of equal amounts of matter and antimatter. But our universe consists predominantly of matter. And thankfully so, because when matter comes into contact with antimatter, the result is a huge explosion of gamma rays and x-rays! As stated in$E=mc^2$, the amount of energy that is released is dependent and proportional to the mass of the matter and antimatter. In short, if there were equal amounts of matter and antimatter after the big bang, the amount of energy released would completely destroy the universe - we would not exist. This brings in the matter-antimatter asymmetry problem within our universe, one of the unsolved mysteries of the world. Scientists have found that there were around one billion and one particles per one billion anti-particles, and so when they interacted, the one billion particles and antiparticles annihilated each other, leaving just one particle with one billion photons.

There are a few theories as to why this imbalance occurred. One of which involves neutrinos, which is a very abundant subatomic particle in the universe. Neutrinos are special because they practically have 0 mass, and they don't have a charge. Some physicists have suggested that neutrinos could then be its own antiparticle, and that it could transition between being a particle and an antiparticle. If most of these neutrinos were acting as matter after the big bang, it could explain why there is more matter than antimatter.

USES AND EXPLORATIONS OF ANTIMATTER

So what has the discovery of antimatter brought us? Well, endless possibilities, one of which is successful is part of the medical industry - hospital PET scans, or positron emission tomography scans. The way it works is that positrons (or anti electrons) are injected into the brain, and once it meets electrons (matter), then they will annihilate each other, emitting gamma rays. The light pattern emitted from a normal brain would differ from one that has abnormalities.



There are also possibilities that antiprotons could be used to treat cancer through irradiation, which is being investigated by CERN. According to their results, a beam of antiprotons creates 4 times as much cell damage as opposed to a beam of protons. This is good news as it could mean that treatments using antiprotons would allow the patient to be exposed to less radiation for the same effects.

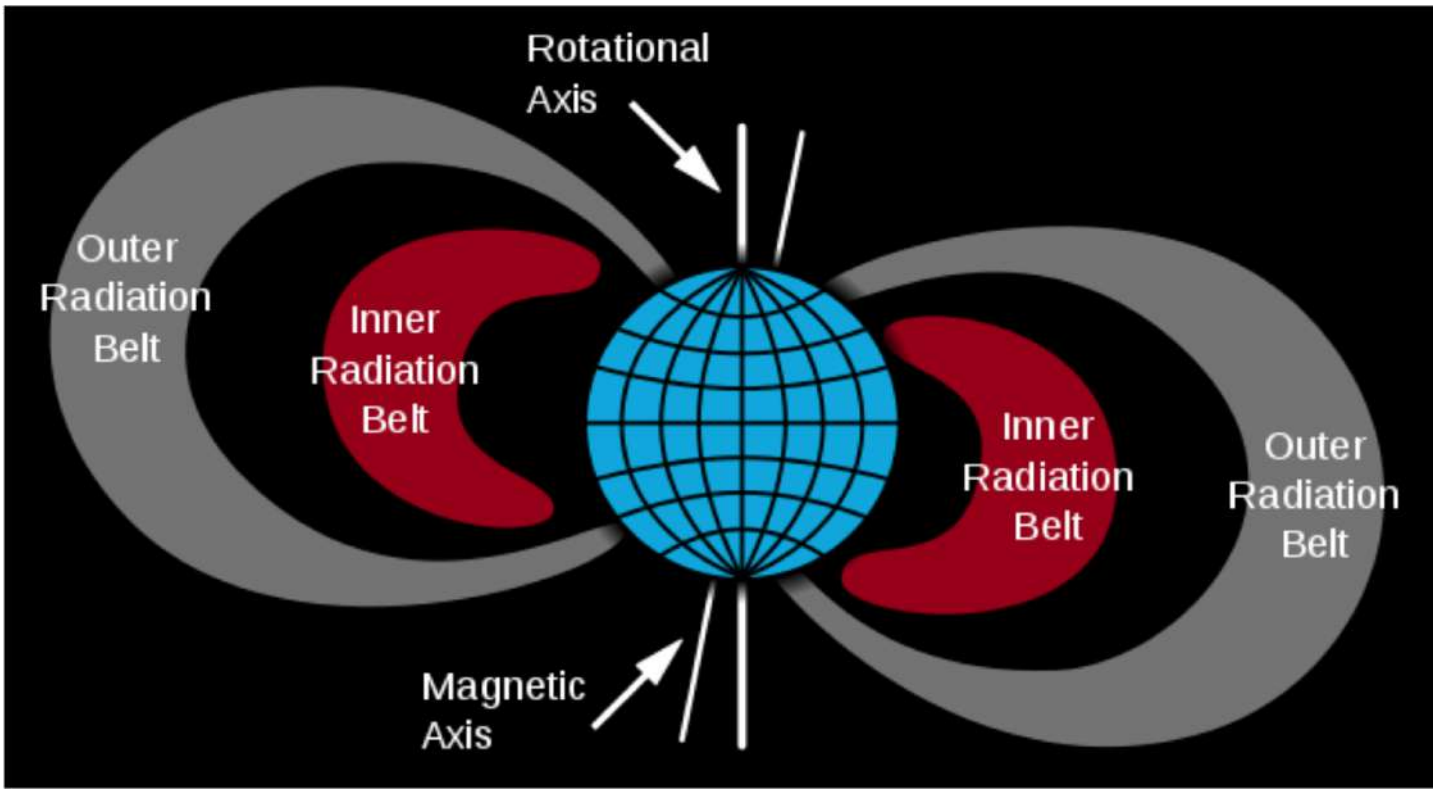
If you're worried about the appearance of antimatter bombs, you will be glad to hear that it is much too expensive and time consuming to create enough antimatter to make an impact that large. A milligram of antimatter requires $100 billion USD, and the fact that explosions occur when antimatter and matter collide makes storage very tricky.

Generating power through use of antimatter has also been a topic of discussion. Just 0.5kg of antimatter would be enough to provide the entire US enough power for 2 days! However, creating that much antimatter and storing it is a large obstacle that scientists have yet to solve.

Another idea brought up is using antimatter to fuel spaceships by utilizing the energy emitted when matter and antimatter interact. While this is a possibility, it is currently not very feasible due to the same problems of above, problem of creation, expense and storage.

The good news is, a small antimatter belt has been found to circle the Earth by the satellite PAMELA, launched in 2006. This happens when cosmic rays create new particles and antiparticles (due to collisions with other particles) which sometimes end up stuck inside the Van Allen Radiation belts, trapped by Earth's magnetic field. Perhaps if we could find a way

to use this source of antimatter we would be able to achieve even more with the discovery of antimatter, although storage would still be an obstacle we would need to overcome.



CONCLUSION

Antimatter can open a range of possibilities and further advance various industries, however, many of them are not currency feasible due to their peculiar and yet special nature to explode when in contact with matter. But there are still vast amounts of research going into this scientific discovery, perhaps in the future we would be able to achieve those ambitious ideas stated above...

BIBLIOGRAPHY

Uses, people.physics.anu.edu.au/~cms130/phys2013/antimatter/id15.htm.

"Antimatter - How It Is Made [2019]." YouTube, YouTube, 10 Dec. 2019, www.youtube.com/watch?v=z7I0edsIB60&feature=emb_rel_pause.

"Cracking the Antimatter Mystery: A Three Minute Guide." Nature News, Nature Publishing Group, 17 Apr. 2020, www.nature.com/articles/d41586-020-01117-x.

Halper, Mark. "The Practical Uses of Antimatter." ZDNet, ZDNet, 6 June 2011, www.zdnet.com/article/the-practical-uses-of-antimatter/.

Highfield, Roger. "Making Antimatter and Putting It to Use." New Scientist, 12 May 2009, www.newscientist.com/article/dn17113-making-antimatter-and-putting-it-to-use/.

Klotz, Alex, and Alex KlotzPh.D. McGill University. "Learn the Basics of Positron Emission Tomography (PET)." Physics Forums Insights, Alex Klotz Https://Www.physicsforums.com/Insights/Wp-Content/Uploads/2019/02/Physics_Forums_Insights_logo.Png, 26 Nov. 2020, www.physicsforums.com/insights/basics-positron-emission-tomography-pet/.

Ron CowenAug. 9, 2011, et al. "Antimatter Belt Found Circling Earth." Science, 10 Dec. 2017, www.sciencemag.org/news/2011/08/antimatter-belt-found-circling-earth.

"What Is Antimatter Explained." YouTube, YouTube, 14 June 2020, www.youtube.com/watch?v=nUBVMUiZtQ4.

"A Beam of Antimatter Could Help to Unravel the Secrets of the Universe." Eniscuola, 16 July 2015, www.eniscuola.net/en/2014/03/06/beam-of-antimatter-could-help-to-unravel-the-secrets-of-the-universe/.

minutephysics. "Antimatter Explained." YouTube, YouTube, 20 Sept. 2014, www.youtube.com/watch?v=Lo8NmoDL9T8.

RANDOM DISCONTINUOUS MOTION

BY GABRIEL FREITAS 12D

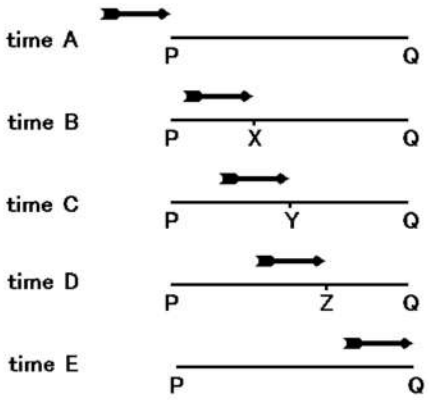
There is a concept which corrupts and upsets all others. I refer not to the evil, whose limited realm is that of ethics; I refer to the infinite. The concept of infinity is still quite mysterious in the world of modern science. Perhaps the dilemma which best showcases the uncertainty of the concept of infinity is Zeno's second paradox: Achilles and the tortoise.

In a 100 metres race, Achilles runs ten times faster than the tortoise and gives the animal a head start of ten meters. Achilles runs those ten meters, the tortoise one; Achilles runs that meter, the tortoise runs a decimeter; Achilles runs that decimeter, the tortoise runs a centimeter; Achilles runs that centimeter, the tortoise, a millimeter; Fleet-footed Achilles, the millimeter, the tortoise, a tenth of a millimeter, and so on to infinity, without the tortoise ever being overtaken. Zeno argues that the slowest will never be overtaken by the swiftest, since the pursuer has to pass through the place the pursued has just left such that the slowest will always have a certain advantage. Furthermore, modern science can't even determine whether Achilles and the tortoise ever finish the race. This is where infinity comes in. Depending on whether space is quantized or not, the two racers might spend more time running than you might think. From a mathematical standpoint, the following sequence represents the distance travelled by Achilles during the race:

$$10 + 1 + \frac{1}{10} + \frac{1}{100} + \frac{1}{1{,}000} + \frac{1}{10{,}000} + \ldots$$

The more attentive readers will notice that, firstly, Achilles never catches up to the tortoise, and secondly, when assuming space is not quantized, meaning space can be divided infinitely, neither Achilles nor the tortoise ever complete 100 metres. How come can they possibly never complete a finite distance of 100 metres despite both of them always moving towards the finish line? Believe it or not, this isn't the only "simple" concept modern science can't prove or disprove.

Zeno was the first man who legitimately pondered over the puzzle of motion. This wasn't the only paradox he formulated, nor was it the most famous one. The arrow paradox is one that will really take you for a ride. Surprisingly, he argued that motion was actually an illusion, but was he correct? Allow me to present you the riddle of the arrow:



Imagine an arrow in flight. At each and every instant in time, it is located at a certain position. If the instant is durationless (a specific point rather than a time period), then the arrow does not have time to move and is therefore at rest at that specific instant. During subsequent instants, it must also be motionless due to the same reason.

Considering that the entire flight of the arrow consists of instants, all of which the arrow is at rest, Zeno concludes that the flying arrow is always at rest and cannot be moving: its motion is simply an illusion. Until this day, this conclusion still prevails when the instant is durationless. Let's suppose that the arrow actually moved during an instant. This would mean the instant has a "start" and an "end" to it which as a result means that the instant contains multiple parts, which would mean the instant is not durationless. This leads to a contradiction since we are discussing the flight of the arrow in terms of durationless instants. There is no way that's true! How come is the arrow not moving? Don't worry if you can't come to a conclusion, I doubt our science teachers would be able to agree on one themselves!

If Zeno is right, then everything in existence would be still. The sun would not rise and set, your eyes would not blink and your heart would not beat either. Your perceptions and your mind would be at rest at all times, which would certainly be the greatest revelation. Don't worry though, in an article that may portray science as something that has proved absolutely nothing, you will be pleased to know that motion is indeed real. If our mind was at rest at all times, then how would it possibly create the illusion of motion then? Two immobile things simply cannot generate a mobile one in the world we live in.

If motion is real, then Zeno's argument is undoubtedly incorrect. Where is his mistake? Zeno's argument relies heavily on the idea that time consists of discrete durationless instants in which the arrow is at rest. The truth is that there is no proof as to whether time is quantized or not, only speculation. If time is not quantized, then motion seems to be an illusion, as portrayed by the arrow paradox, however, we know that motion is indeed real, so time can't consist of durationless instants. If that's the case, then how come does poor Achilles never finish his race?

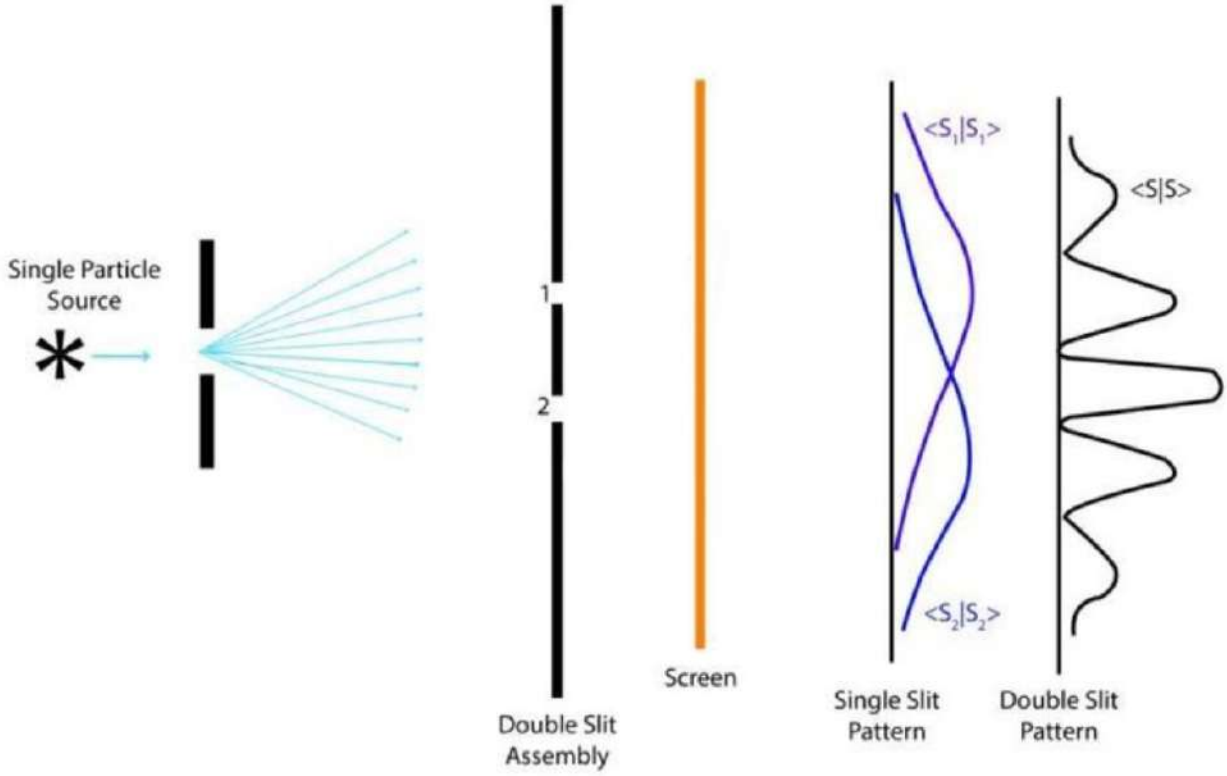
If space and time are not quantized, this would mean that every point in a rotating wheel is in motion, meaning there is no centre. The most exciting thing about this is that you are free to make your own judgement. What do you think? Is time quantized or not?

The real question is how do we describe motion if we can't determine whether time is quantized or not? This is a common misconception when it comes to motion. Motion has nothing to do with what occurs during instants, but rather what occurs between instants. Motion is simply the occurrence of being in different locations at different times. If an object has the same location at a subsequent instant, it is at rest, otherwise, it's in motion. Therefore, since the arrow is in different locations at different times, it is moving. As the philosopher, Henri Bergson once said "movement is composed of immobilities." This is counterintuitive and therefore difficult to understand. Don't be ashamed of reading it again in order to understand it, I had to do so an embarrassing amount of times…

Think of it like a movie. Your screen streams a video at a certain number of frames per second, usually 60fps (unless you are a true gamer with a beefy monitor). The motion of an object in real life is comparable to one in a movie, it's only at one position in a frame or instant, but is the jump from one point to another continuous as in a movie? Is motion continuous?

It may seem quite bizarre to imagine motion as not continuous, we often make the intuitive assumption that it is, except science might not be as intuitive as you think. Don't worry though, if you think motion is continuous, you are not alone. Both Newton and Einstein thought so. At first sight, the existence of continuous motion seems quite intrinsic and intuitive. An object will perpetuate its velocity if no force is imposed on it, as there is no cause to change its velocity. Moreover, a moving object is in one position at an instant, and it can only be in neighboring positions at the adjacent instants. If the object "skips'' a position, motion is not continuous. Sounds confusing, I know. Think of it like this: say Usain Bolt is sprinting 100m from start to finish. If motion is continuous, then Bolt must be at all points in the track he ran at some point. I doubt we will ever see Bolt skip a position as if he is capable of teleportation, the same way a car can't skip a point to avoid a traffic jam. It sounds simple enough, until we consider infinity. There are infinitely many points between 0-100m that Bolt goes through, even fractions of kilometres (10-24 metres). How come Bolt travels through infinitely many points in a finite time interval? What is the last point he goes through before the finish line?

