Lent
2025
Edition 18

young scientists' journal.



IN THIS EDITION

LENT

ISSUE 18

2025

Editors' Note

Young Scientists' Journal

LENT EDITION 2025

Contributions to this Issue:

This edition would not have been possible without the hard work of our dedicated editorial team. We would also like to thank Mr. Reeves and Dr. Griffin for their guidance and support for running the journal.

We're excited to present the Lent 2025 edition of the LGS Young Scientists' Journal, fostering curiosity and enthusiasm for STEM across our school. This platform empowers students to explore scientific ideas, share research, and engage in meaningful discussions, showcasing their passion and dedication.

This term, we feature thought-provoking articles on the mysteries of the northern lights, the psychology behind phobias, the rise of dental tourism, and the enigmatic nature of black holes. The incredible efforts of our writers and researchers have made this edition truly remarkable, and we encourage even more students to participate in future issues. We hope you enjoy reading this collection and find inspiration in the discoveries shared!

Cover Images:

'Turkey Health Tourism Dentistry' by Ozan Kose

'Histone methylation, molecular model' by Juan Gaertner

'Northern Lights and Hvítserkur rock formation' by Juan Maria Coy Vergara

'CRISPR-Cas9 genome editing enzyme' by Artur Plawgo

Key word definitions are from the Cambridge and Oxford English Dictionaries.

Contact us!

youngscientistsjournal@leicestergrammar.org.uk

@LGS_Senior

Young Scientists Journal

@YSJournal

LENT 2025

The Truth Behind Dental Tourism

By Navin Bhat (Year 12)

Key Words:

Dental Tourism:
travel to a foreign country for dental treatment, especially because it is less expensive than in your own country

Implant:
to put an organ, group of cells, or device into the body in a medical operation

Dental tourism, also known as dental travel, refers to the practice of individuals traveling to another country to receive dental care. This growing trend is driven by the promise of affordable treatments, high-quality services, and the opportunity to explore new destinations while undergoing dental procedures. However, dental tourism also presents challenges, including the risks below-standard care and its complications.

Reasons for Dental Tourism

Several factors contribute to the growing popularity of dental tourism, with cost being one of the most significant drivers. In countries like the United Kingdom and the United States, dental procedures can be extremely expensive. As a result, many individuals try to find affordable alternatives in countries where dental care is considerably cheaper. For example, a dental implant in the UK may cost upwards of £2,000, while the same procedure in countries like Mexico or Hungary can be as much as 70% cheaper, even when including in travel and accommodation costs (Medical Travel Market, 2021).

Apart from cost savings, another key reason for dental tourism is access to advanced treatments. Many dental clinics in popular destinations offer state-of-the-art procedures that might not be readily available or affordable in the patient’s home country. For example, certain types of cosmetic dental treatments, such as full smile makeovers or dental implants, are offered in some countries at a fraction of the cost found in the UK (Colgate, 2022). Furthermore, dental tourism also appeals to those seeking to avoid long waiting times in countries where there is high demand for dental services.

Figure 1. Before and after dental implant treatment (VK Smile Studio, 2024).

Positives of Dental Tourism

Dental tourism offers several benefits that make it an attractive option for many patients. The most obvious advantage is the potential for significant cost savings. For example, in places like Mexico, Thailand, and Hungary, dental treatments can be much more affordable, sometimes allowing patients to undergo multiple procedures while saving money compared to domestic treatment costs (Medical Travel Market, 2021). Additionally, the quality of dental care in some countries meets or exceeds international standards, with many clinics employing highly trained professionals and using modern equipment (Colgate, 2022).

Another positive aspect of dental tourism is the opportunity to combine medical treatment with leisure. Many dental tourists enjoy exploring new destinations while receiving care, turning their trip into a mini-vacation. For example, Costa Rica is known for its beautiful natural landscapes and affordable dental services, which makes it a popular choice for dental tourists (Wikipedia, 2022). In some cases, dental tourists can receive high-quality treatment and recuperate in a relaxing environment, enhancing their overall experience.

Negatives of Dental Tourism

Despite the many benefits, dental tourism comes with some risks and challenges. One major concern is the lack of quality assurance. While many dental clinics abroad offer excellent care, not all clinics maintain the same standards as those found in the UK or other Western countries. Some clinics may use substandard materials or outdated techniques, which can lead to complications and additional costs (Medical Travel Market, 2021).

A notable example of where dental tourism went wrong involves a British woman who sought dental care in Turkey. She underwent a series of cosmetic dental treatments, including veneers, but experienced severe complications due to poor-quality materials used by the clinic. The woman was left with ongoing dental problems and had to spend thousands more to correct the work once she returned home (Thantakit, 2022). This case highlights the risks associated with dental tourism, particularly when clinics do not meet international standards.

Another drawback is the limited legal recourse if something goes wrong. If a dental tourist experiences complications after returning to their home country, they may struggle to hold the foreign clinic accountable. Different countries have different laws regarding malpractice, and patients may not be able to pursue legal action as they would in their home country (Medical Travel Market, 2021).

Additionally, post-operative care can be challenging. After major dental procedures like implants or full smile makeovers, patients often need follow-up appointments to monitor their recovery. For dental tourists, arranging follow-up care once they return home can be difficult, and complications may arise if issues are not detected and treated promptly.

Key Words:

Quality Assurance:
the things a company does to make sure that its products and services are as good as they should be

Postoperative:
relating to the period of time that immediately follows a medical operation

Popular Dental Tourism Destinations

Several countries have become well-known destinations for dental tourism due to their affordable treatments and high standards of care. Mexico is one of the most popular countries for dental tourists, particularly for those from the United States. The proximity to the US makes Mexico an attractive option, with cities like Los Algodones, often referred to as "Molar City," offering hundreds of dental clinics catering to international patients (Medical Travel Market, 2021).

Hungary is another leading destination, particularly for European dental tourists. Budapest is home to many dental clinics that offer high-quality services at much lower prices than those in the UK or Western Europe (AGD, 2020). The country's reputation for excellence in dental care has made it a go-to choice for individuals seeking cosmetic and restorative treatments.

Thailand is renowned for its combination of affordable dental services and appealing tourist destinations. Cities like Bangkok and Chiang Mai are well-equipped with modern dental clinics that cater to international patients, offering a wide range of treatments, including implants and veneers (Thantakit, 2022). Thailand's tourism industry, alongside its competitive dental care prices, makes it a popular destination for dental tourists from around the world.

Costa Rica also attracts a significant number of dental tourists, particularly from the United States. Known for its natural beauty and affordable healthcare system, Costa Rica offers high-quality dental care at a fraction of the cost found in North America (Wikipedia, 2022).

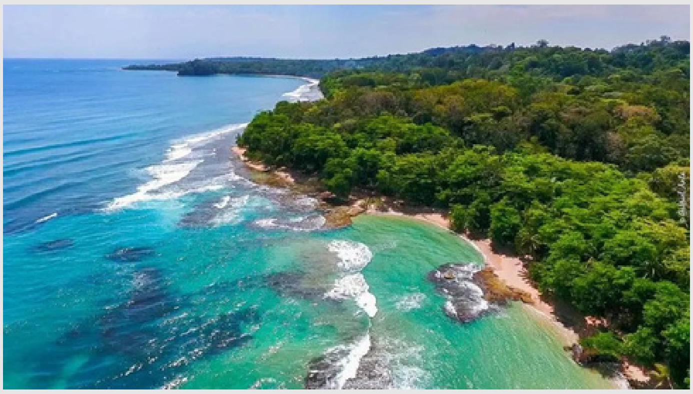

Figure 2. Costa Rica (The Explorer's passage, 2025).

Tips for a Safe Dental Tourism Experience

While dental tourism can be a cost-effective and rewarding experience, it's important for patients to take certain precautions to ensure their safety. First, patients should thoroughly research dental clinics before making a decision. It's essential to check the clinic's credentials, read patient reviews, and verify that the clinic is accredited by international dental associations (Thantakit, 2022). A recommendation from a trusted local dentist can also be helpful in identifying reputable clinics abroad.

Second, patients should plan for post-operative care. This means ensuring that they have access to a local dentist who can monitor their recovery or offer advice should any issues arise (Medical Travel Market, 2021). Finally, patients should beware of unusually low prices. While dental tourism is often cheaper, extremely low prices may indicate subpar care or the use of inferior materials.

Conclusion

In conclusion, dental tourism offers numerous benefits, including substantial cost savings, access to high-quality care, and the opportunity to explore new destinations. However, it also presents certain risks, such as the potential for substandard care, complications, and difficulties with follow-up treatment. By carefully researching clinics, seeking advice from local professionals, and planning for post-operative care, patients can minimise risks and enjoy a positive dental tourism experience. Ultimately, dental tourism can be a viable option for those seeking affordable and high-quality dental treatments abroad, but it requires careful consideration and preparation.

Bibliography:

AGD (2020). Worth the trip: A look at dental tourism. Available at: https://www.agd.org/constituent/news/2020/01/20/worth-the-trip-a-look-at-dental-tourism [Accessed 6 Mar. 2025].

Colgate (2022). What is dental tourism? Available at: https://www.colgate.com/en-us/oral-health/threats-to-dental-health/what-is-dental-tourism [Accessed 6 Mar. 2025].

Medical Travel Market (2021). Top dental tourism destinations worldwide. [online] Available at: https://medicaltravelmarket.com/news/top-dental-tourism-destinations-worldwide [Accessed 6 Mar. 2025].

The Explorer's Passage (2025). The ultimate travel guide on Costa Rica in 2025. [online] Available at: https://explorerspassage.com/chronicles/costa-rica-travel/ [Accessed 26 Mar. 2025].

Thantakit (2022). Which countries are the best for dental tourism? [online] Available at: https://www.thantakit.com/which-countries-are-the-best-for-dental-tourism [Accessed 6 Mar. 2025].

VK Smile Studio (2024). Why is dental tourism in Antalya so popular? [online] Available at: https://www.vksmilestudio.com/blog/dental-tourism-antalya/ [Accessed: 26 Mar. 2025].

Wikipedia (2022). Tourism in Costa Rica. [online] Available at: https://en.wikipedia.org/wiki/Tourism_in_Costa_Rica [Accessed 6 Mar. 2025].

LENT 2025

Why do we Fear? The Science Behind Phobias

By Imogen Brooker (Year 7)

Key Words:

Phobia:
a type of anxiety disorder (a mental illness that makes someone very worried and affects their life) that involves an extreme fear of something

Chronic:
continuing for a long time

ANS:
automatic nervous system

OCD:
obsessive compulsive disorder

Arachnophobia:
a very strong fear of spiders

What is a Phobia?

Phobias are extreme and irrational fears of a person/people, place, object, feeling or animal. They are different to normal fears. The NHS Inform (n.d.) say that a fear only becomes a phobia when someone organises their life around avoiding the thing that triggers the phobia. The NHS (n.d.) says phobias are also a type of anxiety disorder. Harvard Health (2024) suggests that in children, phobias can be short-term problems lasting around a month, but in adults, 80% of phobias become chronic conditions and do not go away without proper treatment.

Why do we have Phobias?

According to the NHS (n.d.), phobias can develop from a traumatic/ negative childhood experience. Mind (2021) says that phobias can be learned, (for example, if someone's parents are very anxious, then their child might develop a phobia). They also say that someone's genes could potentially make them more vulnerable to developing a phobia.

Symptoms

The NHS claim that when faced with their phobia, someone can experience tachycardia (Also known as increased heart rate. The Cleveland Clinic (2021) say that anxiety trigger the body's ANS, which increases heart rate.). Another symptom is perspiration. The Aurora Healthcare say your body does this because when you become excited or scared, your body releases hormones linking to stress like adrenaline and cortisol, which make people sweat. Harvard Health (2024) says that a person with a phobia will have feelings that are irrational and out of proportion to the actual threat. For example, imagine you are on holiday, and you decide to go diving. You are swimming around, and suddenly you can see an enormous shark. Most people would be scared in this situation, but a person with galeophobia (the fear of sharks in the ocean) may avoid swimming in the sea entirely.

Mind (2021) says that people can feel nauseous when around their phobia, and according to Houston Methodist (2021), this happens because outside of your brain, your gut holds the second largest number of nerves in your body. The hormones and chemicals released when someone is anxious can cause gut-related problems such as nausea, stomach cramps, loss of appetite and indigestion.

Panic Attacks

Sadly, this is a common symptom of many

phobias and other anxiety disorders. According to Better Health (n.d.), around 35-40% of people will experience a panic attack (also known as an anxiety attack) in their lives. The NHS (n.d.) say that a panic attack can have symptoms of chest pain, a choking sensation, feeling faint and more.

The Most Common Phobias

Verywell Mind (2024) states that arachnophobia, the name for a phobia of spiders and other arachnids, is one of the most common phobias. Cleveland Clinic (2021) suggests that this phobia is more common in females then males, and approximately 3-15% of the population have it. Verywell Mind (2024) also says that acrophobia is another very common phobia, with Cleveland Clinic (2021) saying that approximately 3-6% of the population suffer from it.

The Rarest Phobias

According to The Recovery Village (2024), arachibutyrophobia is one of the rarest phobias. It is the name for the intense fear of peanut butter sticking to the roof of your mouth. This phobia can stem from another phobia of choking. The Recovery Village (2024) also say that another rare fear is optophobia, the fear of opening one's eyes!

