Advent
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Edition 14

young scientists' journal.

Editors' Note

Young Scientists' Journal

ADVENT EDITION 2023

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We express our gratitude to all the contributors of articles in this edition of the YSJ, and extend special thanks to Mr. Reeves and Dr Griffin for their technical assistance with the journal.

We are delighted to bring you the Advent 2023 edition of the LGS Young Scientists' Journal! The Young Scientists Journal strives to foster a passion for the fields of science, technology, engineering and maths for all pupils across the school.

We provide a platform that allows students to showcase their passion and excitement for research in their respective fields. This term's edition includes articles from a vast range of topics including: the human brain, artificial intelligence, rockets, mantises and many more. We are so pleased to have seen so many amazing contributions, and we would love to see even more people getting involved in the next edition. We hope that you enjoy reading!

Cover Images:

'M81 Galaxy from the Mount Lemmon SkyCenter' By Adam Block.

'Neuron Network' By nobeastsofierce.

'Artificial Intelligence' By National Security Agency.

'Genetic Mutation' By Konstantin Faraktinov.

Key word definitions are from the Cambridge Dictionary.

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Key Words:

Kuiper Belt: a region of the solar system beyond the orbit of Neptune, believed to contain many comets, asteroids, and other small bodies made largely of ice.

Refractor Telescope: a type of telescope that uses a lens or lenses to focus light and form an image

Nebula: a cloud of gas or dust in space

Quantum Efficiency: the effectiveness of an imaging device to convert incident photons into electrons

Low Read Noise: greater ability to detect weak signals out of background signals.

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An Amateur View of the Cosmos: How Capable the Modern Backyard Astronomer Is

By Joey England

In 2019, a group of Japanese astronomers discovered what was at the time the smallest Kuiper belt object ever discovered, at only 2.6 km in radius. They used commercially available telescopes, the RASA 11 (11-inch aperture Rowe-Ackerman Schmidt Astrograph), and consumer cameras – the ZWO Asi1600mm-c (Arimatsu et al., 2019). It was as a very influential event within the astronomy community, as many devoted astronomers owned a RASA, and more importantly, it showed that amateur equipment is more than capable of being used in incredible ways.

Astrophotography is a much more technical side of astronomy, with dedicated cameras, and massive amounts of technology behind it. Although the use of such technology simplifies the whole operation, it remains very complex.

Amateurs being able to take professional-level images has only become possible in recent years with the development of new technologies and high-end tech becoming cheaper.

With a regular refracting telescope, suitable for a young astronomer's collection, the view is likely limited to the moon, a few planets and the Orion nebula. With a camera, a lot more can be done; the modern-day astronomer seldom does visual astronomy, but only astrophotography.

The most important example of this is the CMOS camera. For years, amateur astronomers used old CCD cameras due to their high quantum efficiency, relatively low read noise and because the technology was older and more mature. However recent innovations from sensor manufacturers such as Sony, and the camera system manufacturers ZWO and QHY, have allowed high-end cameras, with CMOS sensors, backlit sensors with no amp glow, extremely powerful Peltier cooling systems and higher quantum efficiency to be released (better than their CCD counterparts). The CMOS sensor only really overtook the CCD camera around 2020, and this had huge implications for astronomers, given that CMOS cameras are inherently cheaper.

When lockdown rolled in, astronomy was on the rise worldwide. Everyone got more accustomed to using online spaces, resulting in large astronomy community projects, including the Big Amateur Telescope (BAT).

Key Words:

Variable Star: a star whose brightness as seen from Earth changes with time.

Protoplanetary Disks: a rotating disc of dense gas and dust surrounding a young newly formed star.

OIII: a spectrum of light that is centred on 500nm – the easiest wavelength for human eyes to see.

Catalogue: a list of astronomical objects, typically grouped together because they share a common type, structure, origin, means of detection, or method of discovery

The BAT was a project started in 2021 and its initial aim was to take photos comparable to those of the Hubble telescope by using data collected by many different observers across the world.