Infinity makes it impossible for us to prove the existence of continuous motion. If continuous motion is not the real motion, then what is? Since we've never seen or experienced any other form of motion, how could it be the real motion? In order to discover the real motion, we must enter into a smaller and smaller space, even an infinitesimal space. Now comes one of the few times that we choose to genuinely listen to our science teachers: let's analyse an experiment, which is perhaps the most bizarre experiment ever, the mysterious double-slit experiment.



Motion is far more peculiar than we all perceive it to be. Solely the apparent motion of macroscopic objects can be seen by the human eye. How about the motion of microscopic particles? This famous experiment, named the double-slit experiment, first discovered by Thomas Young, is so simple that anyone can comprehend it, however, it cannot be explained in terms of continuous motion. To the left of the diagram, we have a particle source which emits one particle at a time. In this case, an electron. Next to that, there is a barrier with two symmetric slits or holes, let's name them slit 1 and slit 2. Next to that we have a screen which will record the position of the electron after it comes into contact with it. After emitting a certain number of particles while having both slits opened, we get a pattern as to where the particles hit the screen. This pattern is the one to the right labelled "Double Slit Pattern". Now, the experiment will be run with only one slit opened at a time. Firstly only split 1, then, only split 2. We would imagine that after running the experiment again, the combination of patterns caused by having split 1 and split 2 opened separately will be the same as having them both opened at the same time, but to our great surprise, this is not the case. The pattern caused by both slits combined, labelled "Single Slit Pattern" is extremely different to the other one.

More importantly, notice that having one slit shut at all times somehow allows the electrons to reach positions that it initially couldn't when both slits were opened. Somehow, just having one slit opened affects the position where the electron lands, despite it not going through it. It appears that one unique particle must pass through both slits at once, which therefore implies that its motion is not continuous. Hence, it seems that the motion of microscopic objects (also applies to photons, neutrons, atoms, and even molecules). How can a single particle travel through two slits at once?

The shorter answer is that no one really knows. No scientist has ever provided a solution to the double-slit problem. Modern science aspires to extract energy from a black hole, build chips which can be inserted into our brains, and cure diseases that are currently irremediable while still not being able to solve such a simple experiment.

Perhaps the key to understanding motion is hidden within what causes it. The theory which is nowadays widely accepted, also the one that you will learn in class is the concept of inertia, or in other words, Newton's first law of motion. In Newton's world, motion and rest are equivalent. An object can sustain its motion just as it can sustain its rest. For an object in motion to change its velocity, an external force must be applied. This law perfectly accords to the macroscopic experience as well as appears to be logical and self-evident, however, it leads to a mighty trap which no one has come out of.

Step back and picture Zeno's arrow. It has revealed that motion is fundamentally being in different positions at different times, as well as there being no motion at each durationless instant, thus, no motion is existent for an object to maintain at every instant; motion and its velocity merely don't exist at durationless instants. Therefore, Newton's theory is not wholly valid (I apologise Mr. Bayne).

In a sense, the concept of inertia diverts our attention from position change, which is what motion is, to velocity change, which is an presumed characteristic of motion. This fact was neglected by Newton and all exceptional minds after him. Despite this unfortunate imperfection, Newton's explanation of inertia can push us towards a correct outcome. According to Newton, neither external force nor internal force is the cause of motion, leaving us with only one possibility: motion has no cause. Nothing determines how the position of an object varies in reality. This is completely incomprehensible when compared with the reality before our eyes, however, rather than denying it solely due to the fact that it doesn't match past experience, open up your minds to the unexpected.

So far, we have mainly discussed motion in terms of durationless instants, assuming that time and space are not quantized. Let's change our approach: let's assume that both space and time are quantized. Scientists that believe both space and time are quantized also believe that the minimal values for each one is a planck length (1.610-35m) and a planck time (5.4 10-44s). Hence, any physical being can exist in a region larger than the planck length, as well as any physical becoming can occur in a time interval longer than the planck time, however, the opposite is impossible. As a result, a particle is no longer in one "0-sized" durationless instant, but in a planck length and a planck time. Surprisingly, continuous motion is actually impossible when assuming space and time are quantized, with only one exception.

For an object to be in continuous motion in this instance, it must move one planck length in one planck time. Imagine a particle in an instant, it can't skip a planck length otherwise it's motion will not be continuous, the same way it can't move half planck length every planck time otherwise the particle will be at rest half of the time. Therefore, the only speed it can move at is a planck length per planck time. That my friends, is the speed of light (3108ms-1). From this we can conclude that in a quantized universe, light is the only thing that moves continuously, meaning that, to our great surprise, everything else doesn't, unless of course it's at rest. Eminently, this doesn't match our experience. Therefore, the motion of objects simply can't be continuous, but discontinuous and random.

Unsurprisingly, this dilemma boils down to a great scientific debate: determinism vs nondeterminism. Here is where you express your own opinion on how the world works. Determinism is the idea that there is absolutely no randomness in our universe, the idea that everything happens for a reason. The exact same result will always be retrieved from the same initial condition or state. In terms of motion, no matter how random it may seem, it can always be represented by an equation derived from the mind of a super-mathematician. In terms of our daily lives, we have no control over the decisions we make and the choices we take - they are all "predetermined". Almost like we are all following a script. Quite bizarre, isn't it? Nondeterminism is obviously the exact opposite: nothing is predetermined.

Now, of course, a compromise can be made from this, you don't have to choose either one or the other, however, having some aspects of our lives being deterministic while others aren't just makes science that much harder to understand. Quantum mechanics is the perfect example of this. The macroscopic world appears to be logical and comprehensible. With enough information and understanding of certain formulas, you can accurately predict where an object is going to be in the future.

In contrast, the microscopic world seems to be rather nondeterministic, so much so that no one really understands it, and I mean it. There is no such thing as a “quantum mechanics expert” somewhere around the world because no one really understands it, so don’t be ashamed if you don’t! Despite this, don’t be scared to think of the world in a completely different way. Always be open and prepared for the unexpected. Problems like this demonstrate how little we know about the universe we live in. If anything, contrary to what science classes might suggest, sciences are subjects that leave you with more questions than answers, and I am thankful that they do so. Can you imagine how boring the world would be if we weren't such fools?

BIBLIOGRAPHY

Baez, J., G. Unruh, W. and G. Tifft, W., 1999. Is time quantized? In other words, is there a fundamental unit of time that could not be divided into a briefer unit?. [online] Scientific American. Available at: <https://www.scientificamerican.com/article/is-time-quantized-in-othe/> [Accessed 3 January 2021].

Finkel, D., 2018. Mysteries of continuous movement. [online] The Hindu. Available at: <https://www.thehindu.com/children/mysteries-of-continuous-movement/article22814525.ece> [Accessed 3 January 2021].

Hugget, N., 2002. Zeno’s Paradoxes (Stanford Encyclopedia of Philosophy). [online] Plato.stanford.edu. Available at: <https://plato.stanford.edu/entries/paradox-zeno/> [Accessed 3 January 2021].

Gao, S., 2008. God does play dice with the universe. Bury St. Edmunds, Suffolk: Arima Pub.

Papa-Grimaldi, A., 1996. Why Mathematical Solutions of Zeno’s Paradoxes Miss The Point: Zeno’s One and Many Relation and Parmenides’ Prohibition.. [online] Research Gate. Available at: <https://www.researchgate.net/publication/36444364_Why_Mathematical_Solutions_of_Zeno's_Paradoxes_Miss_The_Point_Zeno's_One_and_Many_Relation_and_Parmenides'_Prohibition> [Accessed 3 January 2021].

Gao, S., 2011. Interpreting Quantum Mechanics in Terms of Random Discontinuous Motion of Particles. [online] Research Gate. Available at: <https://www.researchgate.net/publication/265028500_Interpreting_Quantum_Mechanics_in_Terms_of_Random_Discontinuous_Motion_of_Particles> [Accessed 3 January 2021].

Qi, R., 2002. Quantum mechanics and discontinuous motion of particles. [online] Arxiv.org. Available at: <https://arxiv.org/ftp/quant-ph/papers/0209/0209022.pdf> [Accessed 3 January 2021].

DO CARROTS REALLY HELP YOUR VISION?

BY HYUNSOO LEE 12E

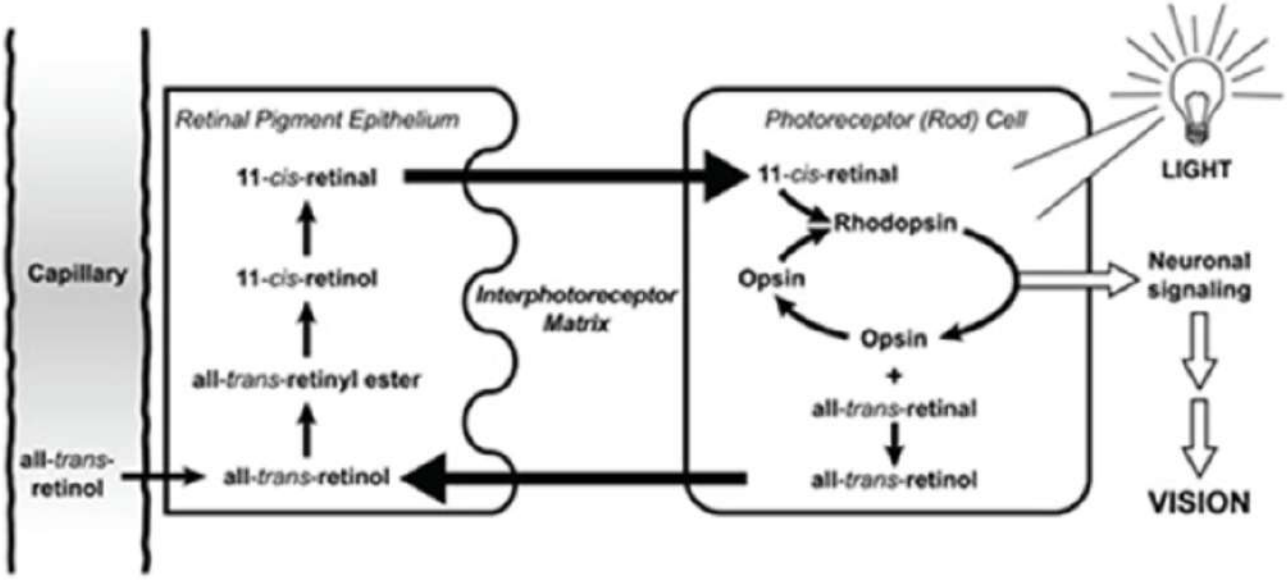
As a kid, you heard it over and over from your mom—"Eat your carrots. They'll help you see better!"—but do they really? The answer is: not really.

The start of this myth goes back to the early 1940s, when World War II was taking place. At the time, British pilots had access to a new radar system called the Airborne Interception Radar, which allowed them to more accurately target their enemies during night-time missions. As an effort to keep their new technology veiled, the British government spread a rumor that British pilots have good night vision due to their constant carrot consumption. Even though it is not evident whether the rumor had an effect on the Nazis or not, it did impact the British citizens, under the auspices of the numerous posters and news reports advocating carrot consumption. The British Ministry of Food even created a fictional character called ''Dr. Carrot'' in order to encourage children to eat carrots. As a result of all the efforts made, by the time the war ended, a copious amount of carrots were produced—rigidifying the vegetable's position as a superfood that is capable of improving vision.

As improbable as it may seem, the claim made by the British government is not a complete fraud. Indeed, it is partially true as the vitamin A in carrots is an essential contributor to the human eyes.

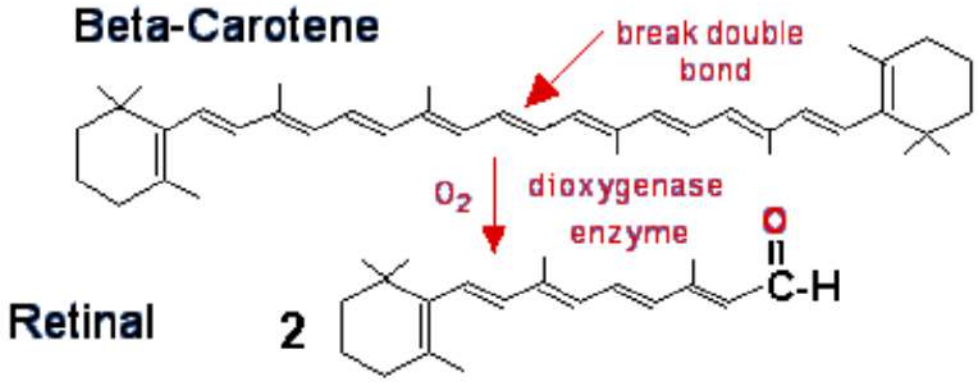
VITAMIN A AND THE EYE

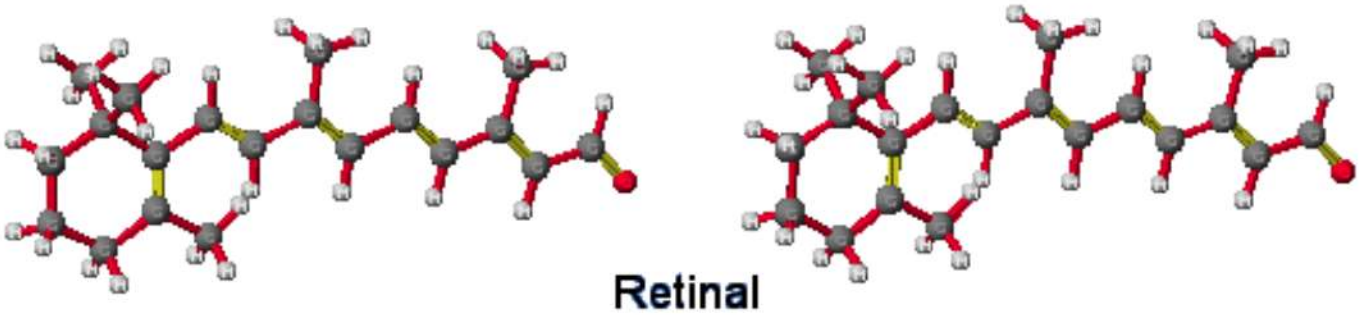
Vitamin A is a generic term including a group of fat-soluble organic compounds such as retinol, retinal, retinoic acid, and etc. Vitamin A is able to contribute to human vision after going through a number of steps..



The route that vitamin A takes to contribute to human vision is pretty intricate. At first, retinol (vitamin A), in the form of all-trans-retinol, is transported to the retina—a layer that locates itself at the back of the eye—and passed through the empty spaces in the retina to gather in retinal pigment epithelial cells (RPE). In the RPE, the collected all-trans-retinol is esterified to a retinyl ester, which is accumulated until demanded. When a photoreceptor cell—a cell in retina that transforms detected light into signals—requires it, retinyl ester is cleaved and isomerized into 11-cis-retinol to 11-cis-retinal via oxidation, which can now escape the RPE and join either of the two major photoreceptor cells: rod cell, which manages night vision, and cone cell, which is responsible for colour perception. As 11-cis-retinal is merged to either of the two photoreceptor cells, 11-cis-retinal can get together with a special protein named opsin to form rhodopsin (aka visual purple). After the formation of rhodopsin, it can absorb a photon of light and send the according signal to the brain. As a consequence, the rhodopsin is split into opsin and all-trans-retinal, which can be reduced to form all-trans-retinol that travels back to the RPE, completing the visual cycle.

Nonetheless, carrots are not the direct precursors of vitamin A. Instead, they contain an organic pigment called β-carotene, a type of carotenoid. Although not all of the 750 types of carotenoids are able to be converted to retinol (vitamin A), β-carotene is a provitamin A carotenoid, meaning that it can be transformed into retinol. Some other examples of provitamin A carotenoids include α-carotene and β-cryptoxanthin and some examples of non-provitamin carotenoids include lutein, zeaxanthin, and lycopene.





When an ordinary carrot is consumed, at some point when the carrot is being digested, the β-carotene in it will be cleaved into two identical molecules of retinal. The formed retinal could either be oxidized to form retinoic acid or reduced to form retinol, which can further be derived to form retinyl ester for storage.

As vitamin A is a key contributor to human vision, vitamin A, and therefore carrots might be misconstrued to 'improve' eyesight. However, consuming the required amount of vitamin A only has an effect on 'maintaining' vision and cannot exceed the natural limits of the human eyes.

ONLY CARROTS?

Although carrots are excellent suppliers of vitamin A, many other sources of vitamin A exist—mainly divided into plant sources and animal sources. Plant sources of vitamin A, including carrots, are mostly yellow, orange, and red fruits and vegetables as they contain provitamin A carotenoids—the precursors of vitamin A—which exist as coloured pigments. Many green vegetables also contain carotenoids, although their yellow and orange pigments are covered up by the strong green pigment of chlorophyll. Animal sources of vitamin A include animal products such as meat, fish, and diaries and contain retinyl esters (preformed vitamin A) instead of provitamin A carotenoids. This is a significant difference as the absorption of retinyl esters is an independent process, unlike the absorption of vitamin A from provitamin A carotenoids that is affected by various food-related factors such as: how processed the food is, the amount of dietary fat present in the meal, the food matrix, other carotenoids in the diet, and many more. In fact, the vitamin A equivalency ratio for β-carotene (from food sources) varys from 3.8:1 to 28:1. As this does not take the variance of absorption of β-carotene into the human body—which fluctuates from 5% to 65%—into account, the actual amount of vitamin A that a plant-based meal would give is nearly impossible to be anticipated.

DEFICIENCY

As said, vitamin A is essential for maintaining vision and if the required amount of vitamin A is not consumed, a series of problems related to vision—which eventually leads to blindness—occur.

The initial symptom that indicates vitamin A deficiency is weakened dark adaption, or night blindness. This is followed by anomalous changes happening in conjunctiva, a tissue that lines the eye and eyelids. If the deficiency is severe or ignored for a long period of time, it eventually causes xerophthalmia, a condition that ultimately results in blindness.

Although vitamin A deficiency is followed by dire consequences, people in developed countries rarely suffer from its symptoms since vitamin A can be consumed from an uncountable number of sources. However, when it comes to less developed countries, vitamin A deficiency is a very serious problem. Statistically, an estimate of 19.1 million pregnant women across the globe—especially in less developed regions such as Southeast Asia—suffer from vitamin A deficiency and over half of them have night blindness. Plus, 250,000 to 500,000 kids are becoming blind annually and vitamin A deficiency is one of the main causes of it—once again proving the significance of the issue.