The Difference Between Mysophobia and OCD

The stereotype of OCD is that it is a mental disorder causing someone to obsessively clean and worry about germs. This is partly true, but there is a lot more to it than that. The NHS (n.d.) states that someone with OCD will experience frequent obsessive thoughts and compulsive behaviours. Mysophobia is the intense fear of germs/contamination. Impulse Therapy (2023) says that someone with mysophobia will excessively wash their hands if they cannot avoid the bacteria, while people with OCD have a habit of washing their hands when they become overwhelmed, stressed or anxious. Impulse Therapy (2023) also says that in mysophobia, the main factor is the intense fear of touching something and becoming sick, but in OCD, (particularly contamination OCD) it is the obsessive cleaning of the individual's home and/or body.

Treatment

Phobias can be treated with CBT (cognitive behavioural therapy) and sometimes exposure therapy (a type of CBT). CBT helps change thinking patterns, while IPT (Interpersonal Therapy) looks at how people relate to each other. Cognitive behavioural therapists are used for long-term illnesses, while IPT is used maybe for generally 12-16 weeks. Exposure therapy is when the patient is gradually exposed to the feared object, which can be through in vivo exposure, which is actual exposure to the object, imaginal, which is imaging the feared situation, or interoceptive, which is exposing someone to the sensations related to anxiety, like hyperventilation.

Bibliography:

Better Health (n.d.). Panic Attacks. [online] Available at: https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/panic-attack [Accessed: 2 Apr. 2025].

Cleveland Clinic (2021). Arachnophobia. [online] Available at: https://my.clevelandclinic.org/health/diseases/21852-arachnophobia-fear-of-spiders [Accessed: 2 Apr. 2025].

Harvard Health (2024). Phobia. [online] Available at: https://www.health.harvard.edu/a_to_z/phobia-a-to-z [Accessed: 1 Apr. 2025].

Houston Methodist (2021). Can Anxiety Cause Nausea?. [online] Available at: https://www.houstonmethodist.org/blog/articles/2021/may/can-anxiety-cause-nausea-and-5-more-questions-about-how-anxiety-might-feel/ [Accessed: 1 Apr. 2025].

Impulse Therapy (2023). Mysophobia vs OCD. [online] Available at: https://impulsetherapy.com/mysophobia-vs-ocd-understanding-the-key-differences/ [Accessed: 2 Apr. 2025].

Mind (2021). Symptoms of phobias. [online] Available at: https://www.mind.org.uk/information-support/types-of-mental-health-problems/phobias/symptoms-of-phobias/ [Accessed: 1 Apr. 2025].

NHS (n.d.). Overview - Obsessive compulsive disorder. [online] Available at: https://www.nhs.uk/mental-health/conditions/obsessive-compulsive-disorder-ocd/overview/ [Accessed: 2 Apr. 2025].

NHS (n.d.). Overview - Phobias. [online] Available at: https://www.nhs.uk/mental-health/conditions/phobias/overview/ [Accessed: 15 Mar. 2025].

NHS (n.d.). Panic Disorder. [online] Available at: https://www.nhs.uk/mental-health/conditions/panic-disorder/ [Accessed: 2 Apr. 2025].

NHS inform (n.d.). Phobias. [online] Available at: https://www.nhsinform.scot/illnesses-and-conditions/mental-health/phobias/ [Accessed: 1 Apr. 2025].

The Recovery Village (2024). Weird phobias. [online] Available at: https://www.therecoveryvillage.com/mental-health/phobias/weird-phobias/ [Accessed: 2 Apr. 2025].

Verywell Mind (2024). 10 of the most common phobias. [online] Available at: https://www.verywellmind.com/most-common-phobias-4136563 [Accessed: 2 Apr. 2025].

LENT 2025

Designer Babies: Is using CRISPR-Cas9 Gene Editing a Scientific Phenomenon or an Ethical Horror?

By Grace Dhesi (Year 12)

Key Words:

CRISPR:
clustered regularly interspaced short palindromic repeat: a piece of DNA that includes short, repeated sequences

Designer Baby:
a baby whose genes have been chosen by its parents and doctors so that it has particular characteristics

Gene Editing:
the process of changing genes using scientific methods, in order to cure or prevent disease

In November 2018, the world's first ever "designer babies" were born, via CRISPR-cas9 (Clustered Regularly Interspaced Short Palindromic Repeats) technology – Lulu and Nala – a set of twins conceived with genetically modified embryos, altering a gene to prevent the children from contracting HIV from a HIV-positive father (Rose et al., 2019). Chinese scientist He Jiankui revealed that he had used CRISPR gene-editing technology to modify the DNA of twin girls – the mechanism of CRISPR being to "permanently modify genes in living cells and organisms", targeting specific stretches of genetic code and to edit DNA at precise locations and hence allowing gene editing and an element of designing the babies produced (Broad Institute, 2018).

While Jiankui claims to have only used CRISPR gene-editing technology for treating a serious genetic disease, this invention and introduction of altering the genome of babies was widely criticized for crossing ethical boundaries and posing dangerous problems within what CRISPR technology can be used for in future – whereby genetic modifications could be used not just for medical reasons, but for enhancing intelligence, appearance, or athletic ability (Cheung and Nie, 2019). This controversy raises a crucial question for the future of genetic modifications, however, questioning whether CRISPR-cas9 technology has the potential to revolutionize medicine, or to open the door to a future of genetic inequality and ethical dilemmas?

Historically – from the double helix structure first being discovered by James Watson and Francis Crick in 1953 to the 1970s whereby from understanding restriction enzymes and DNA ligase, Paul Berg became the first scientist to ever create a recombinant DNA from more than one species, genetic modification seemed to have a slow and generally controlled discovery process, controlled further coming into the 2000s whereby many countries introduced rules and regulations for when it came to genetic manipulation, to maintain ethical practice (Synthego, 2019). And from this point, gene-editing was used to find the first even preventative cancer vaccine; the Hepatitis B vaccine, known to reduce risk of liver cancer – followed in the 2012 by the discovery of CRISPR as a genome engineering tool by Jennifer Doudna and her team. CRISPR technology works through pinpointing the specific genomic site requiring modification and cutting that section out – and creating a corrected version of the DNA section, inserting the DNA at the target site and using repair mechanisms to mend the edited site. Comparing CRISPR to previous gene-editing technology, CRISPR is considered a much more efficient way of gene editing, as it means "researchers can now make targeted and deliberate changes to DNA sequences relatively easily" (Thorne, 2021), as well as CRISPR technology being more easily accessible – whereby any amateur scientists with a basic laboratory are able to use CRISPR technology, which of course raises significant concerns over the usage of biotechnology (Thongpravi and Stasi, 2024).

Although CRISPR technology raises ethical and experimental concerns with the applications of its usage, it also undeniably has a number of possible potential positive uses – including the ability to eliminate genetic diseases that may be faced, such as cystic fibrosis, anaemia and muscle dystrophy (Schmerker, 2024) by correcting mutations with only one treatment, with a permanent effect (Cystic Fibrosis Foundation, n.d., online). This procedure therefore saves time and money in healthcare industries through removing the disease via removing the mutation – also further saving future generations from genetic mutations and diseases. Furthermore, CRISPR technology has shown utility in its ability to provide resistance to strains of HIV, by using CRISPR to edit CCR5 gene in human hematopoietic stem cells (HSPCs), aiming to replicate a natural mutation known which provides said resistance (Xu, 2019). The edited cells were transplanted into a patient with HIV and leukemia, and while the procedure was safe and the modified cells survived, only 5-8% of bone marrow cells carried the CCR5 mutation, which is significantly far below the ideal level for full HIV resistance – displaying the need for further research into the following subject- however the study highlights CRISPR's potential to again cure chronic diseases with

Key Words:

Genetic Modification:
the process of changing the structure of the genes of a living thing in order to make it healthier, stronger, or more useful to humans

Dystrophy:
any of several medical conditions in which a body part or tissue gradually becomes weaker

Genome:
the complete set of genetic material of a human, animal, plant, or other living thing

more research and testing of its possibilities.

CRISPR-Cas9 technology offers significant potential in editing embryonic genomes to eliminate hereditary diseases, which introduced the possibility for healthier generations and elimination of genetic diseases for future generations. By precisely targeting and modifying the specific genetic sequences that cause these diseases, CRISPR enables the correction of mutations responsible for various genetic disorders, including Down Syndrome (Lapid, 2025) – whereby the "technique can identify which chromosome has been duplicated" between the three chromosomes produced by trisomy in chromosome 21, causing down syndrome – further eliminating the replicated chromosome and leaving either chromosome from each parents, and fundamentally removing the disease from the baby's genome.

A designer baby by definition, is a "baby genetically engineered in vitro for specially selected traits" (Ly, 2011, online) – genetically modified so that the parents can choose to change the genetic make of the baby. Undeniably, this control of the baby's genetic make and future is highly beneficial, with benefits including the potential elimination of hereditary disorders – whereby trials have shown that diseases such as cancers, muscular dystrophy and AIDS which have previously had limited treatments which affecting large populations could be cured through CRISPR technology genetically modifying DNA sequences to eradicate these diseases-causing genes (Fernández, 2024). The possible elimination of these hereditary and genetic diseases has significant social benefits including reducing healthcare burdens on a person, their family and healthcare professionals, which in turn could lead to a healthier population, lower medical costs, and a more efficient allocation of healthcare resources, hence allowing for the transformation of public health on a large scale as life-long diseases cease to exist by CRISPR technology (National Human Genome Research Institute, 2023). Furthermore, the ability for parents to have more control over their child's genetic future allows them to select specific traits, giving parents the potential to enhance qualities such as intelligence or physical abilities, which enables parents to provide their children with advantages that align with societal ideals and personal preferences which can further prevent social disturbances as the child progresses through life, including the experience of bullying and further impacts of negative mental health that could follow (Bradley, n.d.). Nonetheless, the genetic editing available to parents can raise ethical concerns regarding the extent of parental influence and the potential societal implications of having control over such choices.

The control which parents and even humanity have over the creation and production of the embryo debatably has several ethical problems concerning humans "playing God" with genetics. From a religious point of view, many religions view life as a gift of God – and the creation and taking away of a life as a divine power reserved solely for God. However, the usage of CRISPR technology to interfere with the process of creating life and altering the natural process of a child's development from the embryo raises concerns over whether humans are exercising a level of power which only God should possess (Henderson and Halpern, 2024).

Additionally, CRISPR technology is all relatively a very new invention – and we are only now seeing the first generation of genetically edited designer babies and designer children – thus there is a possibility that CRISPR technology may have unintended consequences including off-target mutations and unknown long-term effects. Off-target mutations occur when the CRISPR-Cas9 system inadvertently edits unintended genomic sites, potentially disrupting normal cellular functions and leading to adverse conditions or diseases. These unintended mutations could activate oncogenes, leading to tumour formation, or inactivate tumour suppressor genes, increasing the risk of cancer (Bose, 2025). In human embryos, CRISPR editing has been associated with unintended DNA changes adjacent to the target site, raising concerns about heritable genetic alterations with long-term risks, and the long-term effects of such genetic modifications remain uncertain, necessitating extensive research and monitoring to fully understand the implications of germline editing (Lopes and Prasad, 2024), and as research continues, addressing these concerns through improved precision, regulatory oversight, and ethical considerations will be crucial to harnessing CRISPR's full potential responsibly (molecularsciences.org, n.d.).

The potential of CRISPR technology to enable genetic enhancements raises significant ethical concerns, particularly regarding the possible introduction of social inequality to the generation of designer babies, whereby only wealthy and affluent may be able to afford gene editing for their children – meaning that there will be a divide between children that were gene edited, and those who weren't. If access to such advancements is limited to the wealthy, it could lead to a genetic divide, where enhanced individuals possess traits that confer economic and social advantages, thereby widening the gap between socioeconomic classes, which further risks creating a genetic underclass, even further entrenching existing disparities (Sherman, 2017) and mirroring eugenics and social hierarchical prejudices within history. Moreover, the high costs associated with genetic modifications may restrict their availability, ensuring that only affluent individuals can afford these enhancements, which could perpetuate systemic inequities (Scientific American, 2018).

Where do we stand with the global regulation of CRISPR technology currently? Well, global regulations on human genetic editing remain fragmented, with some countries such as the US completely prohibiting research into gene editing - whereas the EU allows research of CRISPR technology applications so long as oversighted by entities such as the EU Commission and the European Medicines Agency (Global Gene Editing Regulation Tracker, 2020). Furthermore, the controversy surrounding He Jiankui's 2018 CRISPR baby experiment, which aimed to confer HIV resistance, exposed ethical concerns, lack of oversight, and unknown risks, leading to widespread condemnation which has also caused many states and countries to undergo the process of changing and reviewing their laws surrounding the regulation of gene editing and using it to produce designer babies. And beyond medical uses, CRISPR's potential for genetic enhancement raises ethical debates of social inequality, man's power and the possible consequences that utilising CRISPR technology could lead to - contrasting all of the possible benefits that this technology could present - making "designer babies" a highly risky - and yet also highly rewarding - process.

Looking at both sides of the CRISPR technology's possible potential and also ethical concerns, it is undeniable that the gene editing technology could be revolutionary with minimising diseases which the next generation may have to face - increasing quality of life and also reducing healthcare burdens on an already overworked healthcare system - however this technology also raises so many ethical concerns and global debates, that the availability and possible uses of CRISPR technology, that the availability and possible uses of CRISPR technology must be carefully regulated. While some argue that responsible use of CRISPR could prevent hereditary diseases without leading to the full-scale genetic enhancement of children, the line between therapeutic applications and human enhancement remains dangerously thin, and if the door to designer babies is opened, it may be impossible to close, leading to unforeseen societal consequences - hence, the question remains as CRISPR technology continues to develop and open new doors of potential uses: Will CRISPR-San95 redefine human evolution, or will society place limits on genetic control?