The targets chosen included the Orion Nebula, in particular protoplanetary disks, and Hubble's variable nebula, which shows "ripples" of light passing through it over months, as the star at the side of it brightens and dims.

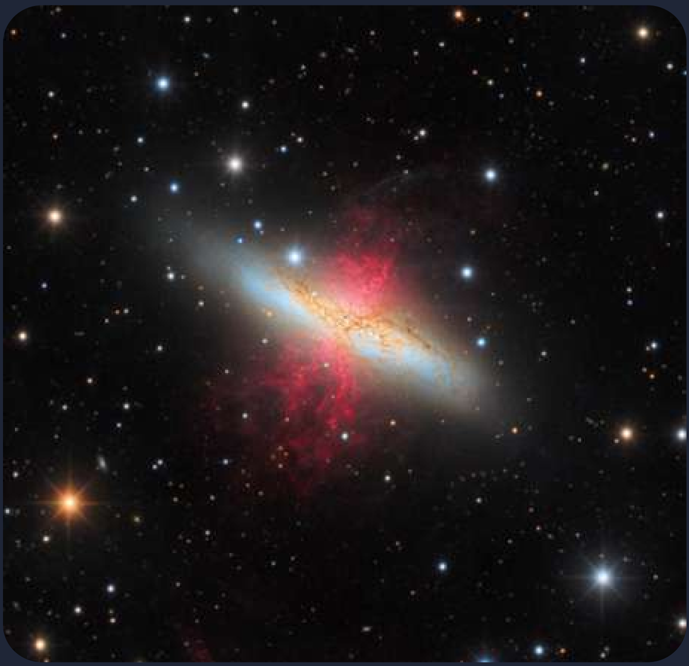

Figure 1: M82 (B.A.T, 2022)

The project has been a huge success with some incredible images being taken, which wouldn't have been possible without the massive collaboration. Thanks to the project, there is now a constant watchful eye on Hubble's variable nebula, and this is helping to understand better the variable star from which light waves are transmitted.

In the US, an independent astronomer called Bray Falls has made a catalogue of nebulae he discovered in the OIII wavelength (any catalogue containing "fal"– he has a few) (Falls, 2024). He did this primarily using wide-field refractor telescopes, as many of his targets were huge. He is credited with the discovery of the largest nebula ever discovered by an amateur astronomer, a large OIII region right next to the Andromeda Galaxy (Fessen, 2023). The fascinating thing is that this is one of the most widely imaged regions of the sky, and yet no one had ever checked that specific wavelength to see if there was anything there.

Now, Falls is no average astronomer; he blurs the line between being an amateur and being professional, however, it is still extremely impressive what an amateur astronomer can see.

With a basic astrophotography setup (small refractor, travel-size equatorial mount and a used DSLR camera – totalling around £500), it is possible to see all of the Messier Catalogue, most of the NGC catalogue, IC and many more. This includes many nebulae, galaxies, and clusters. With some more expensive gear, better emission nebulae become visible, and with monochrome cameras and narrowband filters, the only limit is the size of your house and how big of a telescope can fit into it.

Astronomy is one of those things in which a small investment can give very impressive results, but with experience, can exceed all expectations.

Astrophotography now is more accessible than ever before, and far more capable than most people imagine. Today's amateur astronomer can do more than many professionals could in the past. Discoveries by amateurs or using amateur gear are becoming more and more common, and there are enough astronomers in the world today, that it is guaranteed that someone is always looking up into space, so who knows what they might discover next.

Figure 2: M27 (England, J., 2023)

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The Human Brain

By Aryan Ghosh

The human brain is an organ that has fascinated scientists for thousands of years.