CONCLUSION

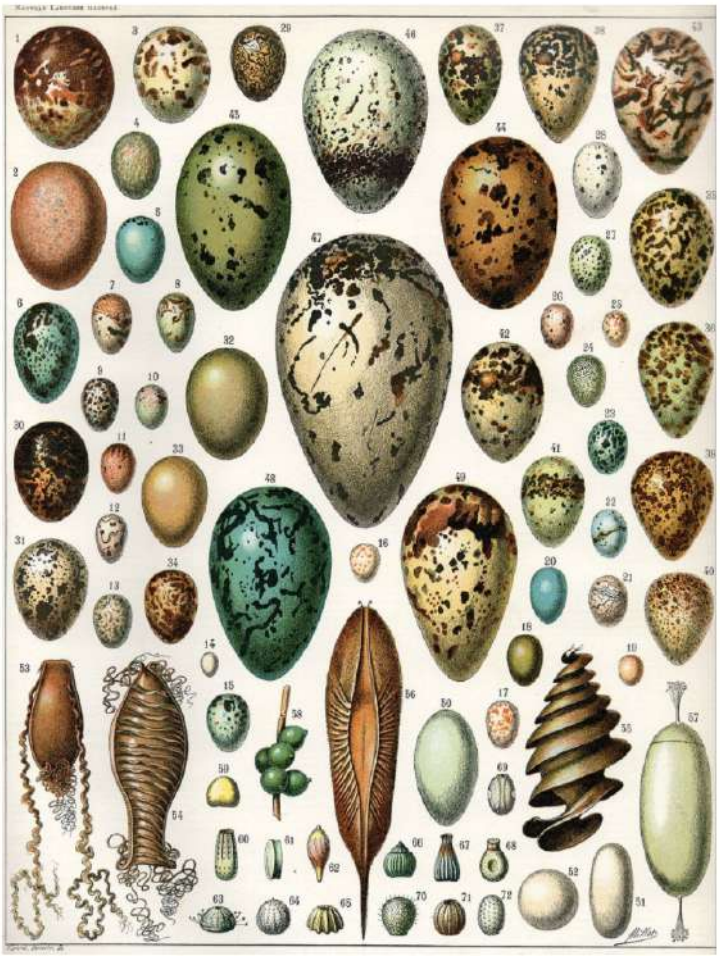
Clearly, eating carrots cannot give you supernatural eyesight like that of a hero in a movie. However, it does help you remain healthy in many ways such as: reducing carcinogenesis (the development of cancer cells from normal cells) and lowering the risk of cancer, decreasing diabetes risk, and of course, maintaining vision—so why not add a carrot to your daily meal?

BIBLIOGRAPHY

- HISTORY. 2015. Do carrots really improve your eyesight?. [online] Available at: <https://www.history.com/news/do-carrots-really-improve-your-eyesight> [Accessed 1 January 2021].
- Higdon, J., Drake, V. and Delage, B., n.d. Vitamin A. [online] Oregon State University - Linus Pauling Institute. Available at: <https://lpi.oregonstate.edu/mic/vitamins/vitamin-A#deficiency-related-disorders> [Accessed 2 January 2021].
- Cis.rit.edu. n.d. Rods & Cones. [online] Available at: <https://www.cis.rit.edu/people/faculty/montag/vandplite/pages/chap_9/ch9p1.html> [Accessed 2 January 2021].
- Higdon, J., Drake, V. and Delage, B., n.d. Carotenoids. [online] Oregon State University - Linus Pauling Institute. Available at: <https://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals/carotenoids#eye-diseases-prevention> [Accessed 3 January 2021].
- Manda, A., n.d. Vitamin A Food Sources. [online] News-Medical.net. Available at: <https://www.news-medical.net/health/Vitamin-A-Food-Sources.aspx> [Accessed 8 January 2021].
- Haskell, M., 2012. The challenge to reach nutritional adequacy for vitamin A: β-carotene bioavailability and conversion—evidence in humans. [online] OXFORD ACADEMIC - THE AMERICAN JOURNAL OF CLINICAL NUTRITION. Available at: <https://academic.oup.com/ajcn/article/96/5/1193S/4577160> [Accessed 8 January 2021].
- George, K., 2019. ANITA VAN DEN BROEK/SHUTTERSTOCK. [image] Available at: <https://www.tasteofhome.com/article/orange-skin-from-carrots/> [Accessed 1 January 2021].
- Draper, J., 2021. Doctor Carrot guards your health! A public health poster from WWII.. [image] Available at: <https://www.pinterest.com/pin/185351340883481966/> [Accessed 2 January 2021].
- Burgess, A., n.d. Child with severe xerophthalmia (Source: SIGHT AND LIFE. Used with Permission). [image] Available at: <http://www.southsudanmedicaljournal.com/archive/2008-02/mother-and-child-undernutrition-vitamin-a-deficiency.html> [Accessed 9 January 2021].

WHICH CAME FIRST, THE CHICKEN OR THE EGG?

BY GRACE ZHENG 12F



A chicken lays an egg; but without the egg, there would be no chicken. The 'chicken or egg' paradox was first devised by philosophers in Ancient Greece and has puzzled mankind since then. At first glance, the question seems to demonstrate classic circular reasoning with no answer, as one continually comes before the other which continually comes before that. However, science seeks to provide a solution to this classic question – so let's settle it once and for all; which came first, the chicken or the egg?

Illustration by French painter Adolphe Millot titled 'Oeufs', meaning eggs in French.

THE FIRST EGG

Initially, the question appears quite straightforward – egg-laying animals roamed the earth long before what we would consider to be the 'first chicken' came along. All female vertebrates laid eggs of one form or another, but it is thought that the earliest reptiles developed the eggshell: a mechanism that keeps eggs moist whilst allowing the female to venture further onto land to lay their eggs. Prior to the development of the egg shell, animals relied heavily on wet environments such as ponds and lakes for reproduction so their eggs would not dry out.

Eggshells represented a significant development in animal reproduction. Initially, amphibian eggs bore a similar appearance to frog eggs today – laid in water surrounded by a thick layer of jelly. The new egg had additional membranes inside that helped form a comprehensive, all-in-one system for the embryo. The embryo can respire, intake nutrients and store excess waste – all without the need for a second aquatic environment. Instead of the hard egg shells we see today, the embryo was thought to be surrounded by a tough, leathery pouch. However, these softer, leathery eggs (also thought to be the first amniotic eggs) would not have fossilized well, leaving no evidence for modern paleontologists to determine the development of eggs during what was to be known as the 'Egg Gap'', a period of time between the Paleozoic Era (541-252 million years ago) and the Mesozoic Era (252-66 million years ago).

There is no doubt that on the evolutionary timeline, the eggs came first. So, the question really should be: which came first, the chicken or the chicken egg?

THE FIRST CHICKEN

The ancestors of our modern chickens came much later than the development of the first eggs. The idea that chickens evolved from dinosaurs has been around since the 19th century. Modern birds are descendants of a specific group of dinosaurs known as the theropods, belonging to the group Theropoda.

Archaeopteryx fossils are often considered to be the transitional animals between dinosaurs and modern birds. Discovered in Germany in the 1860s, the word 'archaeopteryx' is a portmanteau of the words archaīos, meaning 'ancient', and ptéryx, meaning 'wing'. A specimen of the archaeopteryx discovered in Berlin found that the creature not only had flight feathers and tail feathers, but also leg feathers as well as a layer of fluffy body plumage. There are two theories as to why dinosaurs may have developed feathers. The first is for insulation. Since air is a poor insulator and feathers trap small pockets of air, the development of feathers prevents the body heat of the animal from escaping into the cold surroundings. The second is that feathers were developed for the purpose of being 'seen'. Just like how male peacocks use their feathers to attract a mate, dinosaurs could have used their feathers in a similar way. They could have also been used to confuse or scare away predators, whilst helping each dinosaur identify its own kind. Overall, the presence of feathers on dinosaurs for non-flight purposes indicates that feathers were slowly being adapted for a new use. Here, the archaeopteryx is commonly accepted by scientists as the first 'bird' — but their fossils came in time much later than the first egg fossils, at around 150 million years old.

This archaeopteryx fossil discovered in Berlin is one of the best preserved fossils of its kind

Then in 2007 and 2017 respectively, farmers in China discovered what would be the first fossils of two new species of dinosaurs - the Yi qi and the Ambopteryx. Initially, there was a lot of skepticism about whether they were even dinosaurs at all - weighing just half a kilogram, they had complex anatomical features and bat-like wing membranes, using their wings to glide through air. In competition with other tree-dwelling dinosaurs and early birds, they lived in what was to be ancient China and most likely went extinct around the same time the first Archaeopteryx came to be — around 150 million years ago. With a range of gliding animals in our modern world, ranging from squirrels to frogs to even snakes, this discovery shows that the evolution of animals into the air was not at all a linear one and is in reality, much more complex than we think.

An illustration reconstruction of the Ambopteryx

It is believed then that the features of birds then evolved one by one as dinosaurs became increasingly similar to our flying counterparts today: first bipedalism, then feathers, then a wishbone... so on and so forth. Paleontologists like Stephen Brusatte from the University of Edinburgh believe that the end product of this evolution is a “-seamless transition between dinosaurs and birds, so much that you can’t just draw an easy line between these groups.”

A couple hundred million years down the line, we arrive at the birth of the red junglefowl, also known to some as the “original chicken”. Much smaller than their modern domestic descendants, they are widely spread throughout South and Southeast Asia. In the early 2000s, it was confirmed through mitochondrial DNA testing that they were one of the main progenitors of our modern chicken.

Charles Darwin was one of the first to theorise that the domestic chicken was a descendent of the Red Junglefowl

It is believed that what arrives after the junglefowl is an animal that is quite like our modern chicken, but not exactly a chicken - a creature known to scientists as a ‘proto-chicken’. Then, the story goes two ways. The first scenario would be that two proto-chickens mated, and a mutation in the DNA of the zygote in that egg created the first chicken, which went on to lay real chicken eggs. Alternatively, it could be argued that the egg was in reality not a chicken egg, but rather, a proto-chicken egg which gave birth to the first chicken. However, ignoring the definition of whether it is a chicken or proto-chicken, for one thing is for sure — the first chicken came from an egg.

In reality, we cannot pinpoint the exact time the first chicken appeared - just like how we domesticated and bred dogs from wolves, there was no exact point when a ‘dog’ appeared. Overtime, as humans continued to domesticate the red junglefowl for meat (mainly breeding for white meat —

the chicken breast), their wings became increasingly smaller and as a result, their flight muscles were too large and heavy for them to take off into the air. The product of long periods of domestication of the red junglefowl is what most of us are familiar with — the modern chicken. In 1957, a chicken weighed 0.9kg at 56 days old. In 1978, that number increased to 1.8 kg; in 2005, a chicken weighed as much as 4.2 kg — almost a 470% increase.

In conclusion, there is no doubt that selective breeding by humans has had and will continue to have a significant impact on the development of other animal species. Although the lines between the development of different species are often very blurry, there is no doubt that in the question of the chicken or the egg, the egg came first.

BIBLIOGRAPHY

A Guide to the Different Parts of an Egg | Sauder's Eggs. Sauder's Eggs. (2020). Retrieved 5 December 2020, from https://www.saudereggs.com/blog/the-different-parts-of-an-egg/.

Adler, J., & Lawler, A. (2020). How the Chicken Conquered the World. Smithsonian Magazine. Retrieved 5 December 2020, from https://www.smithsonianmag.com/history/how-the-chicken-conquered-the-world-87583657/.

Hsi.org. (2020). Retrieved 5 December 2020, from https://www.hsi.org/wp-content/uploads/assets/pdfs/about_chickens.pdf.

YouTube. (2020). Retrieved 5 December 2020, from https://www.youtube.com/watch?v=c_CCmae8Wrc.

Colchester, & Greenwood. (2020). How chicken became the rich world's most popular meat. The Economist. Retrieved 5 December 2020, from https://www.economist.com/international/2019/01/19/how-chicken-became-the-rich-worlds-most-popular-meat.

Contributor, J. (2020). Archaeopteryx: The Transitional Fossil. livescience.com. Retrieved 5 December 2020, from https://www.livescience.com/24745-archaeopteryx.html.

Ehrlich, P., Dobkin, D., & Wheye, D. (2020). Eggs and Their Evolution. Web.stanford.edu. Retrieved 5 December 2020, from https://web.stanford.edu/group/stanfordbirds/text/essays/Eggs.html.

Hogenboom, M. (2020). Chicken grows face of dinosaur. Bbc.com. Retrieved 5 December 2020, from http://www.bbc.com/earth/story/20150512-bird-grows-face-of-dinosaur#:~:text=The%20idea%20that%20birds%20evolved,an%20early%20bird%20called%20Archaeopteryx.&text=By%20doing%20so%2C%20they%20have,small%20feathered%20dinosaurs%20like%20Velociraptor.

Science of Eggs: Anatomy of an Egg | Exploratorium. Exploratorium: the museum of science, art and human perception. (2020). Retrieved 5 December 2020, from https://www.exploratorium.edu/cooking/eggs/eggcomposition.html.

Singer, E. (2020). How Birds Evolved From Dinosaurs | Quanta Magazine. Quanta Magazine. Retrieved 5 December 2020, from https://www.quantamagazine.org/how-birds-evolved-from-dinosaurs-20150602/.

Singer, E. (2020). How Dinosaurs Shrank and Became Birds. Scientific American. Retrieved 5 December 2020, from https://www.scientificamerican.com/article/how-dinosaurs-shrank-and-became-birds/.

Valjak, D. (2020). The famous Berlin specimen of Archaeopteryx, a transition between dinosaur and bird, was found by a farmer who sold it to buy a cow. The Vintage News. Retrieved 5 December 2020, from https://www.thevintagenews.com/2018/02/27/berlin-specimen-of-archaeopteryx/.

What the world's oldest eggs reveal about dinosaur evolution. Phys.org. (2020). Retrieved 5 December 2020, from https://phys.org/news/2019-03-world-oldest-eggs-reveal-dinosaur.html.

Which came first: the chicken or the egg?. Curious. (2020). Retrieved 4 December 2020, from https://www.science.org.au/curious/earth-environment/which-came-first-chicken-or-egg.

"The Amazing Dinosaur Found (Accidentally) by Miners in ...." https://www.nationalgeographic.com/magazine/2017/06/dinosaur-nodosaur-fossil-discovery/. Accessed 5 Dec. 2020.

"Red Junglefowl (Gallus gallus) - Flickr." https://www.flickr.com/photos/avianphotos/6921889024. Accessed 27 Jul. 2020.

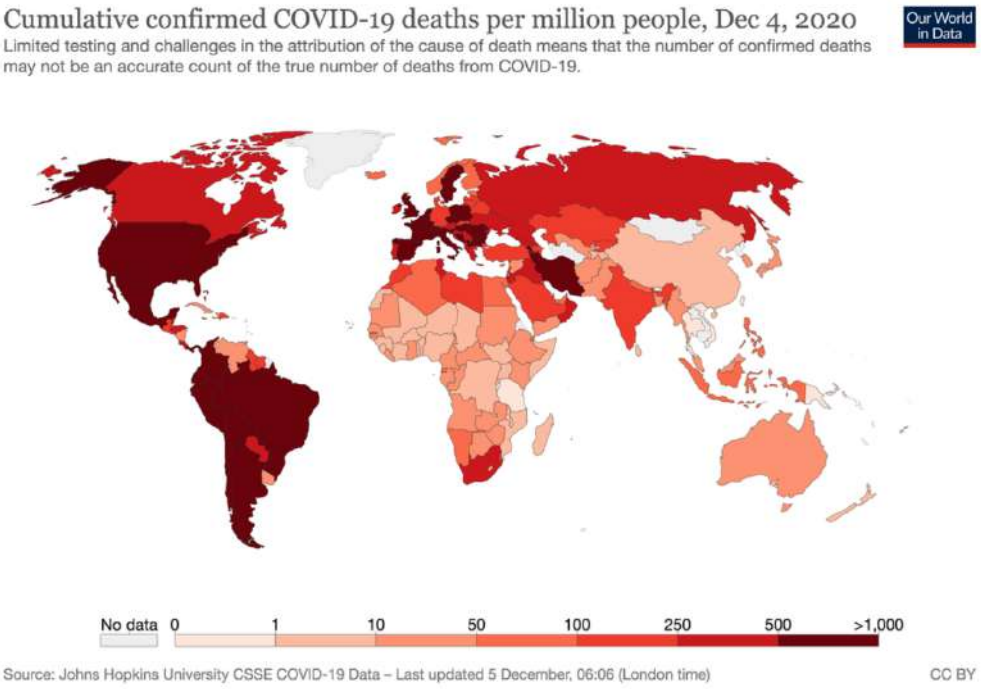
"Archaeopteryx: Facts about the Transitional Fossil | Live Science." 14 Mar. 2018, https://www.livescience.com/24745-archaeopteryx.html. Accessed 27 Jul. 2020.

"File:Adolphe Millot oeufs-fixed.jpg - Wikimedia Commons." https://commons.wikimedia.org/wiki/File:Adolphe_Millot_oeufs-fixed.jpg. Accessed 5 Dec. 2020.

CORONAVIRUS AND ITS EFFECTS ON THE HUMAN BODY

BY AYAHIKO USUI 12F

SARS-CoV-2 or Covid-19 or more commonly known as coronavirus is a virus that we all know too well now, it has disrupted the lives of hundreds of millions of people, shut down schools, businesses and whole economies and we see it on the news every day as new developments are made in combating this mutual enemy.



The first cases of coronavirus emerged in late 2019 in the Wuhan region of China and quickly spread throughout the region and to nearby countries. By late January, there were nearly 8000 cases worldwide in 19 different countries and the WHO declared the virus a Public Health Emergency of International Concern (PHEIC). In recent times, of course, 8000 cases seems like nothing, it looks as though that we see ten times that amount of cases per day in some countries.

Covid-19 has exploded worldwide and has been categorized as a global pandemic by the WHO since March 2020, marking history as the first coronavirus variant to be the cause of a global pandemic. As of the end of 2020, there have been over 81 million confirmed cases and over 1.7 million deaths across 220 different countries as a result of the extensive reach of Covid-19.

Although it is commonly just called coronavirus, SARS-CoV-2 is actually a type of coronavirus that belongs to a sub-type of viruses. Viruses also are a type of pathogen and pathogens are any organism that causes illness or harm to its host. Pathogens can also include types of bacteria and fungi that can also affect your body.