Key Words:

Socioeconomic:
related to the differences between groups of people caused mainly by their financial situation

Therapeutic:
relating to the curing of a disease or medical condition

Evolution:
the way in which populations of living things change and develop over time

Bibliography:

Bradley, S. (n.d.). Pros and cons of gene-editing babies. [online] Available at: https://theweek.com/news/science-health/959606/pros-and-cons-of-gene-editing-babies? [Accessed: 16 Mar. 2025].

Bose, P. (2025). CRISPR-Cas9 Off-Target Effects: Challenges and Solutions. [online] Available at: https://www.azolifesciences.com/article/CRISPR-Cas9-Off-Target-Effects-Challenges-and-Solutions.aspx [Accessed: 16 Mar. 2025].

Broad Institute (2018). Questions and Answers about CRISPR. [online] Available at: https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/questions-and-answers-about-crispr [Accessed: 27 Feb. 2025].

Bruce, R. and Brown, S. (2019). Genetically Modified Babies and a First Application of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR-Cas9). Obstetrics & Gynecology. [online] Available at: https://journals.lww.com/greenjournal/fulltext/2019/07000/genetically_modified_babies_and_a_first.23.aspx [Accessed: 27 Feb. 2025].

Cheung, A. and Nie, J. (2019). He Jiankui's Genetic Misadventure, Part 3: What Are the Major Ethical Issues?. The Hastings Center. [online] Available at: https://www.thehastingscenter.org/jiankuis-genetic-misadventure-part-3-major-ethical-issues [Accessed: 27 Feb. 2025].

Cystic Fibrosis Foundation (n.d.). Gene Editing for Cystic Fibrosis. [online] Available at: https://www.cff.org/research-clinical-trials/gene-editing-cystic-fibrosis#:~:text=The%20CRISPR%20gene%20editing%20tools,the%20site%20of%20the%20mutation [Accessed: 13 Mar. 2025].

Fernández, C. (2024). Seven diseases CRISPR technology could cure. [online] Available at: https://www.labiotech.eu/in-depth/crispr-technology-cure-disease/ [Accessed: 16 Mar. 2025].

Global Gene Editing Regulation Tracker (2020). Gene Editing and New Breeding Techniques: Regulations, Ratings and Index. [online] Available at: https://crispr-gene-editing-regs-tracker.geneticliteracyproject.org [Accessed: 16 Mar. 2025].

Henderson, H. and Halpern, J. (2024). CRISPR & Ethics. [online] Available at: https://innovativegenomics.org/crisprpedia/crispr-ethics/#:~:text=Concerns%20about%20the%20relationships%20between,quite%20literal%3A%20humans%20exercising%20a [Accessed: 16 Mar. 2025].

Lapid, N. (2025). Health Rounds: Gene editing may hold key to preventing Down syndrome. [online] Available at: https://www.reuters.com/business/healthcare-pharmaceuticals/health-rounds-gene-editing-may-hold-key-preventing-down-syndrome-2025-02-19[Accessed: 14 Mar. 2025].

Lope, R. and Prasad, M. (2024). The long-term implications of germline editing: risks and ethical concerns. [online] Available at: https://www.frontiersin.org/journals/bioengineering-and-biotechnology/articles/10.3389/fbioe.2023.1339189/full [Accessed: 16 Mar. 2025].

Ly, S. (2011). Ethics of Designer Babies. [online] Available at: https://embryo.asu.edu/pages/ethics-designer-babies [Accessed: 16 Mar. 2025].

Molecularsciences.org (n.d.). The challenges of CRISPR: Risks, off-target effects, and regulation. [online] Available at: https://molecularsciences.org/content/the-challenges-of-crispr-risks-off-target-effects-and-regulation/ [Accessed: 16 Mar. 2025].

National Human Genome Research Institute (2023). The Impact of Genomic Medicine on Public Health. [online] Available at: https://www.genome.gov/about-genomics/policy-issues/what-is-Genome-Editing [Accessed: 16 Mar. 2025].

Shmerker, J. (2024). CRISPR-Cas9: 10 pros and 7 cons. [online] Available at: https://eu.idtdna.com/pages/community/blog/post/crispr-cas9-what-are-the-10-pros-and-7-cons [Accessed: 13 Mar. 2025].

Synthego (2019). History of Genetic Engineering and the Rise of Genome Editing Tools. [online] Available at: https://www.synthego.com/learn/genome-engineering-history [Accessed: 27 Feb. 2025].

Thorne, L. (2021). How Does CRISPR Compare with Other Gene-Editing Methods?. [online] Available at: https://www.biocompare.com/Editorial-Articles/576583-How-Does-CRISPR-Compare-with-Other-Gene-Editing-Methods/ [Accessed: 2 Mar. 2025].

Thongpravi, O. and Stasi, A. (2024). Biotechnology Innovation in Do-It-Yourself (DIY) Gene Editing: A Call for a New Regulatory Framework. [online] Available at: https://mahidol.elsevierpure.com/en/publications/biotechnology-innovation-in-do-it-yourself-diy-gene-editing-a-cal [Accessed: 2 Mar. 2025].

Xu, L. (2019). CRISPR-Edited Stem Cells in a Patient with HIV and Acute Lymphocytic Leukemia. [online] Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa1817426 [Accessed: 14 Mar. 2025].

Key Words:

Retina:
the area at the back of the eye that receives light and sends pictures of what the eye sees to the brain

Symptoms:
any feeling of illness or physical or mental change that is caused by a particular disease

Symptoms:
any feeling of illness or physical or mental change that is caused by a particular disease

Anatomy:
the scientific study of the body and how its parts are arranged

LENT 2025

Lights, Camera, Retina: Eye Wonder What's Behind the Lens?

By Shiv Vaghela (Year 6)

The Eye: The Ultimate Super-Powered Camera

Have you ever stopped to think about how you see the world? I hadn't either—until last year, when my dad went for a routine eye test and ended up being rushed to the Eye Casualty Department at the Leicester Royal Infirmary. The verdict? A detached retina.

Wait... what? What even is a retina? And why was it suddenly detaching like paint peeling of a wall!

This got me thinking. How does the eye actually work? And did my dad's short-sightedness have anything to do with this? It turns out, our eyes are like tiny built-in cameras with high tech features, including a lens, light sensors, and even an ultra-fast processor (your brain). Each feature has a benefit and without any one of these features, our vision is seriously compromised. Just like a camera, if something goes wrong—like a detached retina—your vision can distort, glitch, or even disappear completely.

The good news is my dad didn't have symptoms; his retina was caught in time thanks to his routine eye test. The moral of the story is to go the opticians every year for an eye test as a minimum. Oh, and I totally forgot to mention that my dad is a photographer, how ironic is that. As you can imagine, he was out of action for a while, pun intended.

Let's Take a Closer Look at the Human Eye

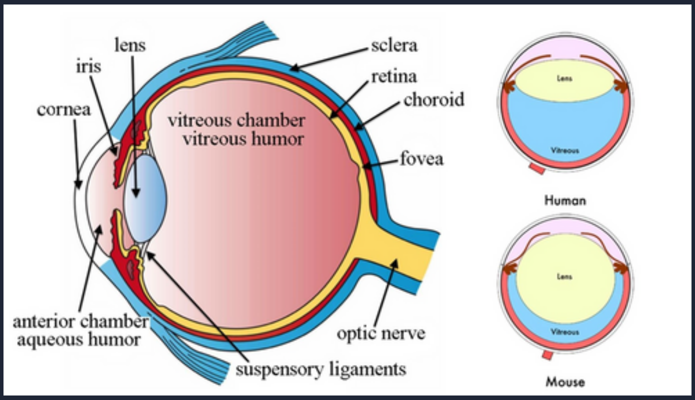

Figure 1. (Exeter Eye, n.d.)

Most of you will recognise this image, we have all seen this is in our science books. This is the anatomy of the eye!

Eye Wonder How We See?

The similarities between the human eye and a camera are clear!

Key Words:

Cornea:
the transparent outer covering of the eye

Pupil:
the circular, black area in the centre of the eye that gets larger and smaller and lets in light

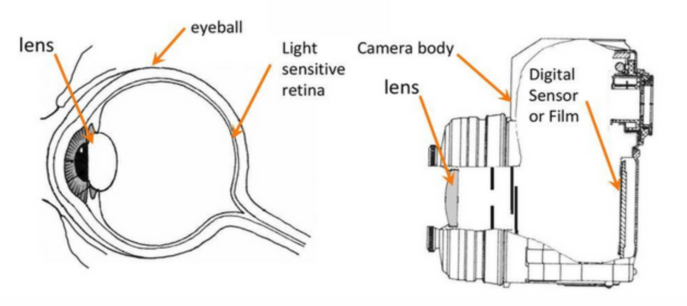

Figure 2. (Montgomery, n.d.)

The eye is basically a living DSLR camera, just without the need to charge it, well sort of, our eyes get charged when we sleep, so no need to be plugged in, beauty sleep is all that is required. Here's how it works:

The cornea (auto-focus lens); light first enters through the cornea, which acts like a camera lens, bending the light so it can be focused properly. In fact, 65-75% of your eye's focusing power comes from the cornea (Lloyd, 2006).

The pupil (your built-in aperture); the light then travels through the pupil, which changes size to control how much light gets in, just like a camera adjusting for bright or dark settings (McDougal & Gamlin, 2015). Ever noticed "red-eyes" in photos? This is actually light reflecting off the blood vessels inside your eye (Cleveland Clinic, 2023).

The retina (the sensor that captures the image); once light reaches the retina, it's transformed into electrical signals. The retina is packed with photoreceptor cells called rods (for seeing in dim light) and cones (for colour). The retina is similar to the sensor of a camera. If the sensor of a camera is damaged, the camera stops working. In the same way if the retina is damaged, this can cause blindness. Signals are sent to your brain via the optic nerve, which then flips the image the right way up. Yes, your brain actually receives everything upside-down first (Banks & Salapatek, 1981).

The Iris and Aperture

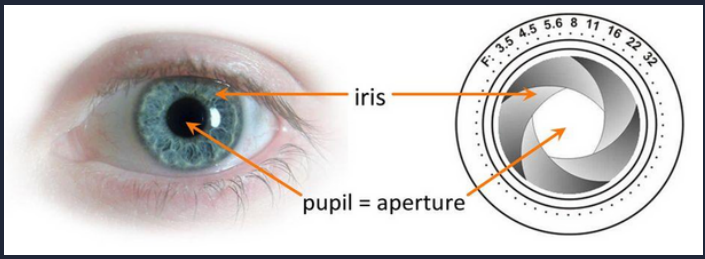

Figure 3. (Montgomery, n.d.)

The above image highlights how both a camera and the human eye controls the amount of light that enters. The lower the aperture, the more light enters the lens. In a dark room our pupils are dilated to allow more light to enter.

Short-Sightedness (Myopia): The Near-Sighted Struggle

Have you ever tried to read something far away and failed miserably? That's Myopia. This is when the eyeball is too long, causing light to focus in front of the retina instead of on it. Our optometrist spoke to my parents about Myopia, something that I had never heard of until then and told them that there is a way to delay my eye prescription increasing.

A lot of people blame excessive screentime for this, and yes, too much screen time can make things worse. However, Professor Jeremy Guggenheim of Cardiff University says genetics play a huge role too. Even if you have laser surgery, your eyeball still continues to grow and therefore you may need to have the surgery performed again in the future!

Figure 4. (Shah, 2023)

Special lenses called MIYOSMART Lenses (developed in the UK) can actually help slow down Myopia progression in children! I have been wearing these special lenses for the past few years and the research shows that the lenses help slow down the short sightedness.

Above is an image of what the MIYOSMART lenses look like: The tiny dots are not visible from a distance however they work in a novel way to help focus your vision. The centre of the lenses offer full myopic correction and the outer parts of the lens have a weaker prescription. The visual information from both parts of the lens triggers a mechanism in your eye and tell it to stop elongating.

Long-Sightedness (Hyperopia): When Close-Up Text Becomes a Blur

If myopia is about eyeballs being too long, hyperopia is the opposite—when the eyeball is too short, making light focus behind the retina. This makes it harder to see things up close, like small text. We can clearly see below that focal point misses the retina and falls behind it.

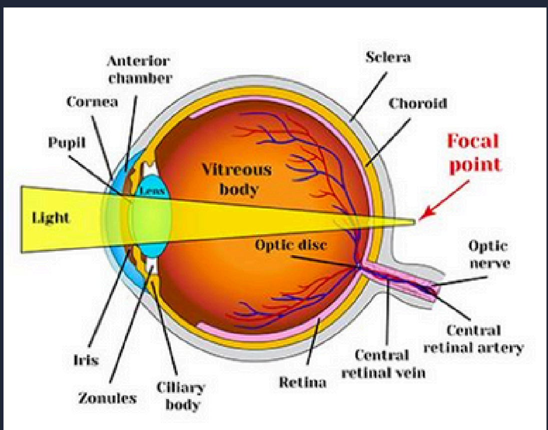

Figure 5. (Plano, 2022)

Floaters, Flashes, and the Ultimate Glitch: Retinal Detachment

Imagine watching your favourite movie, and suddenly, parts of the screen starts flickering, flashing, and going blurry. That's what a retinal detachment feels like! When the retina starts peeling away, it cuts off its connection to the optic nerve. The transfer of sensory information to the brain is limited which could lead to the loss of vision!

There are various warning signs, including floaters which are little black dots that drift around your vision like dust specks; flashes of light, which are tiny lightning bolts in your eye; and blurry or missing parts of your vision. If this happens, you need to seek advice from an ophthalmologist immediately.

The good news is that retinas can be reattached using the following procedures:

Gas Bubble Surgery
A tiny air bubble is placed inside the eye to push the retina back into place (Mullins, 2010).