We, humans, are the dominant species on Earth. This is primarily because of how brilliant our brains function; our brains can do all sorts of spectacular things that set us apart from every other species on this planet. For example, our brains continue to grow until we reach the age of 20! A single human brain can contain billions of different neurons, all of which cater to a slightly different purpose. We also have more cortical neurons than any other species. Despite the fact our brains are much smaller than some animals' brains, we can still retain a lot more information. A blue whale, for example, is more than 2500 times our size, but their brains are only 4 times bigger. This shows that for the size of our bodies, our brains are enormous.

It is possible to divide the human brain into 3 main sections, each with its own special function. These include the cerebrum, the cerebellum and the brain stem.

The Role of the Cerebrum

The cerebrum is the biggest section in your brain and is essentially what makes us human. It is composed of the left and right hemispheres and the grey matter of the brain. All your thoughts (including the one you are thinking right now!) originate in your cerebrum. In addition to this, your cerebrum is what helps you react to the environment around you. It is responsible for higher functions that are absolutely essential to living. These include your memory, ability to read and write and your movement. Of course, these are just it's most important roles; it also has many other functions.

Key Words:

Neurons: a cell that carries information between the brain and other parts of the body

Cranial: of the skull

Endocrine:
relating to any of the organs of the body that make hormones (chemicals that make the body grow and develop) and put them into the blood, or to the hormones that they make

On top of this, the cerebrum works with your cerebellum to complete daily activities.

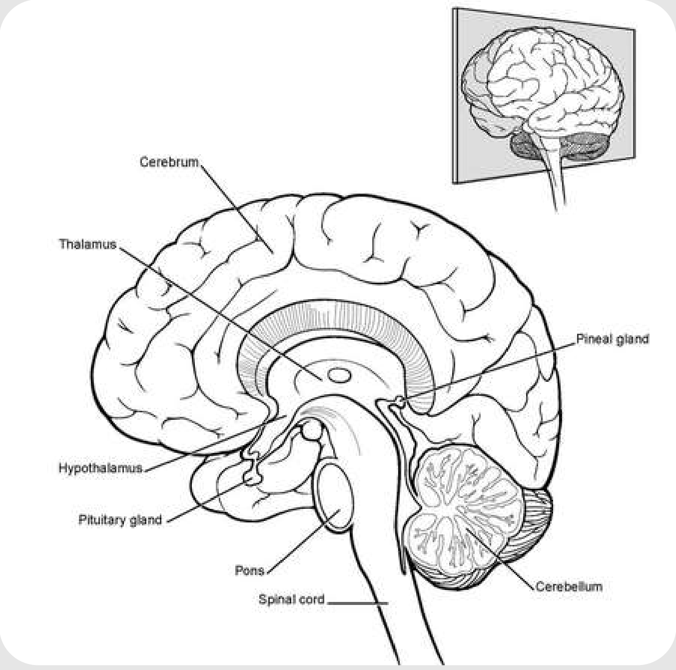

Figure 1: Diagram of the Brain (Rughani, 2015)

What is the Cerebellum?

The cerebellum is just above your spinal cord and is responsible for a wide range of functions in our day-to-day lives. For centuries, scientists believed that the cerebellum's only job was to coordinate muscle movements. This was later proved to be heavily inaccurate.

Many people often mistake the cerebellum for the cerebrum when it is actually another section of the brain. A straightforward way to remember the difference between the two is, the cerebrum is the biggest part of the brain whilst the cerebellum is located near the back and is reasonably smaller. As well as coordinating muscle movement, it also controls your sense of size and distance when judging objects in addition to your sense of rhythm. This was realised when scientists researched people with damage to their cerebellum. They found that people with damage to their cerebellum have trouble with tapping their finger repeatedly to a beat. Surprisingly, it is possible to live without a cerebellum. In extremely rare cases, people are born without a cerebellum, and some have mild symptoms and live normal lives, whilst others have severe symptoms and must receive constant medical treatment for the rest of their lives.