VIROLOGY

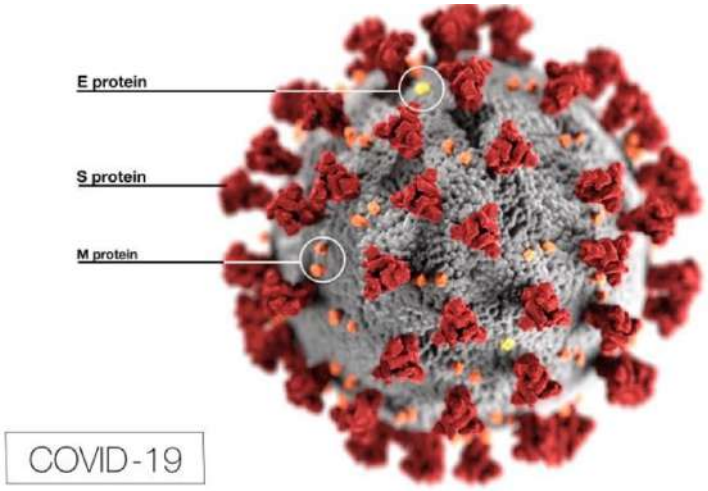
Coronavirus was first compared to the flu when not much information about it was known, however, we now know that it is more dangerous than the flu. This can be attributed to the highly contagious nature of the virus. It travels through the air and from person to person primarily through respiratory droplets originating from sneezing or coughing. Additionally, these droplets may land on surfaces and pose another threat of indirect transmission. Research indicates that the virus found in the droplets might remain infectious for up to three days on plastic and steel surfaces, but this decreases when it comes to cardboard, where it can only remain infectious for a day and further decreases on copper surfaces, on which it can only remain infectious for 4 hours. To prevent infection, governments globally have suggested the use of face masks and routine handwashing with soap. Face masks protect the virus from entering the mouth and nose and thus, prevent people from getting infected. has a protective layer on the shell, called a phospholipid bilayer, this makes up the overall structure of the virus and holds the genome inside. Soap and alcohol are able to disrupt this protective layer and essentially ‘deactivate’ and degrade the virus, preventing it from infecting other people

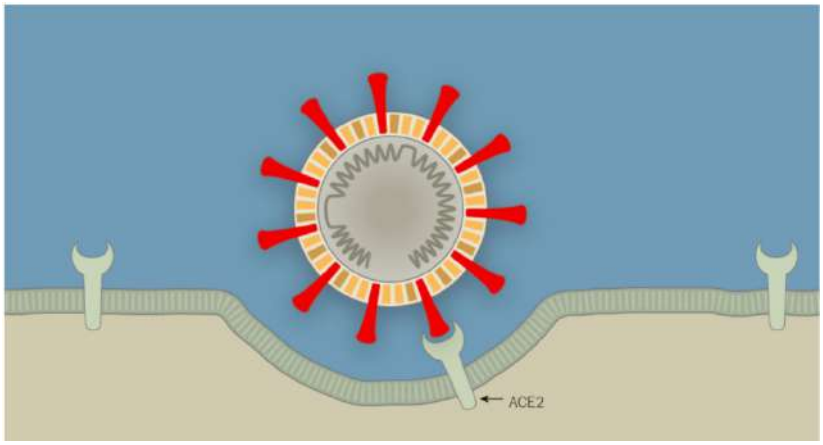
An important differentiating factor between the flu and coronavirus is the “R-naught” value. This value denotes the expected number of healthy people that are infected when one case of infection is present in the population.

The “R-naught” value of the coronavirus ranges from 3.3 to 5.7, which means for each infected person, between 3.3 to 5.7 new infections will be caused in the population if nobody is immune and no preventative measures are taken. On the other hand, the “R-naught” value for the seasonal flu ranges from 0.9 to 2.1. It is thought that this increased “R-naught” value is due to COVID-19’s ability to remain infectious on various surfaces for longer periods of time and also remain airborne for longer periods of time, raising the chance of other people passing through the area to be infected. The “R-naught” value of COVID-19 is significantly higher than that of the flu, pointing to the fact of how much more contagious and infectious the COVID-19 is compared to the flu, posing a new problem for the world to handle.

STRUCTURE AND INFECTION

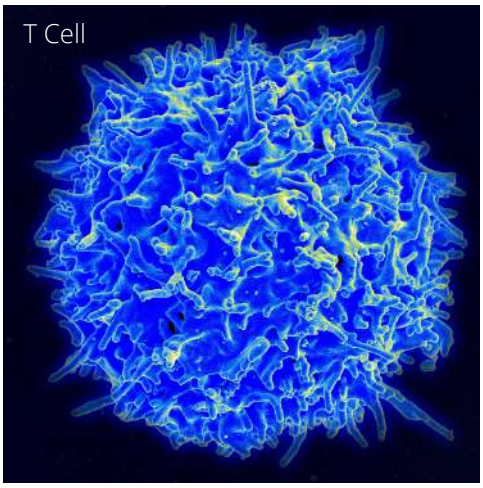
To talk about how coronavirus affects the human body, we must first talk about the structure of it and how that changes what it does. We’ve all seen the illustration of the virus, whether it be on the news, internet, or the signs posted up in malls. Each virus is a spherical shell that is a protective capsule for the genetic material inside and when a person gets infected, the virus ends up in the gateway of the human body, the nose and throat. The aim of every virus is to just replicate and replicate forever, making copies of itself until the host dies, where it then finds a new host and the process begins over. It is in the nose and throat where this process begins.



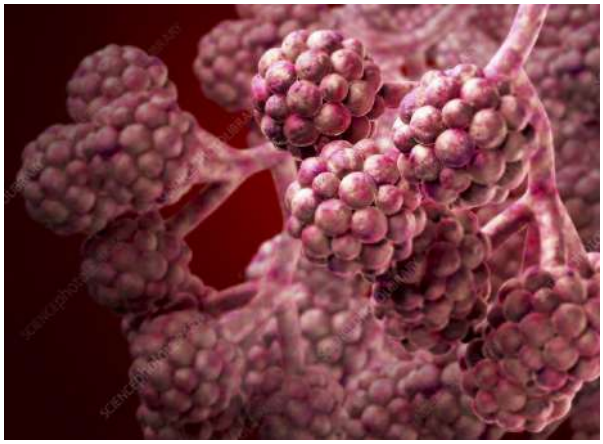


The cells that line your nose and throat are called epithelial cells and they contain an enzyme called ACE2 on the outside, which is important for regulating the blood pressure in the body. However, these ACE2 enzymes also make these cells particularly vulnerable to infection as the coronavirus prefers to infect cells that contain this particular enzyme. It does this by using the long spike proteins found all over the surface, illustrated in red on the diagram, and attaches itself to the aforementioned enzyme. Once this has occurred, the spike protein is able to gain access to the cell by unfolding its protein structure and hooking into the cell membrane and inserts its genome.

The cell has no idea what is going on and accepts this new material as its own, it then begins to carry out the instructions that the material carries, which is to make parts of the virus and reassemble them into the original virus, acting like a virus factory. Because the cell is carrying out its new instructions, it cannot sustain its normal life processes and once the cell reaches a critical point of viruses, the cell dies, and the membrane holding the cell and viruses breaks and releases its contents, making it possible for the new batch of viruses to go on and infect other cells, starting the process all over again.

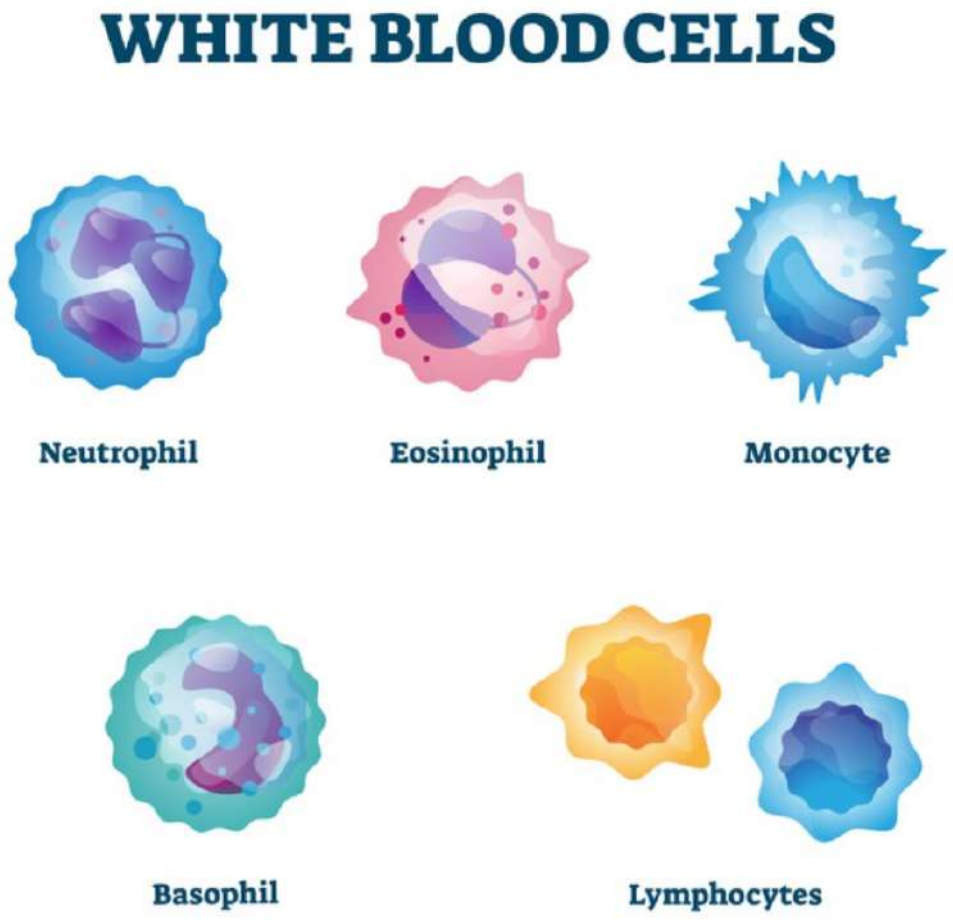


There is a special white blood cell, called a T cell that circulates the body looking for and identifying infected cells. Once it has identified an infected cell, it alerts other white blood cells using a protein called a cytokine. Cytokines signal other white blood cells and the immune system that there is an infection present in the body. Once the pathogen has been identified, and if it is a virus, B lymphocytes start producing and releasing antibodies in response to the presence of antigens found on the surface of the virus. Antibodies work in a number of ways and one of them is to neutralize the virus and prevent it from infecting any more cells. They can also work together and bind the viruses to each other in a process called agglutination. This makes it easier for other immune cells to deal with the virus properly. The third way the antibodies combat viruses is to signal phagocyte cells to arrive, another type of immune cell. These cells are able to completely engulf and destroy the virus by releasing digestive enzymes using a process called phagocytosis.



That is the usual response of the body to a virus and it will do the same thing for COVID-19. However, if the body is not able to naturally beat the virus using its own immune system, the virus is able to make its way to the lungs, where it can turn deadly. Your lungs contain structures called alveoli, which are tiny air sacs that allow your body to receive oxygen and get rid of carbon dioxide. Without them, the body would not be able to receive oxygen and the body would start to die. The cells lining these alveoli are also abundant in ACE2, which also makes it susceptible to infection by the coronavirus. The virus replicates and replicates in the lungs, exactly the same as how it reproduced in the nose and throat, except this time, the immune system response starts to harm the person as well. While the body is battling the virus, it leaves an array of destruction behind - millions of dead white blood cells , this forms pus in the alveoli and is

the start of pneumonia, a symptom that makes it hard for the person to breathe. It can also leave permanent damage on the alveoli by forming scar tissue on the surface and reducing the effectiveness of the alveoli of transporting oxygen and carbon dioxide.

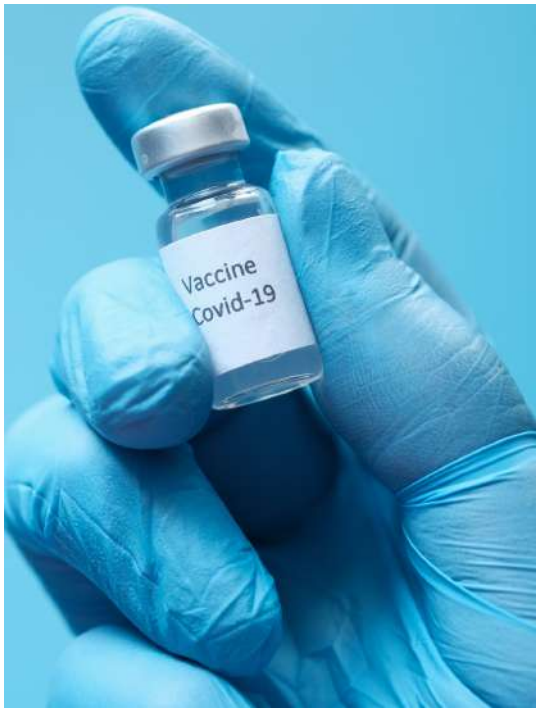


Furthermore, another reason why it can turn deadly is the overreaction of the body's immune system. Cytokines, which were previously mentioned, are proteins that signal a healthy immune response to the infection. Coronavirus, along with other specific pathogens, can trigger what is called a "cytokine storm" where the number of cytokines far exceeds the amount that is necessary. This results in the body sending many more immune cells than needed, wasting resources, energy and damaging the body. There are two types of immune cells that play a large role in damaging the body when a cytokine storm is triggered, neutrophils and killer T cells. Neutrophils are a type of phagocyte, a cell which can engulf and destroy viruses, unfortunately, it can target the wrong cells and also release enzymes that can kill healthy cells and because of the excessive amount of these cells, they often kill as many viruses as healthy cells. Killer T cells are also called cytotoxic T cells because of the way they kill cells. Cytotoxic means toxic to living cells and killer T cells contain cytotoxins that they "inject" into the infected cell and this causes the cell to die. Due to the unnaturally large number of cytokines present, too many killer T cells are at the site of infection and they start to also inject cytotoxins into healthy cells, killing them in the process.

While the immune system is responding to the virus and trying to fight it off, another type of pathogen might slip in and cause more damage to the body. Due to the cytokine storm and the immune system response, the body lacks enough resources to guard and fight against another infection. Bacteria might slip in, and while this would usually not be a problem, the immune system is so focused on fighting coronavirus that it doesn't have the resources to detect it and fight it as it normally does. It makes its way into the lungs, where the response brought by the cytokine storm has destroyed the lungs protective lining and bacteria is able to infect the alveoli, causing pneumonia and a multitude of new problems. Breathing becomes very hard at this point and most patients become critical and need a ventilator, a machine that helps them breathe, to survive.

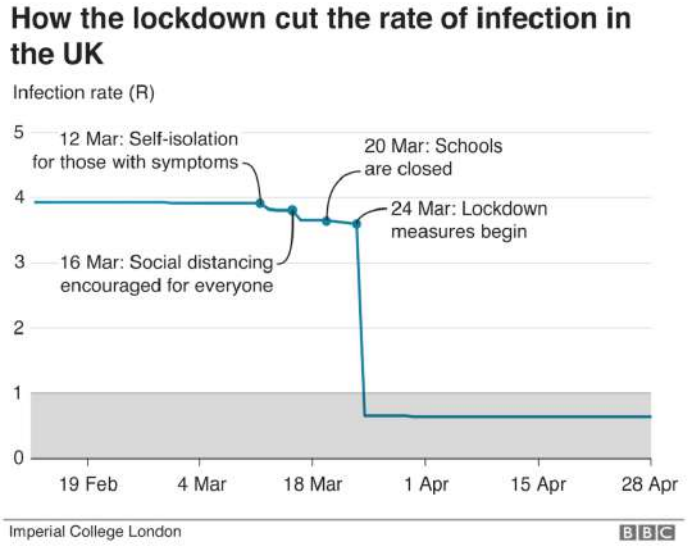
Fortunately, most cases do not turn out like this and most patients recover with mild symptoms, currently, only 0.5% of patients are critical and the rest are in mild conditions and are able to recover without the use of a ventilator.

CONCLUSION



While all this news might seem negative, there are progressions made in science everyday and people around the world are working extremely hard to try and combat this virus. In fact, we've already made huge strides against this virus, there are already 5 vaccines that are approved in specific countries and in use currently. Out of the 5, 3 vaccines are reporting an efficacy rate of over 90%, with the highest being produced by Pfizer-BioNTech, a collaboration between Pfizer, an American pharmaceutical company and BioNTech, a German biotechnology company, their study in The New England Journal of Medicine showed that the vaccine was safe and 95% effective in patients aged 16 or older. There are some doubts on whether the vaccine produced by The Gamaleya National Center of Epidemiology and Microbiology in Russia had gone through enough rigorous testing with a suitable number of cases. Gamaleya reported a 92% efficacy of their vaccine, named Sputnik, but this was based only on 20 cases, which some scientists say is too few to be convincing.

The Pfizer-BioNTech vaccine has recently been granted emergency use approval by the WHO, allowing organisations such as UNICEF and the Pan-American Health Organization to procure and distribute the vaccine to countries that need it.



As we learn more about the virus and how it interacts with us and the environment, we are getting better in improving measures to prevent further and more serious infection. We now know that social distancing is incredibly useful in preventing the spread of the virus and this is reflected in the decrease of the "R nought" value in countries that have implemented lockdown or social distancing measures such as the UK; before any such measures were taken the "R nought" value nearly reached 4, however once lockdown procedures were implemented, it reduced the value to below 1, this is just one example of how we are getting better at understanding the virus and how to protect ourselves.

BIBLIOGRAPHY

Andersen, Kristian G., et al. "The Proximal Origin of SARS-CoV-2." Nature News, Nature Publishing Group, 17 Mar. 2020, www.nature.com/articles/s41591-020-0820-9.

Bardoel, Bart W., et al. "The Balancing Act of Neutrophils." Cell Host & Microbe, Cell Press, 14 May 2014, www.sciencedirect.com/science/article/pii/S1931312814001450.

Coburn, Brian J, et al. "Modeling Influenza Epidemics and Pandemics: Insights into the Future of Swine Flu (H1N1)." BMC Medicine, BioMed Central, 22 June 2009, www.ncbi.nlm.nih.gov/pmc/articles/PMC2715422.