Scleral Buckling
A silicone band is wrapped around the eye to gently press the retina back – this is the procedure that my dad had done. As you can see from Fig 5 below, the blue silicon band squeezes the eyeball and pushes it towards the back of the eye helping the re attachment of the retina.

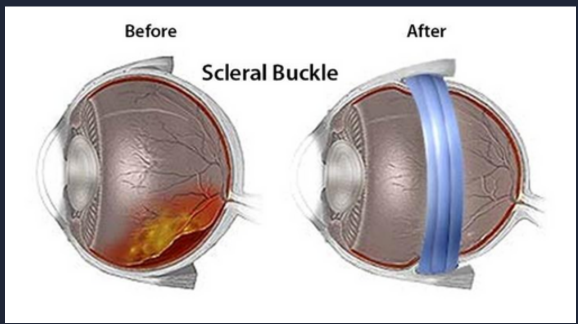

Figure 6. (Retina Nevada, n.d.)

Laser Surgery
A high-powered laser 'welds' the retina back into position.

Why do Retinas Detach?

Retinal detachment can be caused by many things, the most common of which are short-sightedness; sudden trauma such as getting hit in the eye with a cricket ball; ageing and genetics.

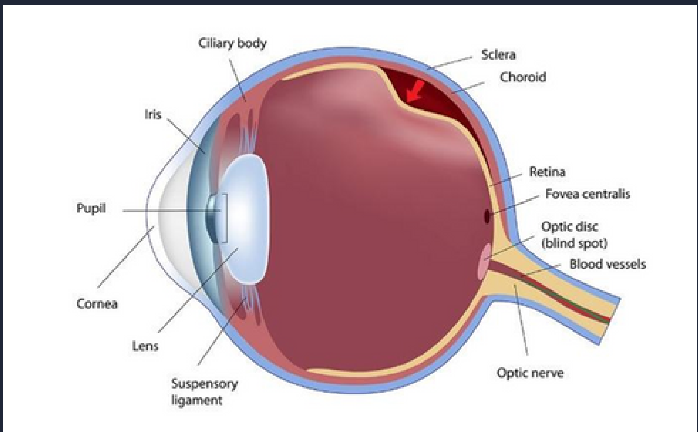

Figure 7. (Grand Rapid Opthalmology, n.d.)

Conclusion

The human eye is an extraordinary biological system that processes lots of visual information however things can go wrong. And understanding the underlying mechanisms allows us to understand the eye and the importance of maintaining good health. The key to preserving eyesight is by a healthy diet, early intervention, scientific advancements, and wearing protective eye where such as sunglasses.

In summary I have really enjoyed researching this topic and I'm fascinated with how the human eye and connections to the brain work. I feel that I have gained an invaluable insight into human eye and if it was not for my dad's detached retina last year, I would not have known as much as I do now. The eye is clearly an spec-tacular organ!

Bibliography:

Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge.

Cleveland Clinic (2023). Why do pupils look red in photos? [online] Available at: https://my.clevelandclinic.org [Accessed: 5 Apr. 2025].

Exeter Eye (n.d.). [online] Available at: https://www.exetereye.co.uk/the-eye/eye-anatomy/ [Accessed: 5 Apr. 2025].

Grand Rapids Ophthalmology (n.d.). [online] Available at: https://www.seeitclear.com/retina-specialist-grand-rapids/retinal-detachments/ [Accessed: 5 Apr. 2025].

Lloyd, C. (2006). The Eye and Vision: A Comprehensive Guide. London: Harper & Row.

McDougal, D. H., & Gamlin, P. D. (2015). The pupillary light reflex pathway. Vision Research, 109, 1-7.

Mullins, R. (2010). Retinal Detachment and Repair Techniques. Oxford University Press.

Plano (2022). [online] Available at: https://plano.co/long-sighted-mean/ [Accessed: 5 Apr. 2025].

Retina Nevada (n.d.). [online] Available at: https://retinanevada.com/what-is-a-scleral-buckle/ [Accessed: 5 Apr. 2025].

Rosalind Montgomery (n.d.). [online] Available at: https://slideplayer.com/slide/13895448/ [Accessed: 5 Apr. 2025].

Shah, B. (2023). [online] Available at: https://www.centralvisionopticians.co.uk/read-this-before-your-child-wears-miyosmart-glasses-for-myopia-important/ [Accessed: 5 Apr. 2025].

LENT 2025

Histone Proteins and Nuclear Function

By Avi Kotecha (Year 13)

Key Words:

Nomenclature:
a system for naming things, especially in a particular area of science

Chromosome:
any of the rod-like structures found in all living cells, containing the chemical patterns that control what an animal or plant is like

Mitotic:
relating to the act or process of mitosis (cell division)

Meiotic:
relating to the act or process of meiosis (of cell division)

Histone proteins are the spool on which DNA wraps itself around (Gilchrist, 2025), controlling the extent of transcription and subsequent translation (Liu, 2023). The histone itself is a large, globular protein that has a partial positive charge (Kumar, 2019), it is rich in amino acids that have a positive "R" group. Such amino acids go by names lysine (lys) and arginine (arg) that make up a large proportion of the subunits for histones (Kumar, 2019). DNA is a key factor for life, and even its nomenclature suggests some link to positive charges and hydrogen bonds – DNA is an acid, thus a proton donator, capable of losing a positively charged particle to form an anion. The globular quaternary structure of the histone protein plays a profound role in the expression of genes, be that in specialised cells or in epigenetic expression of some terrible diseases (cancers, et cetera) (Kumar, 2019) (Paro, et al, 2021).

When the globular "main body" histone protein has been wrapped with a portion of your genome it is known as a nucleosome, acting fundamentally as another subunit for a chromosome, where many nucleosomes tightly wrap around each other to form a condensed chromosome (Annuziato et al, 2008), histones are in fact present in all stages of the cell cycle, where depending on the number and specie of epigenetic marker, the given gene can be hyper-expressed or silenced (Paro & et al, 2021) (Gilchrist, 2025) (Kumar, 2019).

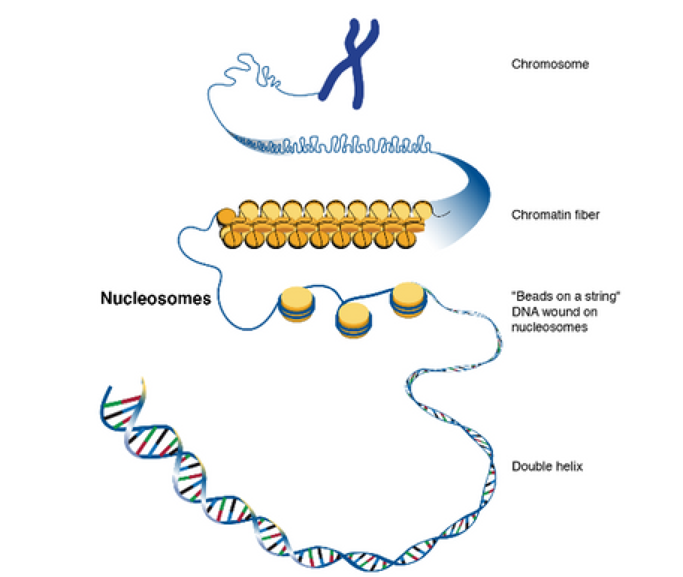

Figure 1. Nucleosome model (Gilchrist, 2025)

The histone itself is made up of a globular octamer and a separate head – the octamer is built of the globular units that associate with the DNA due to ionic bonds between the positive loci of the amino acids and the anionic nature of DNA (Ramaswamy & Ioshykes, 2013). The other "H1" sections of histone proteins are key to form the condensed chromosome that is required in the mitotic and meiotic divisions leading to the production of daughter cells. These separate subsections act a guide to the spooling action of the histone octamer, forming disulphide bridges/ bonds allowing them to form helices.

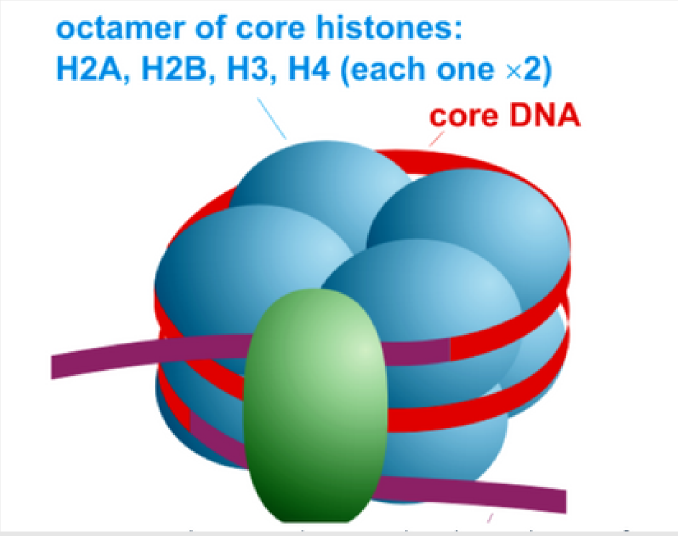

Figure 2. Nucleosome diagram detailing subunits of histone (Geneticeducation, n.d.)

The process of translation and transcription is heavily regulated by the specie and number of epigenetic markers present on the head of the octamer - where methylation leads to an increase in overall positive charge thus causing histones to attach with more strong ionic bonds. Another main specie learned at A level is the acetyl group, that loosens the grip of the protein on the DNA due to the electron density of the carbonyl group, regardless of any acidic proton. This has the converse effect to the methylation. Where linkage DNA has now become longer as the grip of the spool has reduced.

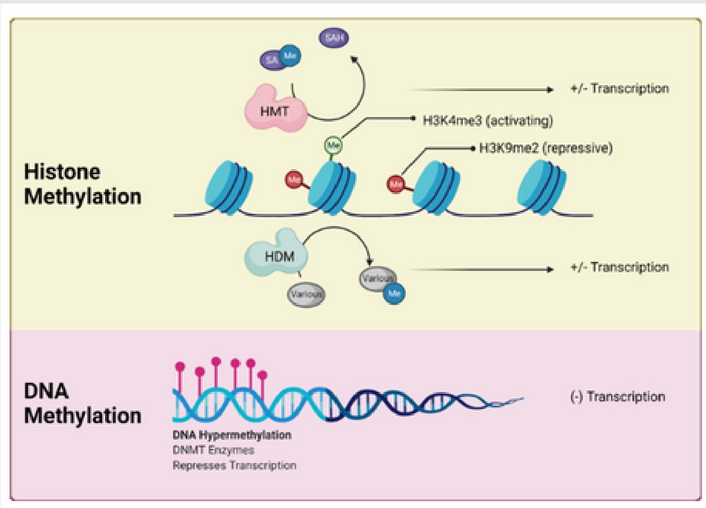

Figure 3. Results of methylation and addition of species to DNA and histone octamer (Roy & al, n.d.)

The nucleosome model of DNA is somewhat similar to a sewing machine - DNA is the thread, and instead of leaving the spool, or histone, it is travelling backwards and is becoming reassociated; DNA is being guided by enzymes called condensins that cause fibrous chaperone proteins to aide the winding process, thus acting as the small hooks that guide the thread.

In this way the workings of the nucleus and the genome have become demystified by my breakdown.

Bibliography:

Annuziato, A. & al, e. (2008). DNA Packaging: Nucleosomes and Chromatin. [online] Available at: https://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310/ [Accessed: 25 Mar. 2025].

Geneticeducation (n.d.). What is DNA packaging in eukaryotes?. [online] Available at: https://geneticeducation.co.in/what-is-dna-packaging-in-eukaryotes/ [Accessed: 25 Mar. 2025].

Gilchrist, D. (2025). Histone. [online] Available at: https://www.genome.gov/genetics-glossary/histone [Accessed: 25 Mar. 2025].

Kumar, V. (2019). Histones types and its functions. [online] Available at: https://microbiologynotes.org/histones-types-and-its-functions/ [Accessed: 25 Mar. 2025].

Liu, R. et al. (2023). Post-translational modifications of histones: Mechanisms, biological functions, and therapeutic targets. [online] Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC10200003/ [Accessed: 25 Mar. 2025].

Paro, R. et al. (2021). Introduction to epigenetics. [online] Available at: https://www.ncbi.nlm.nih.gov/books/NBK585717/ [Accessed: 25 Mar. 2025].

Ramaswamy, A. & Ioshykes, I. (2013). Advances in protein chemistry and structural biology. [online] Available at: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/histone-octamer#:~:text=Small%20basic%20protein%20with%20a%20globular%20domain%20and,of%20histone%20proteins%20H2A%2C%20H2B%2C%20H3%2C%20and%20H4. [Accessed: 25 Mar. 2025].

Roy, Z. et al. (n.d.). Figure - available from: Immunological Reviews. [online] Available at: https://www.researchgate.net/figure/Overview-of-epigenetic-methylation-systems-Histone-methylation-is-controlled-by-the_fig3_360237117/actions#reference [Accessed: 25 Mar. 2025].

Key Words:

Chimerism:
the fact or state in an organism of containing cells or tissues from two or more different species or from two or more genetically different living things

Geneticist:
a person who studies genetics

LENT 2025

Genetic Chimerism: Can One Person Have Two Sets of DNA?

By Sinan Al-Tikrieti (Year 12)

Introduction: Surprising Find of a Geneticist

Barry Starr was a prominent geneticist who had dedicated most of his life to researching the mysteries of DNA. In 2002, Barry was called to assist in a paternity case. A man was confronted with a highly shocking situation: Genetic tests indicated that the man was not the biological father of his child. As the geneticist working on the case, Barry was asked to carry out more tests to study the issue.

What Barry had not expected was that the man in question was the father of his child but was not related to him as a father genetically, and not by error or test failure. The truth was much more bizarre, the father of the child was a human possessing two separate sets of DNA in his body. This was caused by a genetic flaw, chimerism, that had gone unnoticed until now. It had resulted from a process that occurs in the initial phases of pregnancy, where one twin is absorbed by the other.