The Brain Stem

The name 'brain stem' derives from the fact it looks like a flower stalk or a stem and is located at the very bottom of the brain. It is an extremely interesting part of the brain and is in direct contact with your spinal cord. It connects the spinal cord to the cerebellum and cerebrum. One of its many functions is sending messages around your body to keep you balanced. In our brain, we have 12 cranial nerves. These are nerves that attach directly to the brain rather than through the spinal cord. Cranial nerves control your facial movements, taste, and sensations. Our brain stem controls 10 out of 12 of these cranial nerves. Your brainstem controls activities that you deem automatic or natural e.g. swallowing or breathing.

The Hypothalamus

The brain also has deeper smaller structures. One example is the hypothalamus, which is located well within your brain (sort of like the Earth's core) and is the size of an almond!

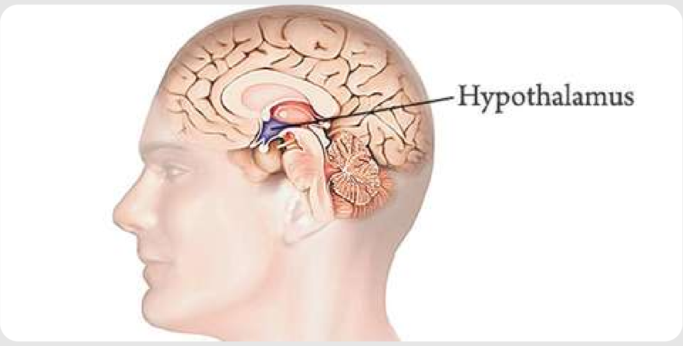

Figure 2: Hypothalamus (Jade, 2017)

It sits directly above your brain stem and is the main link between your endocrine system and your nervous system. This part of the brain is constantly receiving chemical messages from many nerves in the brain. Your hypothalamus can also make hormones and send signals to your pituitary gland. One hormone the hypothalamus is responsible for is dopamine. This is the hormone that makes you feel happy. Without the hypothalamus, feeling happy would not be possible. Some would describe the hypothalamus as the part of your brain that is the coordinating centre of your body. Even with its small size, it still plays an immense role.

The Pituitary Gland

Another key structure is the pituitary gland, which is so tiny that it is often described as pea-sized. Yet, it still has a huge role to play when it comes to the human brain. It's located below the hypothalamus and is classified as an organ itself. The pituitary gland releases many different hormones, such as adrenaline (responsible for the fight or flight response). It can also release growth hormones. Your metabolism (the sum of all the chemical processes in your body) is something that the pituitary gland is responsible for. It also balances the water and sodium levels (salt) in your body.

Why Do We Dream?

Without doubt, the human brain will continue to fascinate humans for centuries to come, and there still remains a lot of questions that we do not have the answers to.

For example, a commonly asked question is "How and why do we dream?" Dreaming is known to happen in the rapid-eye-movement (REM) stage of sleep. It would seem like your eyes were fluttering frantically, but in reality, you are just dreaming. When you are in the rapid-eye-movement stage, the activity in your brain increases dramatically, which explains why we dream. However, many experts are not entirely sure about how we dream. Some think it is to process emotions, whilst others think that it is to consolidate memories and the brain's way of resetting itself.

Memories and the Role of the Cortex

On the topic of memories, people often wonder how we keep and retrieve memories. To understand this, we must first learn a bit about the cortex. The cortex is the grey matter, the outer layer of your brain that is part of your cerebrum. It contains about 15 billion nerve cells. One of the main jobs of the cortex is to sort your memories out. When a memory is created, information flows from the cortex to the hippocampus. The hippocampus is the main switching point for memories in the brain. The memories are then stored in the hippocampus. When you retrieve a memory, the opposite happens and the information flows back to the cortex.

Figure 3: Music and the Brain (Glowacki, 2019)

It is not a secret that our brains are truly spectacular. The individual parts of our brains do completely different things, but when joined together they create an organ which has given us our incredible intelligence.

There is much that scientists have not discovered about the brain because it is so complex, but we hope to discover more in the future, as it is our brains that make us who we are.