"Coronavirus Cases." Worldometer, Worldometer, 2020, www.worldometers.info/coronavirus/.

Couzin-Frankel, Jennifer, et al. "How Does Coronavirus Kill? Clinicians Trace a Ferocious Rampage through the Body, from Brain to Toes." Science, American Association for the Advancement of Science, 17 Dec. 2020, www.sciencemag.org/news/2020/04/how-does-coronavirus-kill-clinicians-trace-ferocious-rampage-through-body-brain-toes.

Cuffari, Benedette. "The Size of SARS-CoV-2 Compared to Other Things." News, News Medical Life Sciences, 16 July 2020, www.news-medical.net/health/The-Size-of-SARS-CoV-2-Compared-to-Other-Things.aspx.

"Getting Your Workplace Ready for COVID-19." World Health Organisation, World Health Organisation, 3 Mar. 2020, www.who.int/docs/default-source/coronaviruse/getting-workplace-ready-for-covid-19.pdf.

Giaimo, Cara. "The Spiky Blob Seen Around the World." The New York Times, The New York Times, 1 Apr. 2020, www.nytimes.com/2020/04/01/health/coronavirus-illustration-cdc.html.

Gibbens, Sarah. "Why Soap Is Preferable to Bleach in the Fight against Coronavirus." Science, National Geographic, 18 Mar. 2020, www.nationalgeographic.com/science/2020/03/why-soap-preferable-bleach-fight-against-coronavirus/.

Goldman, Bruce. "How the Coronavirus Destroys Cells and How Scientists Attempt to Disarm It." Stanford Medicine, Stanford Medicine, 15 Oct. 2020, stanmed.stanford.edu/2020issue2/how-coronavirus-destroys-cells-treatments.html.

Gorbalenya, Alexander, et al. "The Species Severe Acute Respiratory Syndrome-Related Coronavirus: Classifying 2019-NCoV and Naming It SARS-CoV-2." Nature Microbiology, U.S. National Library of

"HKUMed Researchers Discovered Novel Coronavirus (SARS-CoV-2) Can Infect More Efficiently than SARS-CoV in Human Airways and Eyes, Implicating That Eyes May Be an Important Route of SARS-CoV-2 Human Infection - All News - Media - HKU." The University of Hong Kong, The University of Hong Kong, 8 May 2020, www.hku.hk/press/news_detail_20976.html.
Hoffmann, Markus, et al. "SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor." Cell, Elsevier Inc., 16 Apr. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7102627.
"How COVID-19 Spreads." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 28 Oct. 2020, www.cdc.gov/coronavirus/2019-ncov/about/transmission.html.
Janeway, Charles. "T Cell-Mediated Cytotoxicity." Immunobiology: The Immune System in Health and Disease. 5th Edition., U.S. National Library of Medicine, 1 Jan. 1970, www.ncbi.nlm.nih.gov/books/NBK27101/.
Kurzgesagt. "The Coronavirus Explained & What You Should Do." YouTube, YouTube, 19 Mar. 2020, www.youtube.com/watch?v=BtN-goy9VOY.
Laing, Kerry. "Immune Responses to Viruses." British Society for Immunology, British Society for Immunology, www.immunology.org/public-information/bitesized-immunology/pathogens-and-disease/immune-responses-viruses.
"Listings of WHO's Response to COVID-19." World Health Organization, World Health Organization, 15 Dec. 2020, www.who.int/news/item/29-06-2020-covidtimeline.
Lodish, Harvey. "Viruses: Structure, Function, and Uses." Molecular Cell Biology. 4th Edition., U.S. National Library of Medicine, 1 Jan. 1970, www.ncbi.nlm.nih.gov/books/NBK21523/.
MacDonald, Anna. "Antigen vs Antibody – What Are the Differences?" Technology Networks, Technology Networks, 6 July 2020, www.technologynetworks.com/immunology/articles/antigen-vs-antibody-what-are-the-differences-293550.
Mandal, Ananya. "What Are Cytokines?" News, News Medical Life Sciences, 26 Feb. 2019, www.news-medical.net/health/What-are-Cytokines.aspx.
Milligan, Gregg N., and A. D. T. Barrett. Vaccinology: an Essential Guide. John Wiley & Sons, Ltd, 2015.
"Naming the Coronavirus Disease (COVID-19) and the Virus That Causes It." World Health Organization, World Health Organization, 28 Feb. 2020, www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it.
Neuman, Benjamin. "What the Coronavirus Does to Your Body That Makes It so Deadly." The Conversation, The Conversation, 2 Dec. 2020, theconversation.com/what-the-coronavirus-does-to-your-body-that-makes-it-so-deadly-133856.
Ojo, Ademola S., et al. "Pulmonary Fibrosis in COVID-19 Survivors: Predictive Factors and Risk Reduction Strategies." Pulmonary Medicine, Hindawi, 11 Aug. 2020, www.hindawi.com/journals/pm/2020/6175964/.
Roe, Kevin. "High COVID-19 Virus Replication Rates, the Creation of Antigen–Antibody Immune Complexes and Indirect Haemagglutination Resulting in Thrombosis." Wiley Online Library, John Wiley & Sons, Ltd, 3 June 2020, onlinelibrary.wiley.com/doi/full/10.1111/tbed.13634.
Sanche, Steven, et al. "High Contagiousness and Rapid Spread of Severe Acute Respiratory Syndrome Coronavirus 2." Emerging Infectious Diseases, Centers for Disease Control and Prevention, 26 July 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7323562/.
Segal, Anthony W. "How Neutrophils Kill Microbes." Annual Review of Immunology, U.S. National Library of Medicine, 2005, www.ncbi.nlm.nih.gov/pubmed/15771570.
"Similarities and Differences between Flu and COVID-19." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 29 Dec. 2020, www.cdc.gov/flu/symptoms/flu-vs-covid19.htm.
Sriram, Krishna, et al. "What Is the ACE2 Receptor, How Is It Connected to Coronavirus and Why Might It Be Key to Treating COVID-19? The Experts Explain." The Conversation, The Conversation, 12 Nov. 2020, theconversation.com/what-is-the-ace2-receptor-how-is-it-connected-to-coronavirus-and-why-might-it-be-key-to-treating-covid-19-the-experts-explain-136928.
van Doremalen, Neeltje, et al. "Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1." The New England Journal of Medicine, Massachusetts Medical Society, 16 Apr. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7121658.
"WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020." World Health Organization, World Health Organization, 11 Mar. 2020, www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.
Yuen, Kit-San, et al. "SARS-CoV-2 and COVID-19: The Most Important Research Questions." Cell & Bioscience, BioMed Central, 16 Mar. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7074995/.
Sheikh, Knvul, et al. "How Bad Will the Coronavirus Outbreak Get? Here Are 6 Key Factors." The New York Times, The New York Times, 31 Jan. 2020, www.nytimes.com/interactive/2020/world/asia/china-coronavirus-contain.html.
McKeever, Amy. "CDC Reports First Data on COVID-19 Vaccine Adverse Events." Science, National Geographic, 28 Dec. 2020, www.nationalgeographic.com/science/health-and-human-body/human-diseases/coronavirus-vaccine-tracker-how-they-work-latest-developments-cvd/.
Zimmer, Carl, et al. "Coronavirus Vaccine Tracker." The New York Times, The New York Times, 10 June 2020, www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html.
Wires, News. "WHO Grants Emergency Use Approval for Pfizer Covid-19 Vaccine." France 24, France 24, 31 Dec. 2020, www.france24.com/en/health/20201231-who-gives-emergency-approval-for-pfizer-vaccine-1.
Gallagher, James. "Covid Vaccine Update: When Will Others Be Ready?" BBC News, BBC, 8 Dec. 2020, www.bbc.com/news/health-51665497.

PHANTOM AND SUPERNUMERARY PHANTOM LIMB

BY MEGAN CHAN 12N

INTRODUCTION

Supernumerary phantom limb and phantom limb - both so similar yet so different - both being sensations of a limb which isn't there. However, let's first start off with the easier one - phantom limb.

WHAT EXACTLY IS A PHANTOM LIMB?

Phantom limb exists when someone has received and experienced feelings and sensations of a missing/amputated limb that has been removed. Approximately, 80% to 100% of patients who received an amputation of a limb, suffer from this common syndrome. Nonetheless, some still suffer from phantom limb pain which is pain endured in an area where the limb has been amputated (pain from something which simply isn't there). Patients are able to think that the limb is still there due to the nerve endings which continue to send pain signals to the brain in spite of the fact that the limb is gone. In some cases, patients may feel an agonizing pain or even lead to sorts of disabilities, some may even battle a lifetime of chronic pain.

WHAT IS SUPERNUMERARY PHANTOM SYNDROME?

Supernumerary phantom limb syndrome (SPL) is a rare neurological phenomenon which is when a patient misperceives another set of limb which wasn't there entirely. Unlike Phantom Limb syndrome, instead of perceiving a limb that has been amputated, cases of SPL involve patients perceiving a limb in addition to their original set of limbs.

CASE STUDY: PATIENT WHO SUFFERED WITH BASAL GANGLIA HEMORRHAGE EXPERIENCED SPL

In 2017 a patient who was a 78 year old male suffered an episode of a right basal ganglia hemorrhage (a bleed on the right side of the brain) who had a medical history of hypertension which is also known as high blood pressure. 2 days after this incident, the patient expressed a feeling of a phantom arm protruding from his left shoulder in addition to his paretic arm. He claimed that he was able to deliberately move this phantom arm individually from his paretic arm. The phantom arm resembled his paretic arm in shape and size, as well as strength. He was able to wave, move and grip objects with his phantom arm. However, when he was asked to hold a ball, he mentioned that the ball consistently felt like it was slipping out of his hands.

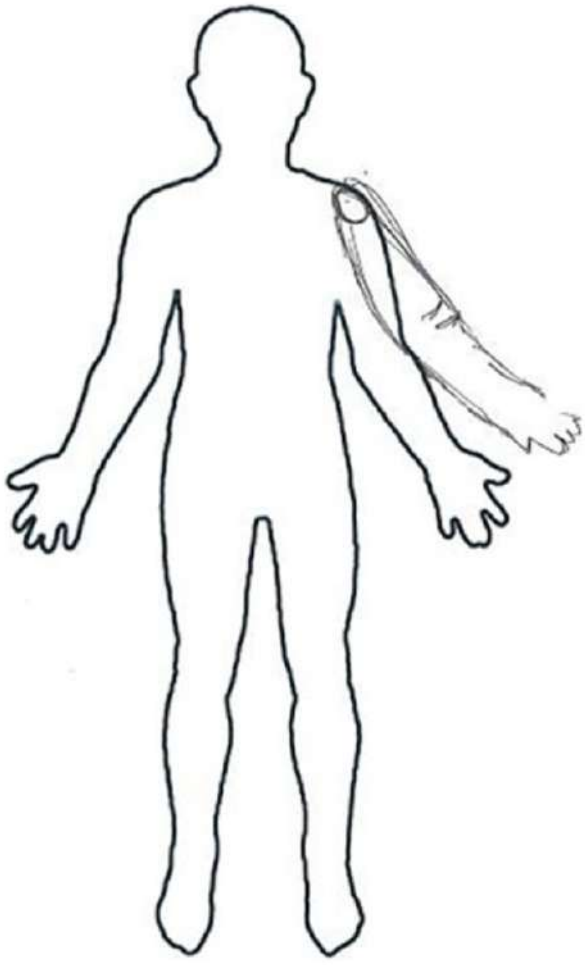


Fig 2 - drawing of supernumerary phantom limb described by patient

The patient was examined with a Mini-mental state exhibition which he scored a 30/30 on. He was also aware that his phantom arm was not real and not normal. The US national library of medicine claims that "He showed no sign of seizure, and the electroencephalography showed that he had normal brain activity. A follow-up neurological examination revealed no deterioration, and brain CT showed no significant changes in the hemorrhage (brain bleed)." Thus he was diagnosed with a complication of his right basal ganglia hemorrhage (bleeding on the right side of the brain) and was treated with anti-hypertensive medications (medications to help and reduce high blood pressure). His phantom arm persisted for 3 weeks which slowly faded away.

CONCLUSION

After taking into consideration the 28 recorded cases of SPL, doctors have concluded cases of SPL were more frequently found on or related to the right side of the brain. However, the reason for this is still unclear and specific treatment protocols have yet to be developed. Cases of SPL tend to come after brain bleeds, strokes and injuries of the spinal cord, all linking back to the neurological connection it lies within. Nonetheless, doctors and researchers have come to consider that the intentional movement of the phantom arm shows that SPL might be a result of "from the impairment of the sensory feedback system for both internal body image and motor movement." - quote the US national library of medicine.

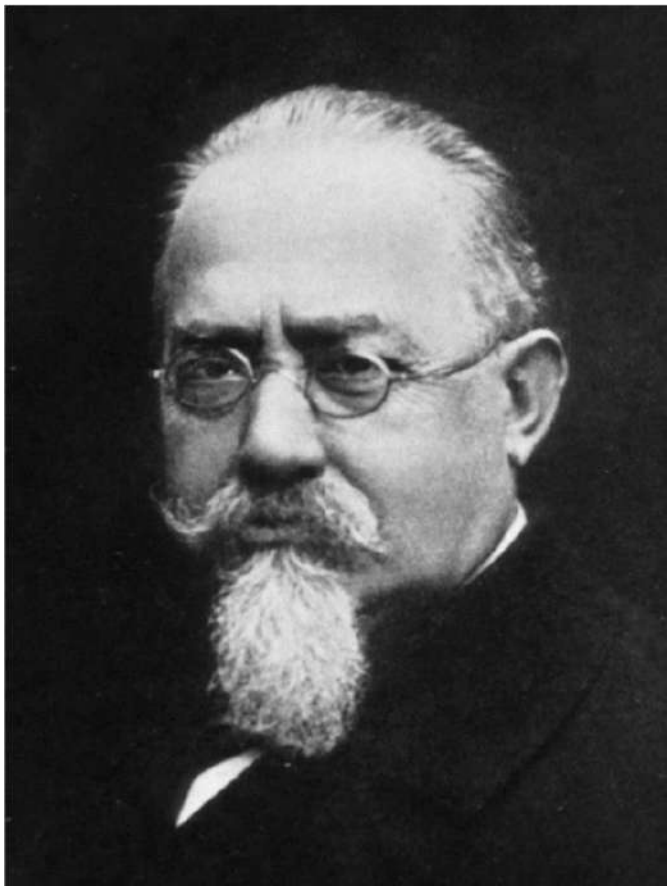
BIBLIOGRAPHY

https://neurosciencenews.com/phantom-limb-treatment-9810/
https://www.winchesterhospital.org/health-library/article?id=96857
https://www.mayoclinic.org/diseases-conditions/phantom-pain/symptoms-causes/syc-20376272
https://www.uofmhealth.org/health-library/ty6877
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5591514/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1014815/?page=1

THE KILLER BRAIN - INSIDE THE MIND OF A CRIMINAL

BY KIMBERLEY NG 12N

It's normal to watch the news to find that a person has committed a crime isn't it? Through years of research and investigations into criminals, scientists and criminologists have long wondered why criminals do the things they do. Are some humans born to be killers or are they slowly molded into one? Evidence has shown that many different factors can contribute to the making of a criminal mind, these include biological influences, social factors as well as environmental factors.



Cesare Lombroso, an Italian criminologist, suggested that criminal behaviour can be predicted based on three statements: a criminal can be identified by physical traits, violent behaviour can be inherited, and criminals are a form of earlier primitive humans. Although his findings are not recognised anymore due to their controversy, it did spark an interest in researchers that such a thing as a biological basis to a criminal brain may in fact exist and inspired the making of the field of neurocriminology.

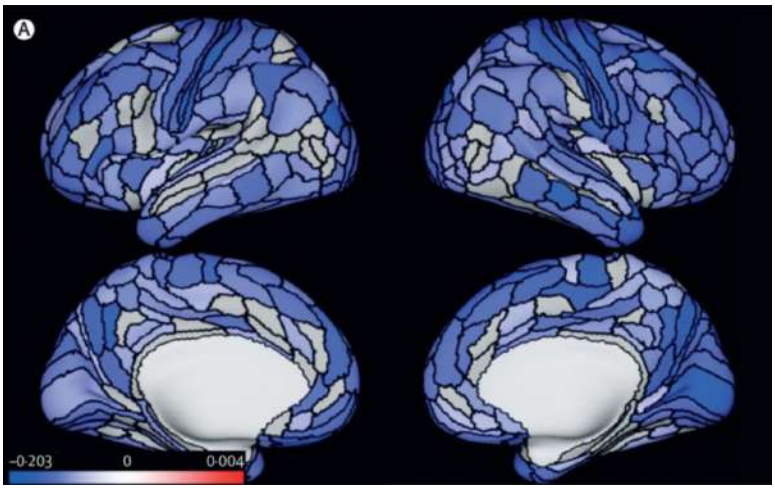
New technology using brain scans have been able to compare the brains of criminals to brains of 'normal' people, to better understand how and if their minds really are different. Dr Adrian Raine, one of the leading neurocriminoligists, conducted one of the earliest brain scans on murderers in the 1990s. Using PET scans (positron emission tomography) a radioactive tracer is injected to show tissue metabolic activity. The scans revealed that the prefrontal cortex of the brain showed the most differences between the murderers and the 'normal' people. The orbital frontal cortex which is a part of the prefrontal cortex, is the decision-maker of the brain along with the morals and ethicality of those decisions. Dr Raine found that the murderers' brains had considerably less activity present than in the brains of average people. This shows that murderers may not be able to control their violent tendencies as their orbital frontal cortex does not function normally.

Many factors can contribute to the overall levels of activity and all the factors can be categorised into either 'nature' or 'nurture'; born to be a killer or brought up to be one.