Barry Starr, a specialist in the field of genetics described it as a “eureka moment” (VerGano, 2015). He had experienced firsthand the complex nature of identity and the biological mechanisms of chimerism.

In this essay, I will consider the intriguing phenomenon of chimerism, a genetic condition that occurs due to a person having two sets of DNA. I will delve into the scientific details behind the phenomenon, real-world occurrences, forensic implications, and the moral issues of handling chimeric persons when they have legal and/or personal issues.

What is Chimerism?

Chimerism is a rare biological phenomenon where an individual possesses at least two distinct DNA sequences, typically resulting from two different zygotes. Human chimerism often results from the merging of two fraternal twins in the initial stages of pregnancy (EasyDNA Ireland, 2014). The fusion of zygotes/embryos leads to an individual with two different genetic compositions which may be distributed across different tissues.

However, fraternal (tetragametic) chimerism is not the only variation of this genetic condition. Other forms exist, each occurring through different mechanisms. Another form includes blood chimerism, which occurs when fraternal twins share a placenta, exchange blood cells, and leave a mix of genetic sequences in the bloodstream.

Microchimerism, another variant, occurs when fetal and maternal cells cross the placenta and

Key Words:

Variant:
something that is slightly different from other similar things

Autoimmune Disease:
a disease in which a person's immune system wrongly attacks its own healthy tissues

Rheumatoid Arthritis:
a disease that causes stiffness, swelling, and pain in the joints (places where two bones are connected) of the body

integrate themselves into different tissues. The last variant is artificial chimerism. This often develops from medical procedures like organ or bone marrow transplants, where the donee integrates the donor's genetic material into specific tissues.

Chimerism leads to severe effects on an individual's genetic makeup, leading to DNA differences among different tissues. Such an irregular condition has led to numerous issues, especially in the area of forensics and diagnosis, as genetic analysis produces varying results in different tissues.

Chimerism: Genetic Mechanisms and Biological Impacts

Chimerism can affect various tissues and organ systems, but it varies depending on the type of chimerism. Different types of chimerism distribute the two sets of DNA differently throughout the body, leading to different levels of impact.

In fraternal chimerism, the mechanism of twin fusion is not fully known; However, it is thought to happen shortly into pregnancy (during the zygote or early embryo stage). The earlier the fusion happens, the wider the genetic mixture will spread, affecting multiple tissues including the skin, blood, and reproductive system at times.

The effects of fraternal chimerism can vary significantly. Almost all cases of chimerism will remain completely undetected, as only upon extensive testing will it be identified. More significant examples include reproductive chimerism, where a person's eggs or sperm contain the DNA of their absorbed twin rather than their own. This can lead to complexities during paternal cases, which I will discuss further below.

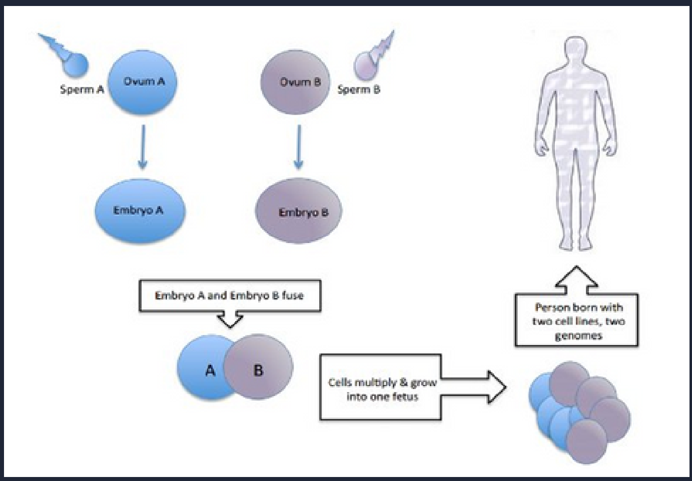

Figure 1. Diagram showing the development of fraternal chimerism (Starr, 2015)

Case Studies of Severe Jaw Injuries

Other forms of chimerism have more localised effects. Blood chimerism, occurring when fraternal twins exchange blood stem cells in the womb, affects only the bloodstream. This results in two blood types coexisting within an individual, complicating blood transfusions and forensic identification, but has limited effect on overall health.

Microchimerism, similarly to blood chimerism, also has localised effects. It occurs when fetal cells integrate into maternal tissues, embedding themselves in organs such as the brain, liver, or skin. Some research suggests microchimerism may contribute to autoimmune diseases like rheumatoid arthritis, as foreign fetal cells could trigger the mother's immune system to attack its own joints (Siegel 2019).

Artificial forms of chimerism formed through medical procedures result in localised effects. In bone marrow transplants, the blood of the recipient may inherit some of the donor's genetic makeup, potentially changing blood type and complicating forensic identification. Similarly, organ transplants also result in localised genetic differences between the transplanted organ and the rest of the body. This can lead to complications like graft-versus-host disease, where the new immune cells attack the host's body.

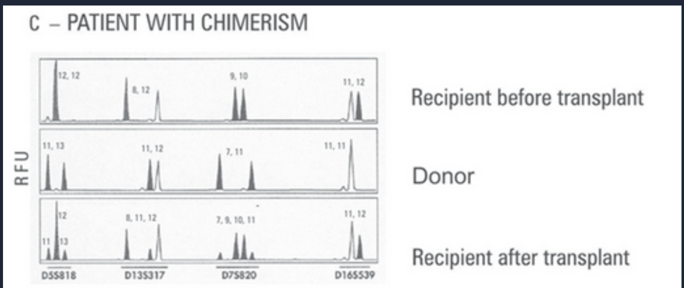

Figure 2. DNA analysis after a bone marrow transplant, showing 62% recipient and 38% donor DNA (Sitnik et al., 2006)

Regardless of the mechanism, the result of having two sets of DNA makes diagnosis more complicated in the event of disease, paternity determination, and forensic testing. DNA testing of various tissue samples like the blood, hair, or saliva from a chimeric individual might give conflicting results, and it would be challenging or even impossible to decisively determine the person's genetic identity or their exact biological relationship to others.

Real-Life Cases of Chimerism

One of the most famous examples of chimerism is the case of Lydia Fairchild, who in 2002 was told she was biologically not the mother of her children. This left Lydia puzzled; she had given birth to the kids but DNA tests found no genetic relation to them. Further research found that Lydia was a chimera that had merged with her twin in the womb sometime in the first few months of pregnancy. Her cervical reproductive tissue had a different DNA compared to the rest of the body. This meant that two sets of DNA existed in Lydia Fairchild: one in her skin and circulating cells, and the other in her cells of the reproductive system (Darby, 2021).

The case initially mentioned at the start (involving geneticist Barry Starr) had upon initial testing presented the father as sharing only 10% of his child's DNA. Upon secondary testing, the father was deemed the uncle of his own child sharing 25% of his child's DNA. Finally, after further investigation, it was uncovered that the man was a human chimera. It turned out that the DNA in the man's sperm was 90% his DNA and 10% that of his twin's, due to fraternal chimerism (Park, 2015). This revelation not only solved the paternity issue but also showcased the complexities of human genetics and the challenge of accurately identifying one's genetic makeup.

Forensic Implications of Chimerism

Chimerism also has serious implications in forensic science, especially in crime scene investigations. In forensic DNA testing, an individual's DNA is heavily relied on for identification and determining relationships (e.g., paternity test/crime scene). If the individual is chimeric, however, the DNA composition of differing regions of the body may be different, giving varying results.

For instance, if the DNA retrieved from a crime scene is compared to that of a sample of a suspected person's blood (who is chimeric), the match is possible but if the DNA is sampled from hair or saliva, it might not match the same person. Such leads to confusion, wrongful convictions, or inability to match the right person.

There have been many instances of chimerism resulting in exonerations, with people having initially been found guilty of offences being later proven to be innocent. This happened when it was discovered that they were chimeras, and that the DNA found at the scene of the crime differed from that of their bloodstream (representing their primary genetic makeup).

Key Words:

Chimera:
an organism that contains cells or tissues from two or more different species or from two or more genetically different living things

Forensic Science:
scientific methods of solving crimes that involve examining objects or substances related to a crime

Genetic:
belonging or relating to genes (parts of the DNA in cells) received by each animal or plant from its parents

However, this can also result in instances of false accusations. In a sexual assault investigation in 2005, police collected a semen sample that had matched with an existing DNA sample found in the database. However, the suspect could not have committed the crime as he was in prison. The true perpetrator was revealed to be a chimeric individual. The falsely accused suspect had donated bone marrow years earlier. As a result, when the chimeric perpetrator committed the crime, his semen contained DNA from his bone marrow donor, who was not at the scene (Berelson, 2022).

Legal and Ethical Implications

Chimerism also introduces complicated legal and ethical issues, especially in areas such as personal identity, genetic privacy, and parenthood. Some of the more profound moral issues surround the issue of the genetic rights of individuals who have two different sets of DNA. In chimerism, it proves difficult to outline the "real" genetic makeup of a person since they could have two different DNA sequences for two parts of their body.

Chimerism in the legal system also leads to difficulties in concluding matters of parental identities, inheritance, etc. For example, a chimeric person would have trouble identifying their biological parents in inheritance, as their genetic makeup would not be consistent throughout all of the cells in their body.

Conclusion

Chimerism is a strange and fascinating phenomenon that heavily opposes our current understanding of human genetic makeup and identity. The case of Lydia Fairchild and others demonstrates clearly the issues raised by chimerism. Furthermore, the presence of two different sets of DNA in a single person raises questions about identity, privacy, and effectiveness of forensic and genetic testing. Not only does this phenomenon place genetics in a new context than what we have traditionally known, but it also leads to the need of addressing questions of ethical / legal nature which have to this point gone relatively uncontested.

Bibliography:

Berelson, M. (2022). Human chimeras: Why forensic DNA testing will never be the same. Royal Institution. [online] Available at: https://www.rigb.org/explore-science/explore/blog/human-chimeras-why-forensic-dna-testing-will-never-be-same [Accessed: 9 Mar. 2025].

Darby, A. (2021). The case of Lydia Fairchild and her chimerism. Embryo Project Encyclopedia. [online] Available at: https://embryo.asu.edu/pages/case-lydia-fairchild-and-her-chimerism-2002 [Accessed: 8 Mar. 2025].

EasyDNA Ireland (2014). Identical, fraternal and chimera twins. [online] Available at: https://www.easydna.ie/knowledge-base/twins-identical-fraternal-chimera/ [Accessed: 2 Mar. 2025].

Park, A. (2015). Chimera twins: The case of the vanished twin and the complex genetics of human identity. Time. [online] Available at: https://time.com/4091210/chimera-twins/ [Accessed: 9 Mar. 2025].

Siegel, J. (2019). Microchimerism and rheumatoid arthritis: The dual nature of foreign cells in the body. Fred Hutch News Service. [online] Available at: https://www.fredhutch.org/en/news/center-news/2019/09/microchimerism-rheumatoid-arthritis.html [Accessed: 11 Mar. 2025].

Sitnik, R., Torres, M.A., Bacal, N.S., and Pinho, J.R.R. (2006). Using PCR for molecular monitoring of post-transplantation chimerism. Einstein, 4(2), pp. 127-131. [online] Available at: https://www.researchgate.net/publication/26513043 [Accessed: 15 Mar. 2025].

Starr, B. (2015). How can a man be both uncle and father to his child?. KQED Science. [online] Available at: https://www.kqed.org/futureofyou/60135/how-can-a-man-be-both-uncle-and-father-to-his-child [Accessed: 1 Mar. 2025].

VerGano, D. (2015). Failed paternity test reveals a vanished twin. BuzzFeed News. [online] Available at: https://www.buzzfeednews.com/article/danvergano/failed-paternity-test-vanished-twin [Accessed: 1 Mar. 2025].

LENT 2025

Exploring Black Holes

By Nikhil Chunduri (Year 10)

Key Words:

Black Hole:
a region in space where gravity is so strong that nothing, not even light, can escape

Quasar:
the centre of a galaxy (group of stars) that is very far away, producing large amounts of energy

What is a Black Hole?

Black holes begin as stars: collection of energy composed of hydrogen atoms that have collapsed from enormous gas from their own gravity. The core of a star will constantly trigger nuclear fusion. Nuclear fusion in its simplest form is when hydrogen atoms are crushed into helium which releases a large amount of energy in the form of radiation. Apart from being an energy producer, it stabilises the star by pushing against gravity. Stars with more mass than sun can create enough heat and pressure to fuse heavier elements until they reach iron. This form of nuclear fusion creates energy unlike others. The gravity needed for this is 3 times more than the sun itself. With this formation comes a unique feature called the event horizon. The event horizon is what you see when you look at a black hole. As said by NASA themselves: "the event horizon captures any light passing through it, and the distorted space-time around it causes light to be redirected through gravitational lensing. These two effects produce a dark zone that astronomers refer to as the event horizon shadow, which is roughly twice as big as the black hole's actual surface". The black hole also contains a unique hole called a singularity, which is a point where all the infinite amount of mass is contained within, and a place where the laws of physics themselves are broken. There is still research being done but there are two types of singularities. Naked singularities which are hypothetical singularities that are not covered by an event horizon and black hole singularities which are harder to study because of the event horizon present.

What is a Quasar?