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The Best Type of Animal and the Brief Evolution Behind Them

By Avi Kotecha

Key Words:

Diversification: the process of starting to include more different types or things.

Evolution: a process of gradual change that takes place over many generations, during which species of animals, plants, or insects slowly change some of their physical characteristics.

Mutation: a change in the DNA sequence of an organism.

Genotype: the genetic makeup of an organism.

Genes are a crucial component in all life on earth, a beautiful and eloquent way of coding for every trait we see today. The Cambridge Dictionary says “genes are a part of DNA in a cell that controls the physical development, behaviour, etc.” And to be even more specific, it is the universal code for all life on earth, ergo it is the keystone for the evolution of life.

From an aspiring zoo-geneticist, DNA, the simple yet complex code that lasts for just long enough is incredibly fascinating. The genes of animals are the most interesting, but especially those of avian animals, or birds.

The History of the Genetics of Corvid Birds

To start at the beginning, the genetic story of birds stems from a grand dynasty of dinosaurs, Theropod dinosaurs. These dinosaurs shared a common ancestor with “Aves” (birds (sort of)) around 130 million years ago (Benton, 2019). J. Benton discusses this in his eye-opening book, Dinosaurs Rediscovered, (2019), which also considers the links between birds and Theropod dinosaurs.

He mentions that birds are a prime example of the beauty of evolution, and the even starker beauty of the genes responsible; given that the diversification of four species of bird has led to the myriad we see today (Benton, 2019b).

The first real documentation of bird evolution, by the work of the renowned Mendel (1866), The Gene, is Charles Darwin and his finches (1831).

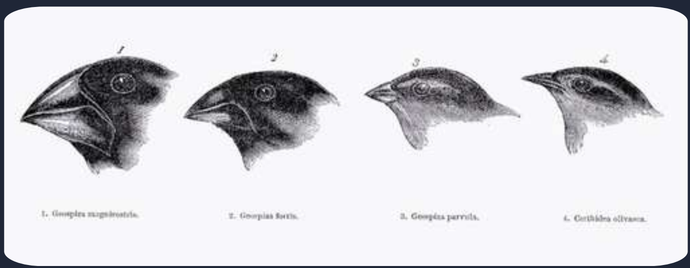

Figure 1: Finches from the Galapagos Archipelago (Darwin, 1831)

Charles Darwin, on his well-known trip to the Galapagos islands, observed the different beak shapes of finches, which have evolved solely to fit a niche type of food, and each from one common ancestor. This is the principle of evolution. Each bird has a similar body shape, but with drastically different beaks.

Figure 2: Terror Bird Head (Deviantart, 2014)

Let us delve slightly deeper, and further into the past. Birds have changed significantly over the course of three million years, with the fluctuation of "Terror birds," as well as the group of flightless birds we call "ratites." These animals truly were the shadow of their Theropod ancestors, reaching over two meters tall and boasting large, hooked bills. Although, of course, much has changed and in the last two million years; birds have become much smaller and have evolved to live under the somewhat indisputable rule of mammals and indeed humans.

Corvids

A fine example of a contemporary generalist, their large, strong beaks can be used in a multitude of fashions, from excavating soil in search of grubs, to tearing carrion off carcasses. Most corvids, such as birds like "Corvus splendens" (or the house crow) are covered in a rich dark black plumage, that acts as a temperature regulator. Light and heat are absorbed by the black feathers instead of the bird's skin, as if the heat entered through this native Indian crow's skin, the bird could die from heat-related illnesses. Similarly, other species such as "Corvus corone" (or the (very common) carrion crow that is native to the UK, and much of the northern hemisphere trap heat inside their thick plumage and absorb it in a sort of halo around the body. This marvel of evolution is all coded for by DNA.

Figure 3: Carrion Crow (no illustrator, 1957)

Melanin is the main component of the pigment found in feathers, which as a pigment is made up of small packets of protein. In other words, the sequence of nitrogenous bases in the DNA is organised in such a way that the structures and shapes that are subsequent reflect light in a certain wavelength, or in this case, reflect little light. These packets are called melanosomes.