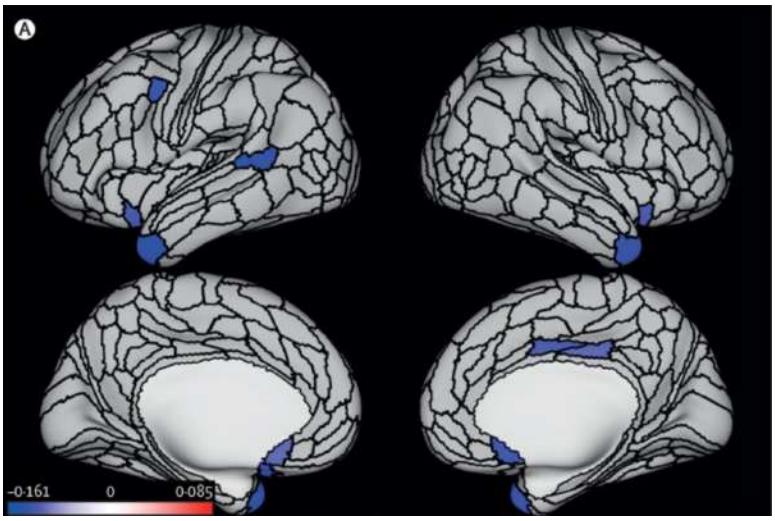
NATURE

The main factor that contributes to the nature of a person's violence is their genetics, which means some people are naturally prone to expressing violent behaviour - more so to those who have been diagnosed with antisocial personality disorder (APD). Those with antisocial personality disorder are unable to empathise with other people's feelings and are also incapable of feeling compassion towards others or feeling regret after they have committed a crime. Their inability to empathise with others combined with their constant desire to thrill-seek makes the nature of their crimes unsurprising.

There have been studies that have shown that the brains of criminals are inherently smaller. A study led by University College London which was published in the Lancet Medical Journal by Dr Christina Carlisi and Professor Essi Viding, found brain differences between people who exhibited antisocial behaviour and had committed crimes only in their adolescence, and those who have continued to commit crimes throughout adulthood. After studying three groups, one where everyone had no history of antisocial behaviour, one where everyone had antisocial behaviour only limited to their adolescence and one where everyone had persistently exhibited antisocial behaviour. Results showed that people with persistent antisocial behaviour had a smaller mean surface area in 282 of 360 brain regions and a thinner cortex in 11 of 360 brain regions, these affected brain regions have been linked to the functions of controlling emotions and motivation. With a decreased surface area and thinner cortices, the overall brain becomes smaller.



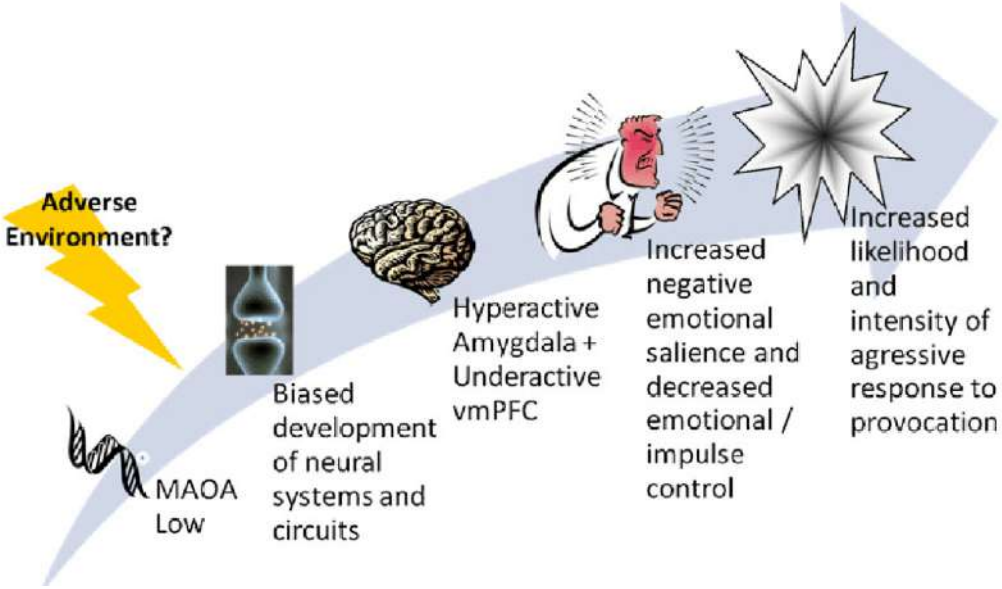
Picture above shows the average brain of a criminal with persistent antisocial personality disorder. Areas in blue are where surface area has decreased (the darker the blue, the more change has occurred).



Second picture above again shows the typical brain of a long term offending criminal with persistent antisocial personality disorder. This time, the blue areas show the cortexes that have become thinner within their brains.

Pictures: Carlisi et al. "Associations between Life-Course-Persistent Antisocial Behaviour and Brain Structure in a Population-Representative Longitudinal Birth Cohort." The Lancet Psychiatry 7, no. 3 (February 17, 2020): 245–53. https://doi.org/10.1016/s2215-0366(20)30002-x.

You may also have heard of the warrior gene, otherwise known as a gene that releases an enzyme called MAOA. The MAOA released regulates the levels of neurotransmitters that control impulse behaviour, fight or flight reactions as well as controlling moods, these neurotransmitters are otherwise known as dopamine, serotonin and epinephrine. There are different variations of this gene that result in different levels of enzyme activity; if they produce high
enzymatic activity, they will have MAOA-H;, if they produce less enzymatic activity, they will have MAOA-L. People with less enzyme activity will not be able to regulate neurotransmitters as efficiently., Rose McDermott, a professor at Brown university, conducted research that found that the presence of MAOA-L could predict more aggressive behaviour in response to provocation and could make a person more prone to inciting violent behaviour.

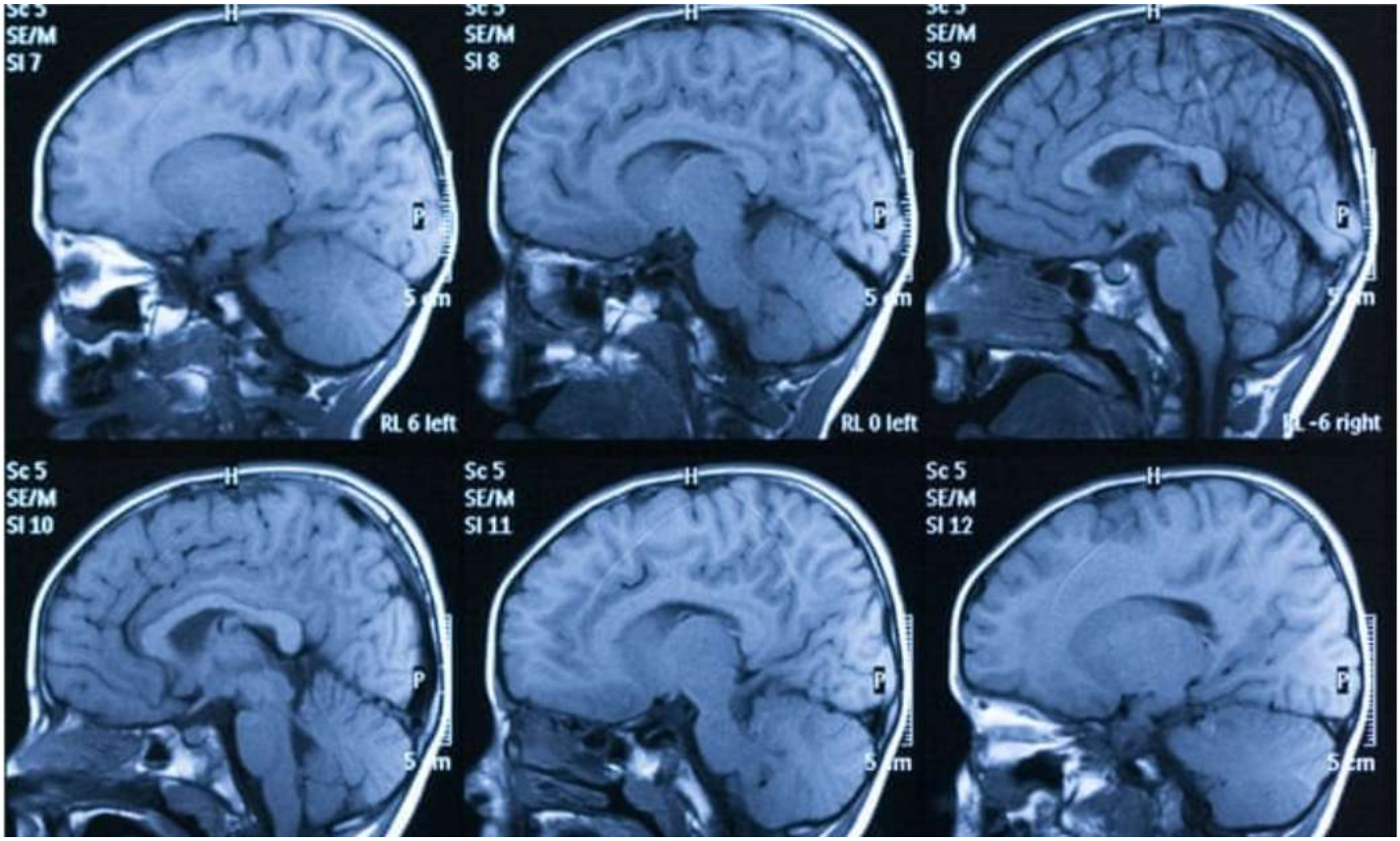


NURTURE

The nurture explanations are based on the fact that one's upbringing and environmental influences have had an effect and further urged a person into becoming a criminal. Brain injuries are the largest factors that may contribute to a person becoming a criminal.

Research from the University of Southern California carried out by Adriane Raine, a leading criminologist, as previously mentioned found that there were abnormalities in metabolic activity in up to six areas in the brains of murderers. He found that there was significantly less glucose uptake in the prefrontal cortex, corpus callosum and the posterior parietal cortex. When comparing the two hemispheres of a murderer's brain, there was less glucose uptake in the amygdala and the hippocampus of the left hemisphere - the more rational side; however in the right hemisphere which is seen as the more emotional side, comprised of the thalamus, amygdala and hippocampus, was functioning normally.

The weak activity due to the low glucose uptake in those areas explain why criminals may not be able to learn from their mistakes and will continue to act on impulse. Raine ruled out mental disorders being the cause of this weak activity because there is no known mental disorder that damages all six of the brain areas. The known causes of brain damage to these areas are shaken baby syndrome, fetal alcohol syndrome and preeclampsia.



A baby's brain is very fragile - the slightest harsh movement could cause subtle brain damage to the prefrontal cortex in the baby resulting in shaken baby syndrome. This damage is not obvious or observable but could affect the baby in the future as it will encourage violent behaviour.

Even before a baby is born, if the fetus is exposed to alcohol (fetal alcohol syndrome), it increases the chances of damaging the corpus callosum. The corpus callosum is the connection between the two hemispheres of the brain and is responsible for communication between the more emotional hemisphere and the rational hemisphere.

Preeclampsia is a pregnancy condition where the mother experiences high blood pressure, this could cause damage to the baby's hippocampus. Damage to the hippocampus could disrupt the impulses that are relayed from the limbic system to the prefrontal cortex.

CONCLUSION

All these different conditions show that more than one variable can affect a person's brain and cause someone to more likely commit crimes, the brain is very susceptible to changes whether those come from the environment or from their genetics.

BIBLIOGRAPHY

Jay, Lindsey. "'Criminal Minds: The Biological Basis of Criminal Behavior' ." The Triple Helix @ UChicago, September 2, 2015. https://thetriplehelix.uchicago.edu/tth-epub-fall2015/2018/2/10/criminal-minds-the-biological-basis-of-criminal-behavior-by-lindsey-jay.

PET/CT - Positron Emission Tomography/Computed Tomography. Radiological Society of North America (RSNA) and American College of Radiology (ACR). Accessed December 11, 2020. https://www.radiologyinfo.org/en/info.cfm?pg=pet.

Volz, Kirsten G., and D. Yves von Cramon. "How the Orbitofrontal Cortex Contributes to Decision Making - A View from Neuroscience." Progress in Brain Research. Elsevier, May 26, 2009. https://www.sciencedirect.com/science/article/pii/S0079612309013065.

Pascual, Leo, Paulo Rodrigues, and David Gallardo-Pujol. "How Does Morality Work in the Brain? A Functional and Structural Perspective of Moral Behavior," September 12, 2013. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3770908/.

Ucl. "Lifelong Antisocial Behaviour Linked to Brain Structure Differences," February 18, 2020. https://www.ucl.ac.uk/news/2020/feb/lifelong-antisocial-behaviour-linked-brain-structure-differences.

Chalmers , Vanessa. "Criminals Have 'Smaller BRAINS': The 'Handicap' May Explain Why Offenders Steal and Are Violent ." Associated Newspapers, February 17, 2020. https://www.dailymail.co.uk/health/article-8013069/Criminals-smaller-BRAINS-handicap-explain-offenders-steal-violent.html.

Carlisi, Christina O, Terrie E Moffitt, Annchen R Knodt, Honalee Harrington, David Ireland, Tracy R Melzer, Richie Poulton, et al. "Associations between Life-Course-Persistent Antisocial Behaviour and Brain Structure in a Population-Representative Longitudinal Birth Cohort." The Lancet Psychiatry 7, no. 3 (February 17, 2020): 245–53. https://doi.org/10.1016/s2215-0366(20)30002-x.

Garcia-Arocena, Dolores. "The Genetics of Violent Behavior." The Jackson Laboratory, December 7, 2015. https://www.jax.org/news-and-insights/jax-blog/2015/december/the-genetics-of-violent-behavior.

"Feeling Aggressive? It Could Be Your 'Warrior Gene' in Action." South China Morning Post, July 9, 2011. https://www.scmp.com/article/973071/feeling-aggressive-it-could-be-your-warrior-gene-action.

"'Warrior Gene' Predicts Aggressive Behavior After Provocation." "Warrior Gene" Predicts Aggressive Behavior After Provocation | News from Brown, January 19, 2009. https://news.brown.edu/articles/2009/01/hotsauce.

"Research Links Brain Damage & Violent Crime -- USC Studies Point To Underlying Causes Of Violent Crime In Young Offenders." ScienceDaily. ScienceDaily, September 13, 1997. https://www.sciencedaily.com/releases/1997/09/970913073401.htm.

"Preeclampsia." Mayo Clinic. Mayo Foundation for Medical Education and Research, March 19, 2020. https://www.mayoclinic.org/diseases-conditions/preeclampsia/symptoms-causes/syc-20355745.

"Are Murderers Born or Made?" BBC News. BBC, March 9, 2015. https://www.bbc.com/news/magazine-31714853.

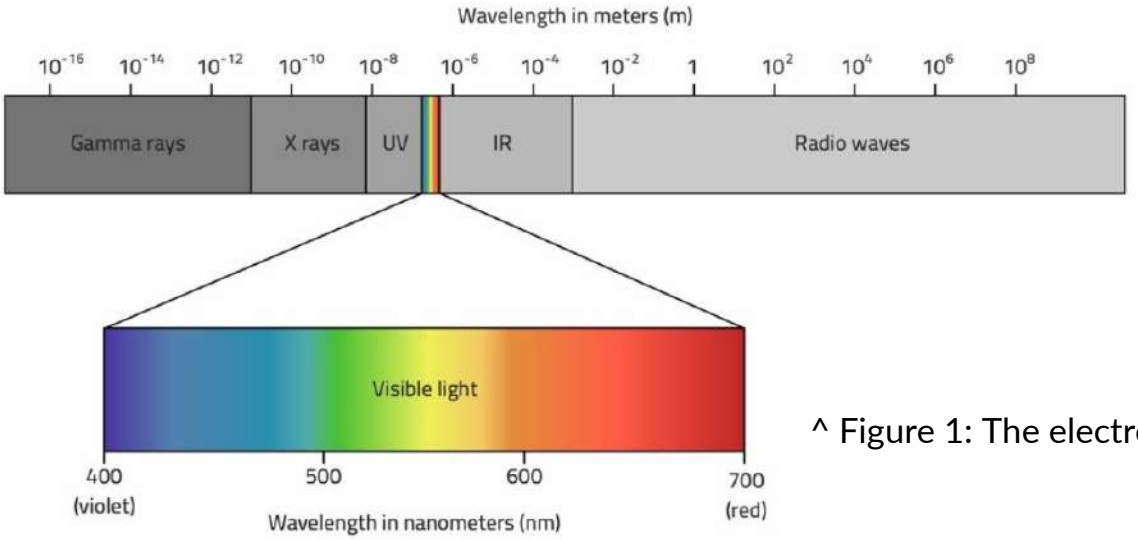
HOW DOES UV LIGHT KILL VIRUSES?

BY YUKA SUZUKI 12R

During the times of a global pandemic, the topic of Ultraviolet light disinfection has been brought up more often than ever. Scientists have known of the effects of UV light on microorganisms such as bacteria and viruses for over 50 years, but how can it help in the battle against the Coronavirus?

WHAT IS UV LIGHT?

UV (Ultraviolet) light is a type of electromagnetic radiation. We are exposed to UV light every day through natural sunlight. As shown on the electromagnetic spectrum, UV radiation is invisible to the eye as it is outside of the visible light region. It has a shorter wavelength compared to visible light, which also means UV light has a higher amount of energy.



^ Figure 1: The electromagnetic spectrum.

UV-A LIGHT

This is the type of UV light with the least amount of energy, and the type of UV light we are most exposed to from the sun.

UV-A light is also used in tanning beds. Although they are the weakest radiation, overexposure to this type of light can damage the skin and cause skin aging.

UV-B LIGHT

TUV-B light has a higher amount of energy than UV-A light, but less than UV-C.

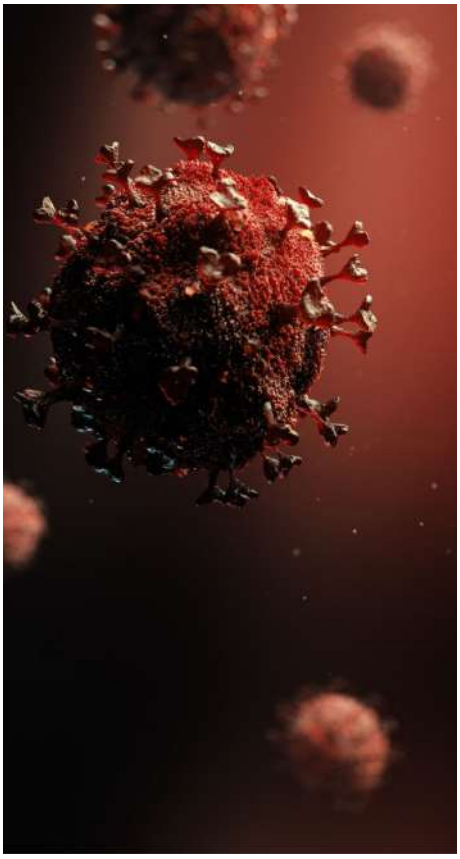
Sunlight contains a small amount of UV-B light, and overexposure to this light can lead to skin cancers and sunburn.