The universe is like a vast, gargantuan ocean that is sprinkled with islands which we know as galaxies. Just a small fraction of atoms are in these "islands" while the rest are believed to be drifting in an intergalactic median. This intergalactic median contains the raw materials of creation: hydrogen and helium, which eventually flow into the galaxy to create stars. Being a single grain in the massive universe, quasras exist in the heart of galaxies, shining with the power of a trillion stars. They blast out huge jets of matter and are known to completely reshaping the cosmos around them and can kill galaxies. These huge jets of matter mean they shine brighter than even the entire milky way. The light of a quasar doesn't come from the inside of the black hole but rather the accretion disk: a large disk of gas that constantly orbits the quasar. This amount of light coming from the disk must mean there is some sort of "special" method for the luminosity, but this is on the contrary. They use the same fuel as stars: matter – the case is just that black holes are far better at using them as a fuel than stars. The energy released from matter falling into a black hole is 60 times greater than the energy produced by nuclear fusion. This is because energy from a black hole is produced from gravity and not nuclear reactions. An accretion disk is formed when a large amount of matter falls in at the same time. They are pulled in at such high speeds around the black hole which eventually creates a disk. The quasar's "prime time" was 3 billion years ago just a bit after the big bang. The universe is constantly expanding therefore the universe was very dense during that time. This means the intergalactic median was highly dense in terms of gases meaning that quasars had a lot of eat but now as the universe has expanded, this means gas is less dense. Food makes them release light and radiation. These releases work like a particle accelerator, being shaped like jets. Despite this, they create fumes of gas that constantly expand. These can grow hundreds of light years in size.

Quasars kill galaxies. When I say that, rather than being fully destroyed they're left in a state to which they can never return from. Since they emit so much light and radiation, it leaves the galaxy too hot for star formation. Stars are gases that collapse into themselves and then get hot. In a gas already hot, atoms move quickly meaning they collide more and faster. They exert pressure that resists gravity and gravity causes star formation. This means cold gas is better for star formation. Furthermore, quasars push gas outside of the galaxy and lose way more raw materials for star formation.

Regardless, this is a good thing for life because the abundance of star formation leads to more frequent supernovas which can kill planets. In a way quasars help sustain galaxies rather than killing. They prevent devastating supernovas that can kill several planets including ours. An interesting question served by "Kurzgesagt – In a Nutshell" is if the milky way had its own quasar in the past.

What is a Gravastar?

There are two possibilities to when a star collapses: A neutron star and a black hole but there is a third less known possibility known as the gravastar. When the core collapses, it is crushed down like a rock being pulverized. The core then transmutes into pure energy because of how much the atoms are crushed. This energy is akin to that of a new universe and just like a new universe it tries to expand but can't be due to several forces like a cosmic hammer. This forms a new substance that forms the shell. Said substance is very unique in the fact that it is so thin that a single atom is "big" compared to it. The substance is very strong as it was formed from two very strong forces and is so tight that a supernova would be required to move the layer. A gravastar is as massive as 10 suns and its shell are -273 degrees. How does a gravatar become this cold. Atoms usually vibrate in everything which creates thermal energy and therefore heat but a gravastar lacks atoms and is nameless. The inside of the shell is pumped up with the maximum amount of "nothingness" that it can have – any more would break the laws of physics, just like how black holes do, but what is this nothingness? The inside is a perfect vacuum that contains some of the most primitive energy in the universe. The fundamental nothingness at the core of it all. A vacuum isn't JUST a lack of atoms in an area. It is an actual concept that links everything together. Particles are like waves in an ocean, and you can't have waves without an ocean. The vacuum is this ocean – an ocean that creates reality itself. This vacuum has inherent energy and is very abundant, yielding x10 to the

Key Words:

Galaxy:
one of the independent groups of stars in the universe

Supernova:
a star that has exploded, strongly increasing its brightness for a few months

Gravastar:
a theoretical astrophysical object proposed as an alternative to black holes

Vacuum:
a space from which most or all of the matter has been removed, or where there is little or no matter

power of 44 more energy than the vacuum outside of the shell – an unbelievable amount of energy in a tiny space, just like a black hole. The room you're reading this in likely has 99 percent of this vacuum. In fact, you have a vacuum inside you. Within the trillions of particles making up your cells there is a vacuum. Now, when studying Geography, we would have learnt about the water cycle and how water always eventually returns to the sea if there is no outside interference. This applies with the vacuum in the shell of a gravastar. This vacuum is always trying to return to its "ocean", but it can't because of the dense shell. It quite literally is the universe's best prison. This creates a perpetual deadlock that can never end.

Black holes were initially something that was hypothetical but after years and years, black holes were confirmed even though they sound like something from fiction. This is the same situation gravastars and quasars are in. Black holes were initially imagined to be small. Maybe a few times the mass of the sun but upon confirmation, scientists could not be wrong any more. This is why we do science. To discover the unknown in our universe. To change what things we think about the universe to the truth. A truth closest to what we can get.

Bibliography:

Kurzgesagt – In a Nutshell (n.d.). Gravastar. [online] Available at: https://youtu.be/BmUZ2wp1lM8?si=KqSj_vu8gp-gEzJW [Accessed: 2 Apr. 2025].

Kurzgesagt – In a Nutshell (2024). Black Hole's Evil Twin – Gravastars Explained. [online] Available at: https://youtu.be/BmUZ2wp1lM8?si=KqSj_vu8gp-gEzJW [Accessed: 2 Apr. 2025].

Kurzgesagt – In a Nutshell (2024). The Black Hole That Kills Galaxies – Quasars. [online] Available at: https://youtu.be/V4Z8EdiJxgk?si=Ho7Cltvo3xkkxUZF [Accessed: 2 Apr. 2025].

Kurzgesagt – In a Nutshell (n.d.). What is a Quasar?. [online] Available at: https://youtu.be/V4Z8EdiJxgk?si=XkomgJjItDZJ09SJ [Accessed: 2 Apr. 2025].

NASA (n.d.). Anatomy of a Black Hole. [online] Available at: https://science.nasa.gov/universe/black-holes/anatomy/ [Accessed: 2 Apr. 2025].

NASA (n.d.). What is a Black Hole?. [online] Available at: https://science.nasa.gov/universe/black-holes/anatomy/ [Accessed: 2 Apr. 2025].

Key Words:

Pathogen: a microscopic organism which can cause a disease

Antibodies: substances produced by the human body to fight off disease

Immune System: produces antibodies to fight off diseases

Genetic Diseases: conditions caused by a problem in someone's genes which are passed down from the parents

LENT 2025

MRNA – Cracking the Code To Disease

By Theo Wong (Year 11)

Disease has been a long-time thorn in the flesh of the human race. It has been the cause of major calamities across history, with the most notable example perhaps being the infamous black death during the 14th century, which wiped out more than a third of the European population with an estimated 25 million deaths in Europe between 1347 and 1351 (Encyclopaedia Britannica, 2024).

Even now, disease has persisted in its aims to hinder humanity in more ways than one. The outbreak of SARS-CoV-2 in 2019 was certainly a living reminder of the threat these pathogens pose to us.

By 2024, the COVID-19 pandemic claimed approximately 7 million lives around the globe (Worldometer, 2024) with some estimates claiming that the real death toll was in the excess of 18.2 million between the years 2020 and 2021 alone (Society for Healthcare Epidemiology of America, 2024). In addition to this, in 2021 alone, upwards of 10 million people died from cancer (Ritchie and Roser, 2024), a figure which is only expected to rise in the future.

What if I told you, this could all change.

Advances in medicine and science have potentially brought us a solution, a gamechanger, a weapon which could defeat the persistent adversary of mankind.

What is mRNA?

mRNA, otherwise known as messenger Ribonucleic Acid, is the single stranded molecule which carries the instructions to make protein. It holds an essential role in making out bodies function, and it is found in all living cells. It was discovered in the year 1960, by researchers François Jacob and Jacques Monod, and has been studied by scientists for decades because of its potential to be used to treat and prevent disease (Pfizer, 2024). Vaccines, however, have already existed long before the discovery of mRNA.

What are Vaccines?

Vaccines teach your immune system how to create antibodies to fight off diseases (NHS, 2023). It does this by injecting a weakened version of a pathogen, or a destroyed pathogen, into the blood, which is easily fought off by the immune system. Antibodies are created by white blood cells, which multiply and fight off the pathogen, then a few remain in the blood having stopped multiplying (CDC, 2024), which will react in the same way if the same disease ever enters the body again. The world's first successful vaccine was created by Edward Jenner in May 1796, used to inoculate an 8-year-old child to

Key Words:

Genetic Diseases:
conditions caused by a problem in someone's genes which are passed down from the parents

Scepticism:
an attitude of doubt or disbelief about something

Inoculate:
to protect someone from a disease by injecting them with a weakened version of that disease

protect him from smallpox, by using matter collected from a cowpox sore. Less than a century later in 1872, Louis Pasteur created the first laboratory created vaccine for fowl cholera in chickens. The discovery of vaccines has led to the successful eradication campaign of smallpox in 1980, marking the end of a disease which killed over 300,000,000 people in the 20th century alone (WHO, 2025).

How are mRNA Vaccines any Different to Regular Vaccines?

A large difference between mRNA vaccines and regular ones, is that mRNA vaccines do not enter the nucleus and alter the DNA. They work by introducing a piece of mRNA that corresponds to a viral protein, usually a small piece of a protein found on the virus's outer membrane. (People who get an mRNA vaccine aren't exposed to the virus, nor can they become infected with the virus by the vaccine.) By using this mRNA, cells can produce the viral protein. As part of a normal immune response, the immune system recognizes that the protein is foreign and produces antibodies so that if a person is exposed to a virus after receiving mRNA vaccination for it, antibodies can quickly recognize it, attach to it, and mark it for destruction before it can cause serious illness (National library of medicine, 2022).

How has mRNA been used so far?

Despite its discovery in the early 1960s, mRNA technology was not really used on a major scale until the COVID-19 pandemic more than half a century later. The first vaccine approved for use was the Pfizer-BioNTech vaccine on December 2, 2020, by the UK government (Pfizer and BioNTech, 2020), less than 9 months after the virus was officially declared a pandemic by the World Health Organisation on March 11, 2020 (World Health Organization, 2020). The vaccination campaign has been nothing short of a success. By 2024, over 13 billion doses of COVID-19 vaccines have been administered globally, with over 70% of the world's population having received at least one dose of the vaccine (American University, 2024). The mRNA vaccines made by Pfizer-BioNTech and Moderna have accounted for more than 50% of total vaccines administered in many high-income countries such as the US (Our World in Data, 2024). According to Global models, this campaign has prevented an estimated 20 million deaths by 2024 and preventing over 150 million additional cases (The Lancet, 2024). These statistics show the extent of the role that mRNA vaccines have had to play in the pandemic.

Beyond COVID – what next?

Building on the success of the use of mRNA vaccines during the pandemic, the future looks bright for the potential of the vaccine, with research already ongoing to make an mRNA vaccine for numerous other diseases, including Avian Bird Flu, HIV, Malaria and Tuberculosis. In addition, researchers are also working on an mRNA solution to genetic diseases, like sickle cell anaemia and cystic fibrosis, as well as looking for ways to prevent allergic reactions (Penn Medicine). Most notably, however, is the potential cure for cancer, by creating mRNA cancer vaccines which would theoretically activate the immune system to attack cancer cells. King's College London have been trialling an experimental mRNA cancer vaccine which has shown promise in treating advanced lung cancer. According to reports, eight out of sixteen patients whose responses were evaluated demonstrated that their tumour size did not grow, nor did any new ones appear (King's College London, 2024). The potential of these vaccines could potentially mark the beginning of the end to major problems such as cancer, which would have a hugely positive effect on our progression as a society.

Key Words:

Cystic Fibrosis:
a genetic condition where the body produces mucus which clogs organs like the lungs, leading to breathing difficulties and digestive problems

Tuberculosis (TB):
an infectious bacterial disease which primarily targets the lungs

However, there are drawbacks...

Despite the unmatched potential of mRNA vaccines, there are unfortunately many drawbacks which have hindered the vaccines from taking the lead in the vaccination industry. For one, the fact that it was only recently discovered has led to public scepticism and distrust about the nature of mRNA vaccines, which led to an "anti-vax" campaign against the coronavirus vaccines, with twitter being a major hub for misinformation about the COVID vaccines (Pulido et al., 2020). Additionally, the storage requirements for said vaccines make it very difficult to administer doses worldwide effectively – the Pfizer-BioNTech vaccine needed to be stored at temperatures as low as -90°C to maintain its stability (CDC, 2023)! Due to the low temperatures needed to initially store mRNA vaccines like this, expensive specialised freezers are required, which makes distribution to remote areas and regions with limited infrastructure both challenging and costly. The cost of manufacturing these vaccines also does not come cheap, with an estimated $127.1 million needed to produce 100 million doses of the Pfizer-BioNTech vaccine (MSF, 2021), coming to around $1.27 per dose. Despite this seemingly low price, pharmaceutical companies tend to inflate prices exorbitantly, with the cost for a single dose of the Pfizer vaccine in the UK costing between £75 and £99 for a consumer (BBC News, 2020), with the US government being charged $20 per dose. On the contrary, the non mRNA vaccine AstraZeneca charged the US government just $4 per dose (Observer, 2020), showing the clear contrast in price between the mRNA and non-mRNA vaccines. Finally, due to the limited knowledge about mRNA vaccines as of now, we do not fully understand the long-term effects which these vaccines have on the body, as there were many potential side effects with vaccines like the Pfizer-BioNTech, including Anaphylaxis (severe allergic reactions), and myocarditis (inflammation of the heart) (CDC, 2023). These effects, whilst rare, have subjected mRNA vaccines to much scrutiny, increasing public mistrust in this new venture. However, the success of mRNA vaccines during the pandemic was undeniably evident. According to a study conducted by Paltiel, Zheng, & Zheng (2021), the two most effective COVID-19 vaccines studied, were mRNA vaccines, being the Pfizer-BioNTech vaccine with a 95% success rate against the initial strain, and the Moderna vaccine with a 94.1% success rate. When compared against the success rates of other non-mRNA vaccines like AstraZeneca with just 70% effectiveness, the advantages of mRNA vaccines are clear for all to see, being clearly more effective at in preventing COVID-19 during the pandemic.

Conclusion

Although mRNA vaccination technology is in the early stages of its development, it has the potential to become a gamechanger in the future of medicine and could change the course of history forever. The successes of mRNA's debut have already been shown to the world, which could hopefully be a platform for finding the cure to many other incurable diseases like cancer. It may be too early to tell if the key is found through mRNA, but with the promise shown already, mRNA could really crack the code to the problem of disease, once and for all.

Bibliography:

BBC News (2020). Covid vaccine: How will the world vaccinate seven billion?. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Centers for Disease Control and Prevention (CDC) (2023). Clinical Considerations: Myocarditis and Pericarditis after Receipt of COVID-19 Vaccines Among Adolescents and Young Adults. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Centers for Disease Control and Prevention (CDC) (n.d.). Pfizer-BioNTech COVID-19 Vaccine Storage and Handling Summary. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Centres for Disease Control and Prevention (2024). Explaining how vaccines work. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

Dattani, S., Samborska, V., Ritchie, H. and Roser, M. (2024). Cancer. Our World in Data. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 30 Mar. 2025].

Encyclopaedia Britannica (2024). Black Death. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 30 Mar. 2025].

King's College London (2024). mRNA Cancer Vaccine Shows Potential in Advanced Stage Cancer Patients in Phase 1 Trial. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

Médecins Sans Frontières (MSF) (2021). mRNA vaccine technology transfer: process and cost modelling. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

NHS (2023). Why vaccination is important and the safest way to protect yourself. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

National Library of Medicine (n.d.). What are mRNA vaccines and how do they work?. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

Observer (2020). COVID-19 Vaccine Prices: Pfizer, Moderna, AstraZeneca & Oxford. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Paltiel, A. D., Zheng, A., & Zheng, W. (2021). Assessment of mRNA Vaccines Against COVID-19 and Variants of Concern. JAMA Network Open, 4(12), e2135580. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Pfizer (2024). mRNA technology. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 30 Mar. 2025].

Pulido, C. M., Villarejo-Carballido, B., Redondo-Sama, G. and Gómez, A. (2020). COVID-19 infodemic: More retweets for science-based information on coronavirus than for false information. International Sociology, 35(4), pp.377-392. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 5 Apr. 2025].

Ritchie, H. and Roser, M. (2024). Cancer. Our World in Data. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 30 Mar. 2025].

Society for Healthcare Epidemiology of America (2024). Updated COVID-19 global death toll estimate is three times what records indicate. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 30 Mar. 2025].

UK Authorization: Pfizer and BioNTech (2020). Pfizer and BioNTech Achieve First Authorization in the World for a Vaccine to Combat COVID-19. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

UK Health Security Agency (2024). What are mRNA vaccines and how do they work?. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

World Health Organization (2020). WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 – 11 March 2020. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

World Health Organization (n.d.). A Brief History of Vaccination. [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 4 Apr. 2025].

Worldometer (n.d.). Coronavirus update (live). [online] Available at: Banks, M. S., & Salapatek, P. (1981). Development of visual perception. Cambridge. [Accessed: 29 Mar. 2025].

LENT EDITION | 2025

LENT 2025

Can the Gut Microbiome Combat Cancer?

By Vari Shah (Year 12)

Key Words:

Microbiome:
the microorganisms (living things too small to be seen) that exist in a particular environment or in the human body

Metabolism:
all the chemical processes in your body, especially those that cause food to be used for energy and growth

Introduction

The gut microbiome, a complex community of bacteria, fungi, viruses, and archaea residing in the human digestive system, has emerged as a crucial player in human health. Recent research highlights its profound impact on immune system regulation, metabolism, and even cancer progression. Scientists are increasingly investigating whether the gut microbiome can be harnessed to enhance cancer treatment, prevent tumour development, or improve therapeutic outcomes. This essay explores the relationship between the gut microbiome and cancer, focusing on its role in immune modulation, tumour suppression, and potential applications in cancer therapies.

The Gut Microbiome and Immune Regulation

The gut microbiome profoundly influences the immune system, shaping its ability to detect and eliminate cancerous cells. Commensal bacteria help regulate immune responses by training immune cells to distinguish between harmful pathogens and the body's own tissues. Certain bacterial strains, such as Bifidobacterium and Lactobacillus, have been shown to enhance immune surveillance against tumours (Gopalakrishnan et al., 2018).

Moreover, gut microbiota stimulate the production of cytokines such as interferon-gamma (IFN-γ), a protein crucial for antitumor immunity. IFN-γ activates natural killer (NK) cells and cytotoxic T lymphocytes, which play key roles in eliminating malignant cells (Zitvogel et al., 2017). Dysbiosis, an imbalance in gut microbiota, can weaken immune responses, increasing susceptibility to cancer.

Gut Microbiome and Cancer Prevention

Several studies suggest that a healthy gut microbiome can help prevent cancer by reducing inflammation, maintaining gut barrier integrity, and producing beneficial metabolites. Short-chain fatty acids (SCFAs), such as butyrate, acetate, and propionate, are generated through bacterial fermentation of dietary fibre. These SCFAs inhibit tumour cell proliferation and promote apoptosis (cell death), reducing the likelihood of cancer development (Louis et al., 2014).

Furthermore, gut bacteria play a critical role in preventing DNA mutations. Akkermansia muciniphila has been associated with maintaining a healthy gut lining, preventing the leakage of bacterial toxins that could trigger carcinogenesis (Rooks & Garrett, 2016).

Role of the Gut Microbiome in Cancer Therapy

One of the most promising avenues for gut microbiome research in oncology is its potential to improve immunotherapy outcomes. Immune checkpoint inhibitors (ICIs), such as anti-PD-1 and anti-CTLA-4 therapies, have revolutionized cancer treatment. However, response rates to ICIs vary widely among patients, and emerging evidence suggests that gut microbiota composition plays a pivotal role in determining efficacy.

Research by Gopalakrishnan et al. (2018) found that melanoma patients with higher levels of Bifidobacterium and Faecalibacterium showed better responses to PD-1 blockade therapy compared to those with dysbiotic microbiota. Similarly, fecal microbiota transplantation (FMT) from immunotherapy responders to non-responders has been explored as a strategy to enhance treatment effectiveness (Matson et al., 2018).

Gut Microbiota and Chemotherapy

Chemotherapy remains a cornerstone of cancer treatment, yet its success can be influenced by gut microbiota. Certain bacteria, such as Enterococcus hirae and Barnesiella intestinihominis, have been linked to improved chemotherapy responses by stimulating immune-mediated tumour clearance (Daillère et al., 2016). Conversely, dysbiosis can lead to chemotherapy resistance, making treatment less effective.

Additionally, gut bacteria produce enzymes that metabolize drugs, altering their potency. For instance, Clostridium spp. can deactivate certain chemotherapy drugs, reducing their efficacy (Iida et al., 2013). Understanding these interactions may allow clinicians to tailor treatment plans based on a patient's microbiome profile.

Gut Microbiota and Radiotherapy

Radiotherapy, a widely used cancer treatment, is also influenced by the gut microbiome. Studies have demonstrated that gut bacteria can modulate radiation-induced inflammation and DNA damage. Vancomycin, an antibiotic targeting Gram-positive bacteria, has been shown to enhance radiotherapy effectiveness by increasing CD8+ T cell infiltration and IFN-γ expression (Helmink et al., 2019).

Key Words:

Immunotherapy:
treatment that improves ability of the immune system to fight disease

Chemotherapy:
the treatment of diseases using chemicals

Radiotherapy:
the use of controlled amounts of radiation (a form of energy) aimed at a particular part of the body, to treat disease

Metabolite:
any substance involved in metabolism (the chemical processes in the body needed for life)

Conversely, excessive microbial metabolites from dysbiosis can exacerbate radiation toxicity, leading to gastrointestinal complications in patients undergoing therapy. Balancing gut microbiota through probiotics or dietary interventions may reduce side effects and improve patient outcomes.

Future Perspectives: Microbiome-Based Cancer Therapies

Given the increasing recognition of the gut microbiome's influence on cancer, researchers are exploring novel therapeutic strategies, including probiotics and prebiotics to restore microbial balance, dietary modifications to promote short-chain fatty acid production and suppress tumour growth, fecal microbiota transplantation to enhance treatment response in patients with dysbiosis, and microbiome engineering to genetically modify gut bacteria for anticancer effects. These approaches hold promise for personalizing cancer treatments and improving clinical outcomes, positioning the microbiome as a key target in precision medicine.

Conclusion

The gut microbiome plays a crucial role in cancer prevention, immune regulation, and treatment responses. A balanced microbiome enhances antitumor immunity, produces protective metabolites, and influences chemotherapy and immunotherapy efficacy. While dysbiosis can promote cancer progression, strategies such as probiotics, dietary interventions, and fecal microbiota transplantation offer promising avenues for harnessing the microbiome in oncology. Future research should focus on developing microbiome-targeted therapies to optimize cancer treatment and improve patient survival.

Bibliography:

Daillère, R., et al. (2016). Enterococcus hirae and Barnesiella intestinihominis facilitate immune-mediated tumor clearance. Science, 351(6272), pp. 1109-1113.

Gopalakrishnan, V., et al. (2018). Gut microbiome modulates response to anti-PD-1 immunotherapy in melanoma patients. Science, 359(6371), pp. 97-103.

Helmink, B.A., et al. (2019). The microbiome and cancer immunotherapy: implications for efficacy. Science, 366(6471), pp. 97-103.

Iida, N., et al. (2013). Commensal bacteria control cancer response to therapy by modulating the tumor microenvironment. Science, 342(6161), pp. 967-970.

Louis, P., et al. (2014). The role of gut microbiota in colon cancer prevention. Nature Reviews Gastroenterology & Hepatology, 11(10), pp. 649-660.

Matson, V., et al. (2018). The commensal microbiome is associated with anti-PD-1 efficacy in metastatic melanoma patients. Science, 359(6371), pp. 104-108.

Rooks, M.G. and Garrett, W.S. (2016). Gut microbiota, metabolites, and host immunity. Nature Reviews Immunology, 16(6), pp. 341-352.

Zitvogel, L., et al. (2017). Microbiome and anticancer immunosurveillance. Cell, 168(3), pp. 487-504.

Key Words:

Aurora Borealis:
a pattern of coloured lights that are sometimes seen in the night sky in the most northern parts of the world

Turbulent:
involving a lot of sudden changes or violence

LENT 2025

Celestial Symphony: Dancing with the Northern Lights

By Aishani Sarkar (Year 7)

What are the Northern Lights?

Figure 1. (Conreras-Langlois, 2021)

The northern lights are mesmerizing ribbons of light in the sky that have fascinated humanity for thousands of years. Despite their serene beauty, this breathtaking display results from a highly energetic and turbulent process. These amazing lights are often described as waves of the sea, as they tend to move and dance in the night. The most common colour is green; but the amazing array of colours never fail to disappoint. They can't be seen everyday though - everyone looks up at the sky, fingers crossed that they will be able to spot these scientific wonderlands. The lowest part of an aurora is typically 50 miles (80 km) above the Earth's surface. The highest part could be 150 miles (800km) above the Earth. The Southern Lights - aurora australis - are seen in latitudes near the South Pole. The part of space where most of the "dragging, stretching, and snapping" happens is connected by magnetic fields down to the north and south ends of Earth. Because of the shape of Earth's magnetic field, these magnetic field lines create two ovals of aurora around the North and South Poles. The aurora borealis is the scientific name for the Northern Lights, named after the Roman goddess of dawn, Aurora, and the Greek god of the north wind, Boreas. (BBC News, 2014)

Figure 2. (Evans, 2019)

How are the Northern Lights formed?

The aurora is formed when charged particles from the sun collide with the Earth's atmosphere at speeds of up to 45 million miles per hour (72 million kilometres per hour). This is called the solar wind. "Picture this as a big sneeze by the Sun," says Dr Affelia Wibisono, from the Royal Observatory in Greenwich. "It can contain up to a million tonnes of charged particles." Fortunately, our planet's magnetic field acts as a protective shield, preventing these solar particles from causing harm while creating this stunning spectacle. These solar particles, mainly electrons and protons, interact with Earth's upper atmosphere, which is composed mostly of gases

Key Words:

Converge:
to move toward the same point and come closer together or meet

Eject:
to push, throw, or force something out of a place

Altitude:
height above sea level

such as oxygen and nitrogen. The result is an 'excited' gas molecule that releases its energy by emitting light in a host of colours: bright greens and reds from the oxygen and purples and blues from the nitrogen. It happens when the magnetic field lines converge towards the poles, allowing more particles to penetrate the atmosphere. The means that the brighter the sun, the more stunning the view. These collisions produce tiny flashes and the result is a breathtaking display of shimmering lights that dance across the night sky, reminding us of the complex interactions between our planet and the universe beyond. (Canadian Space Agency, 2021)

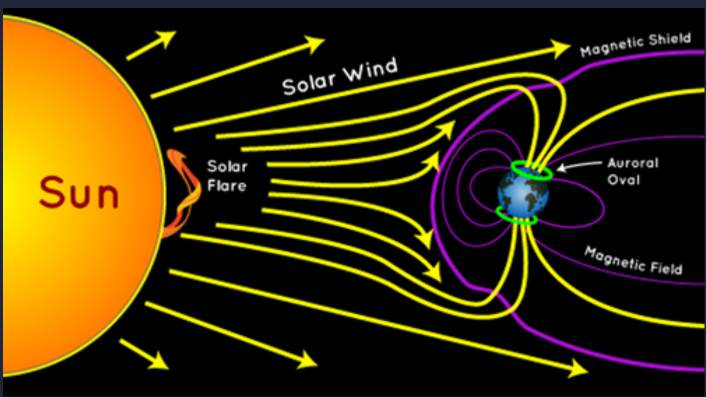

Figure 3. (NASA, 2011)

Why can we see the Northern Lights more Frequently than before?