UV-C LIGHT

UV-C light has the shortest wavelength, the highest frequency and the highest energy. This makes it the most dangerous of the 3 types of UV light.

However, the good news is that UV-C light from the sun is filtered out by the Earth's ozone layer, so we are not usually exposed to this type of light.

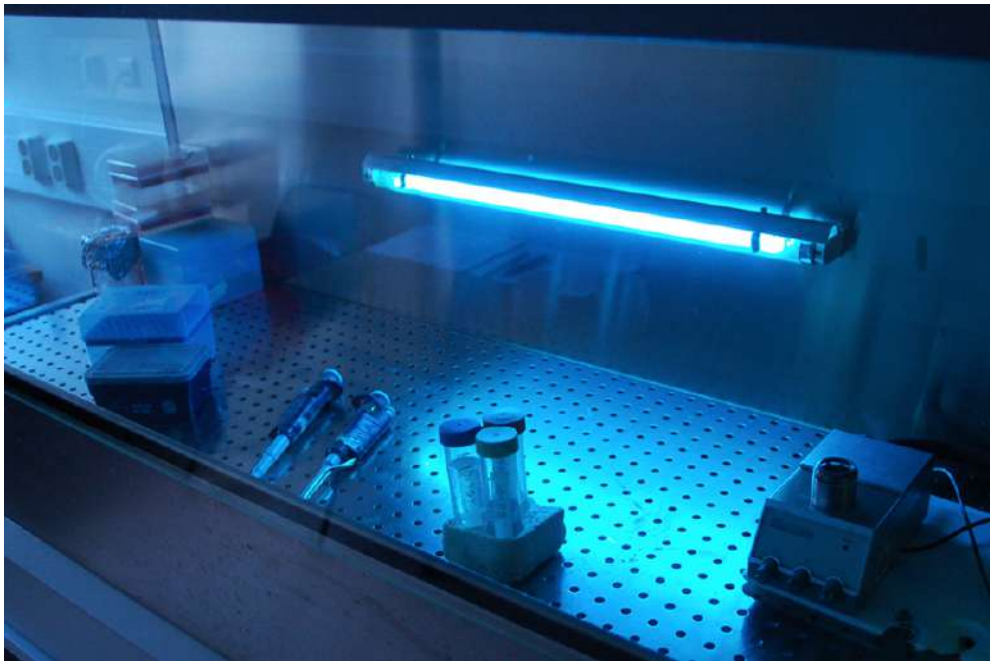
CORONAVIRUS AND UV-C LIGHT



UV-A and UV-B light are not effective in killing viruses, as they have existed on earth for billions of years, and viruses have been able to adapt and survive under these types of light. The most effective type of UV light that can kill viruses and bacteria is UV-C light. This is because it has the highest energy, and can destroy molecules in pathogens, including nucleic acids DNA and RNA which contain genetic material. By doing so, the pathogen is no longer able to replicate and carry out the necessary processes needed to survive and is killed. Because of this, UV-C light is also known as germicidal UV, and is used especially in the healthcare industry to disinfect things such as surgical tools and operation rooms.

A study published in the AJIC proved that UV-C light is capable of killing Covid-19 on surfaces. The study used UV-C light with a wavelength of 222nm, and the results showed a 99.7% reduction of the virus within a time period of 30 seconds. Similar studies were also conducted to find the effectiveness of UV-C light in killing Covid-19 in liquids and in the air, and similar results were obtained. As the structure of this Covid-19 virus is different from others from the coronavirus family, these results are significant in the global fight against Covid-19. In addition, the fact that UV-C light disinfection does not require handling any chemicals, and that the virus cannot be resistant to UV-C light (unlike antibiotics) makes it a very favourable choice.

DANGERS OF UV-C LIGHT



Although UV-C light is very efficient at killing viruses, it also has its downsides. Its ability to destroy molecules inside pathogens unfortunately also means that it can harm the cells in our body. Some of the effects of exposure to UV-C light include damage to the eye, especially to the cornea, and much more extreme skin cancer.

Due to the dangers of UV-C light, it should only be used by trained experts with appropriate gear. If you are not trained in this area, it is best to avoid devices with UV-C light unless it has been evaluated to be safe for use!

QUICK MYTHS ABOUT THE CORONAVIRUS

1) Bathing in sunlight can kill the coronavirus on your body

* No, this is a myth. Sunlight consists of UV-A and UV-B light only, which are ineffective in killing viruses.

2) Drying your hands using the hot air from a hand dryer can kill the coronavirus

* No, this is a myth. Don't slack off washing your hands with soap, as this is the best way to get rid of the viruses and bacteria on your hands!

3) If you cannot hold your breath for more than 10 seconds, you have the coronavirus

* No, this is a myth! Many of those who have been infected by the coronavirus display no symptoms.

BIBLIOGRAPHY

"Components of Electromagnetic Spectrum." Radio2Space, 9 Dec. 2019, www.radio2space.com/components-of-electromagnetic-spectrum/.

Tornberg, Beth. "Using UV Light to Kill Viruses like COVID-19." Lighting Insights Blog, insights.regencylighting.com/can-uv-light-kill-viruses-like-covid-19.

Seladi-Schulman, Jill. "Does UV Light Kill Coronavirus? Facts and Myths." Healthline, Healthline Media, 22 Oct. 2020, www.healthline.com/health/does-uv-kill-coronavirus#disadvantages.

Tornberg, Beth. "Does All UV Light Kill Viruses and Bacteria?" Lighting Insights Blog, insights.regencylighting.com/does-all-uv-light-kill-viruses.

Robertson, Paddy. "Paddy Robertson." Smart Air, 5 Aug. 2020, smartairfilters.com/en/blog/what-uv-ultraviolet-light-how-kill-viruses/.

Kitagawa, Hiroki, et al. American Journal of Infection Control, 2020, Effectiveness of 222-Nm Ultraviolet Light on Disinfecting SARS-CoV-2 Surface Contamination, www.ajicjournal.org/article/S0196-6553(20)30809-9/fulltext#%20.

Mackenzie, Dana. "Ultraviolet Light Fights New Virus." Engineering (Beijing, China), THE AUTHOR. Published by Elsevier LTD on Behalf of Chinese Academy of Engineering and Higher Education Press Limited Company., Aug. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7319933/.

Coffey, Donavyn. "Does UV Light Kill the New Coronavirus?" LiveScience, Purch, 12 July 2020, www.livescience.com/uv-light-kill-coronavirus.html.

"COVID-19 Mythbusters." World Health Organization, World Health Organization, www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters.

"Myth: You Can Self-Check for Coronavirus by Holding Your Breath for 10 Seconds." COVID19 FACTS, www.covid-19facts.com/?p=83896.

LANGUAGE AND CATEGORICAL PERCEPTION: A STUDY OF COLOUR AND SOUNDS

BY YU HANG HUI 12R

A CASE STUDY IN COLOUR PERCEPTION

Голубой (goluboy) and синий (siniy) are the Russian words for light blue and dark blue respectively. Unlike English, Russian does not have a single word that describes what English speakers perceive as 'blue'. Instead, Russians view голубой and синий as 2 distinct colours, similar to how English speakers see red and pink as different colours.

One 2007 study investigated how this variation in linguistic terminology affects the colour perception of native Russian and English speakers. Researchers presented Russian and English subjects with three 'blue' coloured squares arranged in a triangle and asked them to pick out which square on the bottom matched the square at the top.

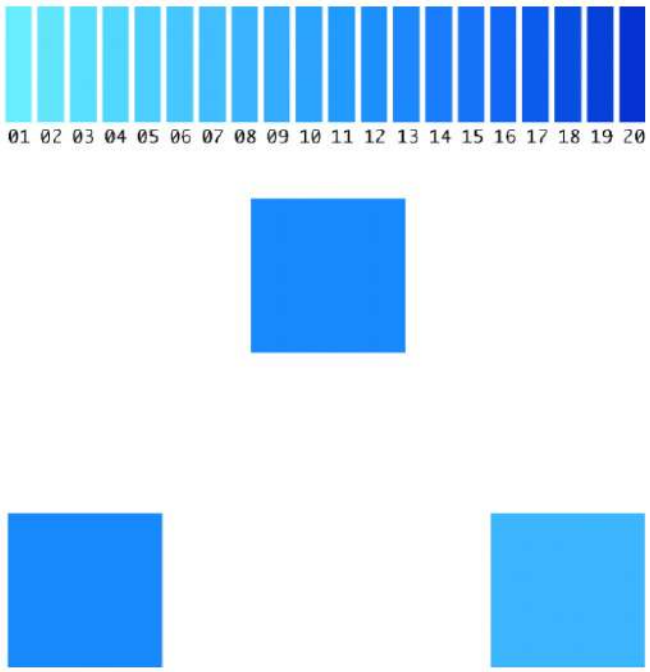


Figure 1: an example of the squares shown to the Russian and English subjects

The results showed that the Russian speakers were able to select the square much faster than the English speakers when the colours in question belonged to different categories, for example when one square was голубой and the other was синий. (Winawer et al., 2007) This is an example of the phenomenon known as categorical perception.

CATEGORICAL PERCEPTION

Categorical perception is when the categories acquired by observers influence how they perceive their surroundings. The observer notices more differences between items from different categories and less unique aspects for items in the same category. (Goldstone, and Hendrickson, 2009)

In the case of the study discussed above, Russian speakers consider dark blue and light blue to belong to different categories, and hence they saw a greater difference between dark blue and light blue hues, which allowed them to make a selection faster. Their English-speaking counterparts viewed all the blue hues as part of one category, and therefore perceived the hues as more similar and took longer to complete the task.

Figure 2: A rainbow

To better understand the concept of categorical perception, consider a rainbow. Most people English speakers would see 7 colours in a rainbow: red, orange, yellow, green, blue, indigo and violet. However, physics clearly demonstrates that the spectrum consists of an infinite number of wavelengths and that the colours in a rainbow change evenly throughout. The reason why 7 distinct colours are seen is due to different hues being categorized and perceived in these categories of colours.

CATEGORICAL PERCEPTION IN SOUNDS

Categorical perception is not unique to sight. In a 1957 study, Alvin Liberman and other researchers made subjects listen to a spectrum of phoneme sounds. Most subjects divided the spectrum into 3 distinct parts of ‘b’, ‘d’ and ‘g’ sound with clear boundaries between each sound. The study indicated that the subjects were more successful in differentiating speech sounds if they belonged to different perceived phoneme categories (Liberman et al., 1957).

Although it must be acknowledged that people from different cultures and languages may initially perceive their surroundings differently, categorical perception can be gained through exposure. For example, people become capable of categorical perception of more sounds when learning new languages. One study discovered that Japanese speakers who are experienced at speaking English are much more capable of distinguishing ‘r’ and ‘l’ sounds than their monolingual counterparts. (MacKain et al., 1981) Another example could be learning tonal languages such as Cantonese and Thai; many non-speakers would find it challenging to hear the distinctions between different tones, while native speakers distinguish tones automatically with ease. Nonetheless, learners of Cantonese and Thai could gain a categorical perception of tones with enough practice.

	Unstopped			Stopped		
High falling	詩	si 53	‘poem’	識	sik 5	‘to know’
Mid	試	si 33	‘to try’	洩	sit 3	‘to release’
Low	事	si 22	‘matter’	食	sik 2	‘to eat’
Extra low	時	si 11	‘time’			
Mid rising	使	si 35	‘to cause’			
Low rising	市	si 13	‘city’			

Figure 3: different Cantonese words with different meanings all pronounced a variation of ‘si’

MISCONCEPTIONS ABOUT CATEGORICAL PERCEPTION

One common misconception about categorical perception is that the differences in observations are actually due to inherent differences in the biological construct of different groups of people. This is not the case.

Researchers from another study involved toddlers from the United Kingdom and the Himba tribe (indigenous people from Namibia in Africa). As opposed to 11 colour terms used by the majority of the world, the Himba people only have 5 colour terms. For example, 'zoozu' describes dark colours, including black, dark red, dark blue and dark purple; 'burou' describes greens and blues. (Grahl, 2016)

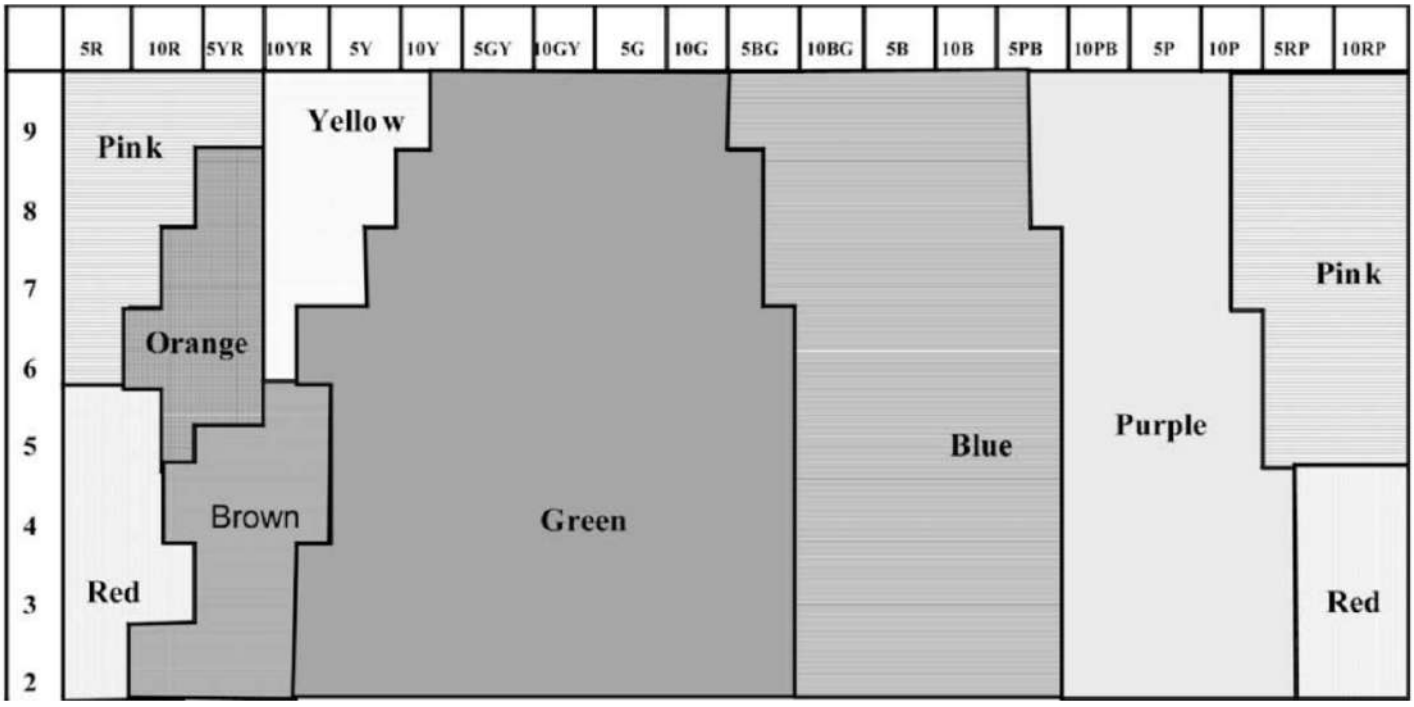


Figure 4: the English colour terms

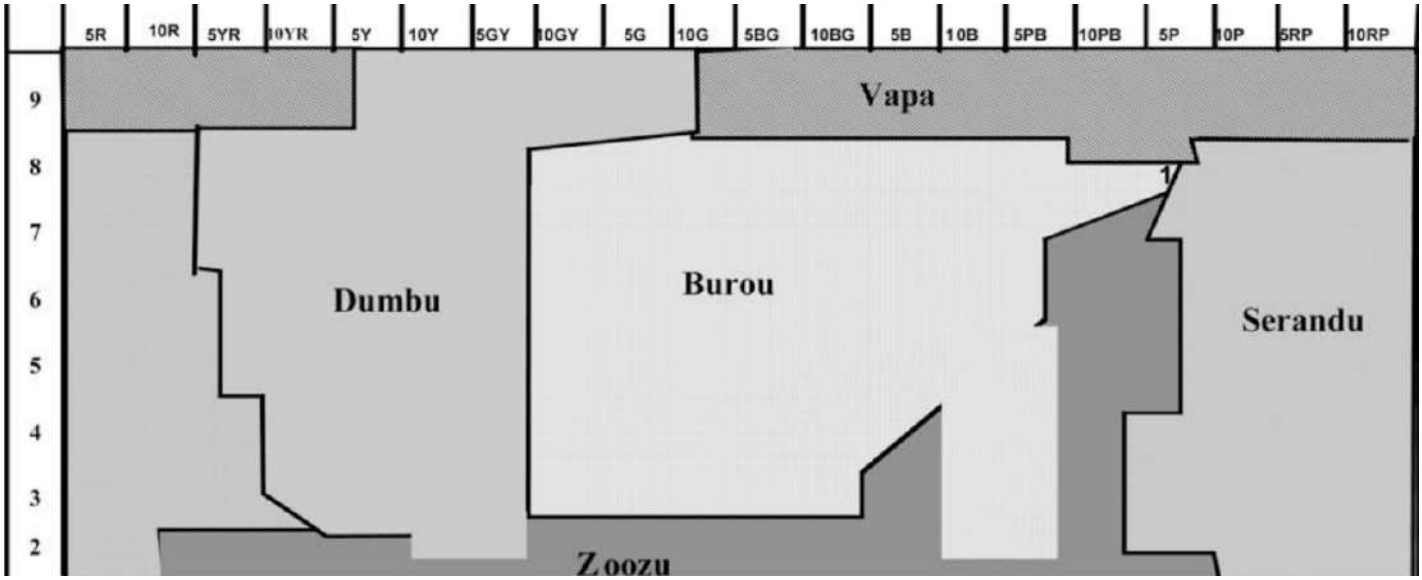


Figure 5: the Himba colour terms

In the experiment, toddlers were asked to pick out a certain coloured from different coloured objects. If the argument for inherent differences in vision is valid, English toddlers who have not yet acquired colour terms should be more advantaged in distinguishing blue and green colours than Himba toddlers who do not know colour terms. However, the results for Himba children were the same as the English children. (Goldstein et al., 2008) Without categories, there is no categorical perception; when categories have not yet been acquired, nothing differentiates different groups of people in their observations of surroundings.