We can see the Northern Lights more than before due to a combination of solar activity and climate factors. The sun operates on an approximately 11-year cycle of solar activity; during periods of heightened solar activity, solar winds and coronal mass ejections intensify, leading to more frequent and brilliant auroras.

Climate change is also a factor. As global temperatures rise, the atmosphere becomes less turbulent, making it easier for the light displays to be seen, particularly in regions traditionally dominated by constant cloud cover, where clearer skies allow for enhanced visibility of the auroras. This doesn't directly change behaviour of the Aurora Borealis; it changes how well we can see them. "The bigger the coronal mass ejection from the Sun, the wider the area around the poles in which particles enter the atmosphere," says Prof Jim Wild from Lancaster University. "Then, auroras will be seen in lower latitudes. (perlan.is, 2025)

What do the Colours Mean?

Though this may shock many, the colours of the lights can tell you how high in the sky it is! The two most common gases in the Earth's atmosphere are nitrogen and oxygen. Oxygen atoms glow green - the colour most often seen in the Northern Lights. Green is the colour that is the highest in the sky. Nitrogen atoms emit purple, blue and pink. These colours are seen less often because nitrogen atoms are harder to energise than oxygen atoms. Only a really big ejection of solar particles produces this kind of display. Sometimes the Northern Lights are scarlet. This is the colour seen when oxygen is energised by solar particles at very high altitudes. (BBC News, 2014)

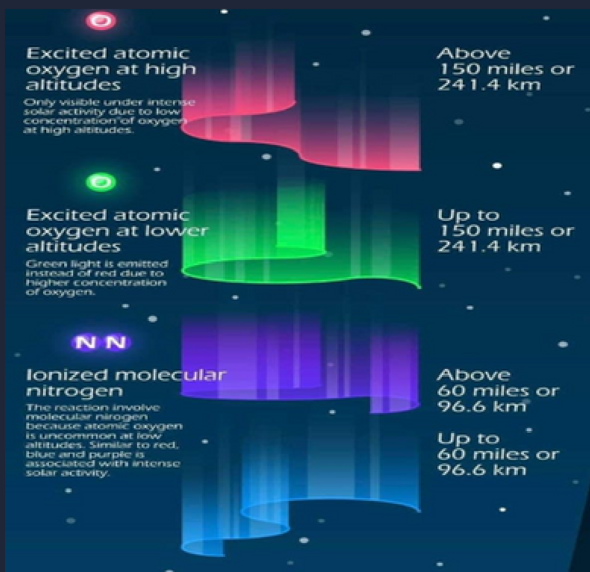

Figure 5. (Thalhuber, 2024)

When and Where can we See Them?

The Northern Lights can be seen best at night with a clear sky. "The brightest aurora are typically around 11pm to midnight local time," according to Andy Smith, a researcher at Northumbria University working on using artificial intelligence to predict space weather. Be aware that they often won't look as bright to the naked eye as they do in photos and video. Professional photographers often set their cameras to take in more light and make the displays look more spectacular. These scientific wonders can be seen almost every night in the northern sky, from August to May. The best places to see the aurora borealis are the Nordic countries of Iceland, Norway, Sweden and Finland, which lie within or near the Arctic Circle. Also, according to the British Geological Survey (BGS), the Northern Lights are seen most often in regions close to the North Pole such as Scandinavia, Greenland, Alaska, Canada and Russia. However, they have also been seen in the Caribbean. This is because of how space connects down to the ground. (Waldek, 2017)

How to take Best Pictures of Northern Lights?

Capturing amazing photos of the Northern Lights is all about the right setting and technique. One of the most important things is to find a dark area to let the colours shine brightly. Make sure to switch your camera to manual mode so that you can adjust everything yourself. It's recommended to start with the ISO at 1600 or 3200 to pick up more of the beautiful colours. Open up your aperture as wide as possible—think of using a low f-number like f/2.8—to let in as much light as you can. Using a shutter speed of 5-15 seconds is best as it helps to capture the movement of the lights while keeping details clear. Tripods are great for making sure that the details don't get blurry. And last but not least, wide-angle lens is also a great choice to show off the massive sky (Canon, 2020), (Hurtigruten.com, 2025).

Figure 6. (Sophie, 2023)

Bibliography:

Canadian Space Agency (2021). What are the northern lights? [online] www.asc-csa.gc.ca. Available at: https://www.asc-csa.gc.ca/eng/astronomy/northern-lights/what-are-northern-lights.asp [Accessed: 4 Mar. 2025].

Canon and Mabinty Taylor-Kamara (2020). How to photograph the Northern Lights. [online] Canon UK. Available at: https://www.canon.co.uk/get-inspired/tips-and-techniques/how-to-photograph-the-northern-lights/ [Accessed: 2 Mar. 2025].

Hurtigruten.com (2025). How to photograph the Aurora Borealis | Hurtigruten UK. [online] Available at: https://www.hurtigruten.com/en-gb/inspiration/northern-lights/photography [Accessed: 8 Mar. 2025].

perlan.is (n.d.). The Impact of Climate Change on Northern Lights | Perlan. [online] Available at: https://perlan.is/articles/climate-change-northern-lights [Accessed: 1 Mar. 2025].

Robinson, J. (2024). Northern Lights: Why are we seeing the aurora borealis more often in the UK and what's the best way to photograph the spectacle? [online] Sky News. Available at: https://news.sky.com/story/northern-lights-why-are-we-seeing-the-aurora-borealis-so-much-in-the-uk-and-whats-the-best-way-to-photograph-the-shimmering-spectacle-13232049 [Accessed: 4 Mar. 2025].

Waldek, S. and Dobrijevic, D. (2017). Aurora Borealis: What Causes the Northern Lights & Where to See Them. [online] Space.com. Available at: https://www.space.com/15139-northern-lights-auroras-earth-facts-sdcmp.html [Accessed: 4 Mar. 2025].

BBC News (2014). What are the Northern Lights? [online] 28 Feb. Available at: https://www.bbc.co.uk/news/science-environment-26381685 [Accessed: 27 Feb. 2025].

LENT 2025

Are Epigenetic Therapies Effective Treatments for Metabolic Disorders?

By Shannon Randhawa (Year 12)

Key Words:

Epigenetics:
the study of changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself

Histone:
any of a group of basic proteins found in chromatin

Inhibitor:
a gene whose presence prevents the expression of some other gene at a different locus

Dysregulation:
a condition in which a process in the body is not controlled in the way that it normally should be

Any conditions that affect any aspects of your metabolism are known as metabolic disorders. Some examples are: Type 2 diabetes, characterised by high blood sugar, insulin resistance, and relative lack of insulin, Maple syrup urine disease, in which the body is unable to use 3 of the essential amino acids, and Phenylketonuria, where the body can't break down the amino acid phenylalanine. Metabolic disorders occur when abnormal chemical interactions in the body, change the body's regular metabolic function (Zakir et al, 2022). Many of these disorders are genetic, which are rarer and more complex, therefore cures for some of these inherited metabolic disorders (IMD) are not yet available. Approximately 20,000 people in the UK are living with IMDs (Metabolic support UK, 2022), and due to the rarity and complexity of the diseases, people struggling may tend to feel helpless and alone.

Epigenetics are a way of influencing the regulation of our DNA sequences without altering them. Epigenetics influence when genes are activated and deactivated (also known as gene expression), and therefore influence which proteins are produced as a result. They allow these changes to occur through chemical modifications that can be due to external factors such as diet, toxins and stress. (Bird. A, 2007). A common epigenetic modification is DNA methylation. DNA methylation is the addition of -methyl groups to cytosine bases in DNA, increasing this process can deactivate genes by preventing transcription (Moore et al, 2013). Errors in this epigenetic process, e.g. silencing of the wrong gene, can lead to abnormal gene activity, which has been found to directly link to metabolic disorders. For example, insulin sensitising genes can be silenced which can lead to insulin resistance in Type 2 diabetes.

Furthermore, another common epigenetic modification is Histone acetylation. This is the addition of acetyl groups by Histone acetyltransferases which increases transcription by making the genes more accessible. (Jenuwein. T, Allis C.D, 2001). However, errors in Histone acetylation can alter patterns in liver and muscle cells, leading to impaired glucose metabolism which can cause Type 2 diabetes (a metabolic disorder). This epigenetic modification is not the only modification to do with Histones. Histone deacetylation can silence genes e.g. genes that regulate glucose metabolism, leading to metabolic disorders.

A final example of an epigenetic modification are non-coding RNAs which regulate gene expression. MicroRNAs attach to messenger RNAs to prevent translation, which silences genes; Long non-coding RNAs can either increase or decrease gene expression (Esteller M, 2011). It was found that unregulated MicroRNAs have led to insulin resistance and consequently leading to Type 2 diabetes. Since epigenetic modifications have risks of causing and exacerbating metabolic disorders (usually Type 2 diabetes), we are led to question, can epigenetics truly be an effective treatment for metabolic disorders when errors in themselves can cause these disorders?

Since IMDs are caused by changes in specific genes that affect metabolism, researchers have delved into finding epigenetic therapies that will be able to reverse and prevent further harmful changes in gene expression. Researchers have found that DNA methyltransferase inhibitors (DNMTis) effectively act as inhibitors to DNA transferases which are enzymes known for adding methyl groups to parts of DNA. This reduces hypermethylation by reactivating genes that cause insulin resistance and is supported by studies suggesting that DNMTis can significantly increase insulin production in beta cells and regulation, therefore they can be used to treat metabolic disorders like Type 2 diabetes.

Since the removal of acetyl groups by Histone acetyltransferases is likely to go wrong and impair glucose metabolism, researchers wanted to find an epigenetic therapy to combat this. They found Histone Deacetylase Inhibitors (HDACis) prevent the acetyl groups being removed from histones to maintain a state that chromatin can undergo gene transcription. HDACis have been found to improve glucose tolerance in animal models of obesity, therefore proving themselves to be effective treatments for metabolic disorders (Wu et al, 2023). Furthermore, experiments found that increasing the activity of histone acetyltransferases can promote the expression of genes that can improve metabolic function, this can be done by Histone acetyltransferase activators. (Yang et al, 2011). These treatments can be criticised for being too uncertain so some may argue that epigenetics are better off ignored as treatments as too much or too little of Histone modifications can lead to metabolic diseases and how will we be certain if histone acetylase or deacetylase are causing the disorder. Finally, non-coding RNA-based therapies use miRNA inhibitors to restore normal gene expression patterns. This has been shown to improve insulin sensitivity in mouse models (Liu et al, 2015).

To conclude, epigenetics play a crucial role in maintaining metabolic processes, and their dysregulation is related to the cause of metabolic disorders. Therapeutic treatments targeting these epigenetic changes offer a promising future for curing these disorders. However, further research and clinical trials are required to fully harness and establish the therapeutic potential of epigenetic treatments for metabolic diseases.

Bibliography:

Bird, A. (2007). Perceptions of epigenetics. Nature, 447(7143), pp.396-398. [online] Available at: https://www.nature.com/articles/nature05913 [Accessed: 5 Mar. 2025].

Esteller, M. (2011). Non-coding RNAs in human disease. Nature Reviews Genetics, 12(12), pp.861-874. [online] Available at: https://doi.org/10.1038/nrg3074 [Accessed: 10 Mar. 2025].

Jenuwein, T. and Allis, C.D. (2001). Translating the histone code. Science. [online] Available at: https://doi.org/10.1126/science.1063127 [Accessed: 7 Mar. 2025].

Liu, J., et al. (2015). MicroRNA regulation of metabolic processes in obesity and diabetes. Current Opinion in Endocrinology, Diabetes and Obesity, 22(3), pp.191–198. [online] Available at: https://www.nature.com/articles/ijo2015170 [Accessed: 12 Mar. 2025].

Metabolic Support UK (2022). Information and Advice. [online] Available at: https://metabolicsupportuk.org/information-and-advice/ [Accessed: 4 Mar. 2025].

Moore, L.D., Le, T. and Fan, G. (2013). DNA methylation and its basic function. Neuropsychopharmacology, 38(1), pp.23-38. [online] Available at: https://doi.org/10.1038/npp.2012.112 [Accessed: 6 Mar. 2025].

Pfizer (2025). Metabolic Disorders Overview. [online] Pfizer. Available at: https://www.pfizer.com/disease-and-conditions/metabolic-disorders [Accessed: 3 Mar. 2025].

Wang, Y., et al. (2015). Histone acetyltransferases as therapeutic targets in obesity. Science Translational Medicine, 3(104), pp.1–12. [online] Available at: https://www.sciencedirect.com/science/article/abs/pii/S0171933514000405 [Accessed: 12 Mar. 2025].

Wu, H., et al. (2023). Histone deacetylase inhibition as a potential treatment for obesity. Nature Communications, 5, pp.1–8. [online] Available at: https://www.nature.com/articles/s41392-023-01333-7 [Accessed: 10 Mar. 2025].

Zakir, F., et al. (2022). Introduction to Metabolic Disorders. [online] ScienceDirect. Available at: https://www.sciencedirect.com/science/article/abs/pii/B9780323996167000013 [Accessed: 3 Mar. 2025].

Contact us!

youngscientistsjournal@leicestergrammar.org.uk