CONCLUSION

In conclusion, categorical perception is a fascinating phenomenon where the categories people are accustomed to influences how they perceive their surroundings, including visual and auditory stimulus. Categorical perception heavily affects people's observations in daily life. Even though categorical perception due to different cultural backgrounds can give subjects a slight advantage in various scenarios, people essentially possess the same abilities to conduct their experiences in life and can adapt accordingly. More generally, it is crucial that people are respectful and patient with others who are momentarily less capable of processing new information.

BIBLIOGRAPHY

Fijałkowski, Paweł. Landscape Photography Of Field With Wind Mill With Rainbow. 2018, https://www.pexels.com/photo/landscape-photography-of-field-with-wind-mill-with-rainbow-1253748/. Accessed 12 Dec 2020.

Goldstein, Julie et al. "Knowing Color Terms Enhances Recognition: Further Evidence From English And Himba". Journal Of Experimental Child Psychology, vol 102, no. 2, 2008, pp. 219-238. Elsevier BV, doi:10.1016/j.jecp.2008.06.002. Accessed 12 Dec 2020.

Goldstone, Robert L., and Andrew T. Hendrickson. "Categorical Perception". Wiley Interdisciplinary Reviews: Cognitive Science, vol 1, no. 1, 2009, pp. 69-78. Wiley, doi:10.1002/wcs.26. Accessed 12 Dec 2020.

Grahl, Bernd. "How Do Namibian Himbas See Colour?". Gondwana Collection Blog, 2016, https://www.gondwana-collection.com/blog/how-do-namibian-himbas-see-colour/. Accessed 12 Dec 2020.

Liberman, Alvin M. et al. "The Discrimination Of Speech Sounds Within And Across Phoneme Boundaries.". Journal Of Experimental Psychology, vol 54, no. 5, 1957, pp. 358-368. American Psychological Association (APA), doi:10.1037/h0044417. Accessed 12 Dec 2020.

Linguistics Berkeley. Tone In Cantonese. 2020, https://linguistics.berkeley.edu/phonwork/ex9_4.php. Accessed 12 Dec 2020.

MacKain, Kristine S. et al. "Categorical Perception Of English /R/ And /L/ By Japanese Bilinguals". Applied Psycholinguistics, vol 2, no. 4, 1981, pp. 369-390. Cambridge University Press (CUP), doi:10.1017/s0142716400009796. Accessed 12 Dec 2020.

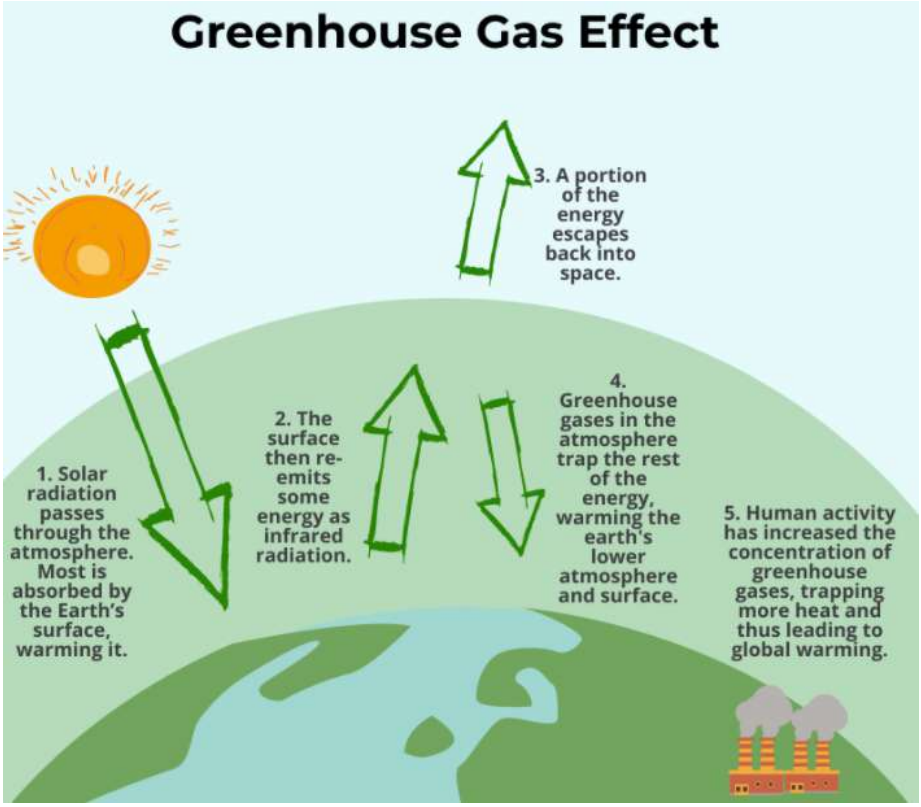
Winawer, Jonathan et al. "Russian Blues Reveal Effects Of Language On Color Discrimination". Proceedings Of The National Academy Of Sciences Of The United States Of America, vol 104, no. 19, 2007. PNAS, doi:https://doi.org/10.1073/pnas.0701644104. Accessed 12 Dec 2020.

CARBON DIOXIDE—IS IT REALLY THAT BAD?

BY AIDAN LUNG 12W

Carbon dioxide, chemically known as CO2, is a gas produced from abundant sources, be it from the minor quantities formed by our natural breathing to the copious volumes generated by the burning of fossil fuels. We are often told that carbon dioxide is bad for the environment. However, how true is such a statement?

USES OF CARBON DIOXIDE



Despite the negative connotations carbon dioxide brings to mind, CO2 has proven to have its uses in certain applications. For example, background levels of carbon dioxide contribute towards the growth of many plants. This information could be further incentive to increase the greenery around the world, both allowing for carbon dioxide to be depleted via natural processes, as well as bringing vegetation back to many places around the world.

In industry, carbon dioxide is used often. In the formation of pure iron from iron ore, carbon dioxide is turned into carbon monoxide, CO, which is then used as a reducing agent in the metal extraction process. Carbon dioxide is also dissolvable in water to form carbonic acid, which helps provide the fizz in carbonated drinks such as soda. Just recently, with the aid of an iron-based catalyst, carbon dioxide has become usable in the production of jet fuel. This has plans to reduce the carbon footprint of aviation travel, and reduce the need to obtain fuel from environmentally damaging processes such as the extraction of crude oil from the earth.

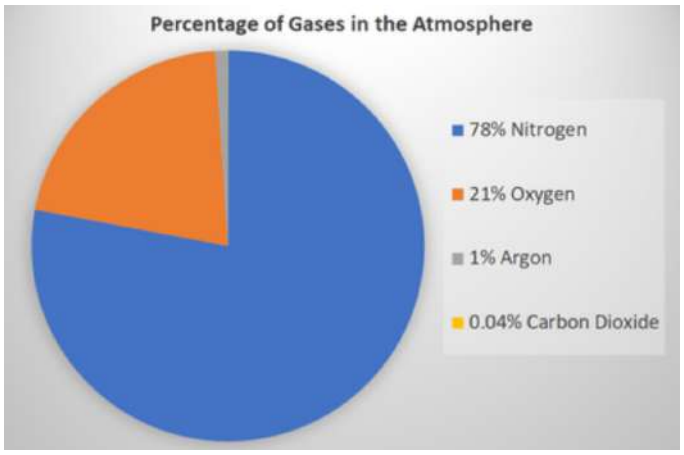
THE CARBON CYCLE

The carbon cycle, simply put, denotes the process by which carbon in the earth enters the atmosphere and then travels back to Earth in a repeated, cyclical pattern. Plants utilise CO2 alongside water in the synthesis of sugar in order to grow. When animals eat these plants, they absorb the carbon dioxide stored in them, and eventually, carbon dioxide is re-released into the earth and atmosphere as the waste

products of digestion or cellular respiration. Afterwards, the carbon released into the earth is naturally given off into the atmosphere over time, or may be manually harvested through industrial means, allowing the cycle to repeat. Some of the carbon dioxide ends up dissolved in the ocean, which can be used by marine life to form calcium carbonate, a key chemical used in the formation of shells in shellfish. After dying, large deposits of calcium carbonate, under high temperatures and pressures in the Earth's crust, can form limestone. Around 80% of the carbon in the earth is located in the lithosphere of the Earth's crust as these inorganic carbonate compounds.

Whilst this system by nature is sustainable, human contributions to the cycle makes it less so. As a result of activities such as the burning of fossil fuels, a process which involves the extraction of carbon-containing compounds known as hydrocarbons from the earth, a surplus of carbon enters the atmosphere. The problem with this is that the atmosphere is only able to re-absorb so much carbon dioxide, meaning a lot of it is left in the atmosphere, which traps heat and contributes towards global warming.

EXCESS SUPPLY OF AND EXCESS DEMAND FOR CARBON DIOXIDE



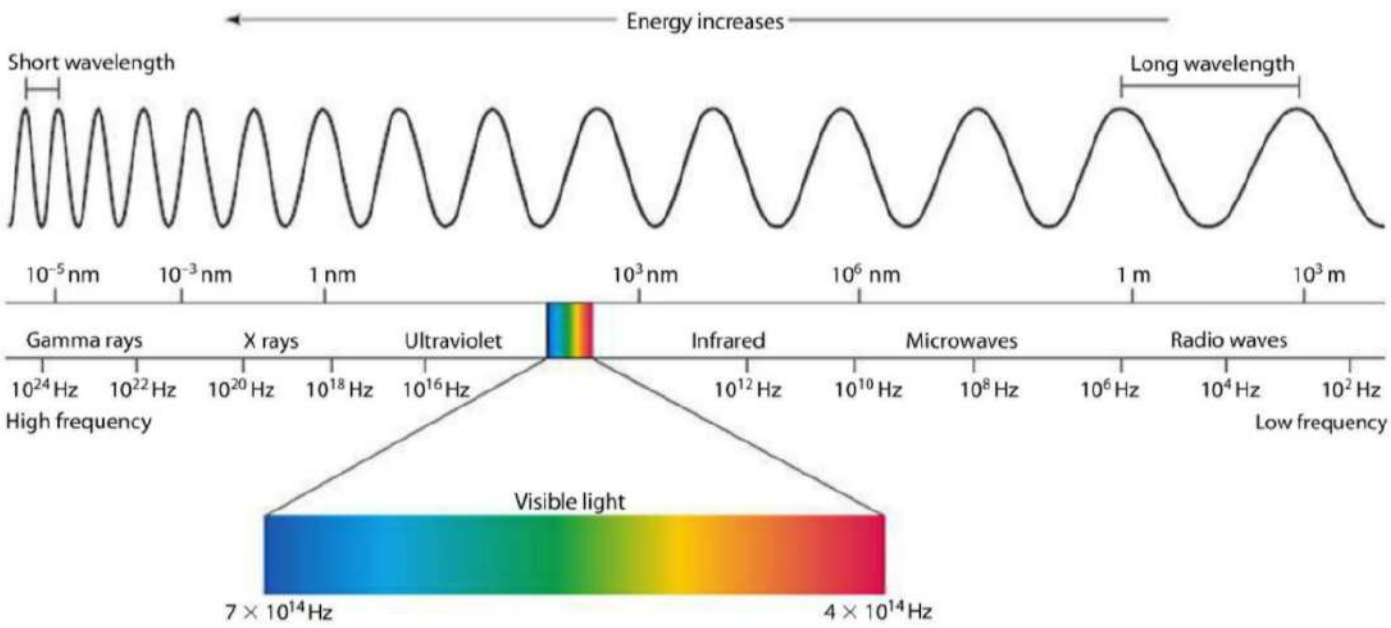
If we have many processes which require the use of carbon dioxide, why is it that we still have so much in surplus just sitting in the atmosphere, and why do we not use that supply of CO2 instead? The simple answer is

that it is simply not worth it. Despite what we are led to believe about rising quantities of carbon dioxide in the atmosphere, only around 0.04% of the air is actually comprised of CO2, and whilst the low concentration of these harmful molecules is still able to cause severe environmental damage, it is just not abundantly available enough for its harvest to be profitable when gathered for industrial uses.

IMPACTS OF CARBON DIOXIDE

Inhaling small amounts of CO2 does little in the way of bodily harm. Carbon dioxide in its common gaseous form is not an irritant, mutagen, and nor is it a carcinogen (does not cause cancer). When taken in larger doses however, carbon dioxide acts as both an asphyxiant and an intoxicant, leading to headaches, dizziness and nausea. This usually occurs when lots of carbon dioxide displaces the oxygen in the atmosphere of confined spaces, leading to oxygen deprivation, otherwise known as hypoxia, and can result in death by CO2 poisoning. Inhaling large quantities of carbon dioxide also causes capillaries to dilate, which happens when the lungs store too much carbon dioxide, increasing CO2 levels in the bloodstream, which can be deadly.

In terms of environmental damage, carbon dioxide contributes towards global warming. The sun radiates energy in the form of different waves. The types of waves produced depend on a characteristic of the wave known as the wave's wavelength, and the specific wavelengths of these waves put them in certain categories on what is known as the electromagnetic spectrum, shown below.



2% of the waves emitted by the sun fall into the ultraviolet (UV) region of the spectrum, 47% fall into the visible light region, and 51% fall into the infra-red (IR) region. Infra-red radiation is more colloquially referred to as heat in wave form. CO2 is a unique gas because it absorbs this infra-red radiation. This is not all the heat the carbon dioxide traps, however. The waves from the visible light region pass energy onto objects on the surface of the Earth, which excites particles in these substances, heating them up, and causing them to also give off infra-red radiation.

Whilst this kind of heating is necessary in keeping the Earth at a temperature which allows for the accommodation of life, carbon dioxide in the mid-troposphere layer, the lowest layer of the Earth's atmosphere, also absorbs this additional infra-red radiation, leading to temperatures higher than what is considered optimal. This is what leads to what is known as the greenhouse effect and global warming. According to NASA, carbon dioxide can remain in the atmosphere for anywhere between 300 to 1000 years, and since the rate at which we add more to the atmosphere supersedes the rate of its depletion, we are left with climate change.

CONCLUSION

Going back to the question we asked at the start, although carbon dioxide has gained a bad reputation due to its harmful effects on the environment, both its use in and formation as a byproduct of industrial processes arguably makes its production worth the societal development it has provided. Despite lacking the sufficient tools and technology to produce, harvest and use CO2 sustainably, it is undeniable that carbon dioxide plays crucial roles in modern society. Consequently, it has and will continue to become increasingly necessary for carbon dioxide reduction methods to be created and employed in the near future to allow us to use and produce carbon dioxide safely and sustainably in the long run.

BIBLIOGRAPHY

Bryner, M. (2020). Why Does Soda Fizz?. Retrieved 26 December 2020, from https://www.livescience.com/32492-why-does-soda-fizz.html

Jason West, T. (2020). CO2 Makes Up Just 0.04% of Earth's Atmosphere. Here's Why Its Impact Is So Massive. Retrieved 26 December 2020, from https://www.sciencealert.com/co2-is-only-a-tiny-part-of-our-atmosphere-but-it-has-a-huge-influence-here-s-why

CO_2 shortage: why can't we just pull carbon dioxide out of the air?. (2020). Retrieved 26 December 2020, from https://theconversation.com/co-shortage-why-cant-we-just-pull-carbon-dioxide-out-of-the-air-99255

Extracting iron - Redox, extraction of iron and transition metals - GCSE Chemistry (Single Science) Revision - WJEC - BBC Bitesize. (2020). Retrieved 26 December 2020, from https://www.bbc.co.uk/bitesize/guides/zv7f3k7/revision/2

Carbon Dioxide. (2020). Retrieved 26 December 2020, from https://www.dhs.wisconsin.gov/chemical/carbondioxide.htm

(2020). Retrieved 26 December 2020, from http://www.festivalglass.com.au/wp-content/uploads/2015/08/Solar-Spectrum-Factsheet.pdf

Department of Agriculture, Water and the Environment. (2020). Retrieved 26 December 2020, from https://www.environment.gov.au/climate-change/climate-science-data/climate-science/greenhouse-effect

A new iron-based catalyst converts carbon dioxide into jet fuel. (2020). Retrieved 26 December 2020, from https://www.sciencenews.org/article/new-iron-based-catalyst-converts-carbon-dioxide-into-jet-fuel

Sizing Up Humanity's Impacts on Earth's Changing Atmosphere: A Five-Part Series

Alan Buis, &. (2020). The Atmosphere: Getting a Handle on Carbon Dioxide – Climate Change: Vital Signs of the Planet. Retrieved 26 December 2020, from https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/

Carbon Dioxide : OSH Answers. (2020). Retrieved 26 December 2020, from https://www.ccohs.ca/oshanswers/chemicals/chem_profiles/carbon_dioxide.html

factory-pollution.jpg. (2020). Retrieved 26 December 2020, from https://www.oneplanetnetwork.org/file/factory-pollutionjpg

What is climate change? | Climate Assembly. (2020). Retrieved 26 December 2020, from https://www.climateassembly.scot/how-it-works/what-climate-change

Earth's Atmosphere - Key Stage Wiki. (2020). Retrieved 26 December 2020, from https://www.keystagewiki.com/index.php/Earth%27s_Atmosphere

Physics, M. (2020). The Electromagnetic Spectrum. Retrieved 31 December 2020, from https://www.miniphysics.com/electromagnetic-spectrum_25.html

troposphere. (2020). Retrieved 31 December 2020, from https://web.physics.ucsb.edu/~lgrace/chem123/troposphere.htm

COPD Hypoxia: Symptoms, Complications, Treatment & More. (2020). Retrieved 31 December 2020, from https://www.healthline.com/health/copd/hypoxia#complications

The global carbon cycle. (2021). Retrieved 10 February 2021, from https://www.science.org.au/curious/video/global-carbon-cycle

What is the carbon cycle?. (2021). Retrieved 10 February 2021, from https://oceanservice.noaa.gov/facts/carbon-cycle.html

ISLAND SCHOOL SCIENCE JOURNAL 2021

SENIOR PHASE

A SELECTION OF ARTICLES WRITTEN BY STUDENTS OF ISLAND SCHOOL

COMPOSED BY
RENEE WONG

EDITED BY
YU HANG HUI, SAMMI HUNG, KIMBERLEY NG, ANGUS SMEATON, ARJUN THIND, AYAHIKO USUI