Albinism in Corvids

As with other black corvids, Fray. R says in 2009, (Corvus corone) is prone to albinism (Fray et al., 2009). Albinism is an excellent example of a genetic mutation regarding the shape of the melanosomes, and the production of melanin. However, such mutations can be fatal in many organisms, as the "Corvus corone" would no longer camouflage, temperature regulate or successfully breed as well as the typical jet-black crow. This demonstrates natural pressure; if all members of "Corvus corone" now have the albinism trait, and a random change in the order of the DNA causes melanisation, this individual will now be able to function more efficiently.

Birds with albinism or indeed any organism with albinism has undergone a mutation of its genetic code, be this a deletion or addition in the base arrangement. The organism will rarely benefit from the mutation but on occasion, it can prove to be a step towards evolution.

Evolution and Flight

In 1952, Rosalind Franklin made a revolutionary discovery about DNA structure. She took an image of the double helix structure, winning her the Nobel prize. It wasn't for another 19 years that a major discovery regarding genetics would be made.

Birds gained the ability to fly through billions of slight alterations to their genotype. This is the nature of evolution; they are random, rarely beneficial changes that cumulate over millions of years. Flight is (mostly) a unique ability; it gives a major advantage to contemporary and archaic birds alike, allowing them to travel long distances where land bound animals may not have been able to, allowing a great dynasty of birds to flourish.

Corvids can fly, and this has been exploited with their large, asymmetrical flight feathers, with low wing loading - this means that each unit area of the wing can carry less weight (DK books, 2011). This also means that increased maneouverability is very much achievable (DK and Hoare, 2011).

Corvids use dramatic displays. From an evolutionary perspective, this serves as an enrichment allowing these birds to grow brains and intelligence, comparable to a small child. This increased intelligence allows these birds to have complex hierarchical social setups.

This therefore is why, personally, corvids and the whole Corvidae family are my favourite birds. They encapsulate the perfect balance of intelligence, genotype, and the all-around visual aesthetic of a well-evolved animal.

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Carrion crow vintage lithograph. (1957) [Photograph]. Mitteleuropäische Vögel. Germany.

ADVENT 2023

Kaftrio: Wonder-drug or Just One More Drug?

By Prakash Easwar

Key Words:

Proteasome: a large protein complex which degrades proteins within cells

Gastrointestinal: In or relating to both the stomach and the intestine

Active transport: The movement of particles across a cell membrane into an area of higher concentration, requiring energy

Epithelial: relating to the epithelium (= the layer of cells that cover most surfaces of the body):

Back in the early 20th century, before genetics became the foreground of modern medicine, patients with cystic fibrosis (CF) were often misdiagnosed or simply left scratching their heads. Surviving beyond primary school seemed improbable for children born with this disease. The first real breakthrough wasn't until 1938, when an American pathologist, Dorothy Andersen, first provided a clinical description. She simply described it as 'cystic fibrosis of the pancreas' due to the characteristic of cysts in the pancreas. However, in-depth identification was not made until 1989.

To understand what CF truly is, we must first look at it at a cellular level. Cystic Fibrosis is an autosomal recessive disorder, which means that both parents must carry an abnormal gene for the disease to develop (Egan, 2015). It stems from a defect in the Cystic Fibrosis transmembrane conductance regulator protein (CFTR; Figure 1). This protein serves as a channel for chloride ions to move from the cells of various tissues, including the lungs and GI tract. Normally, chloride ions can move through the CFTR freely via active transport, which facilitates the creation of a normal, watery mucus. However, patients with CF possess a gene defect affecting CFTR, causing it to malfunction and misfold (Fraser-Pitt and O'Neil, 2015). This means there is an absence of CFTR protein on the epithelial surface, and therefore there is no way for chloride ions to be pumped out.

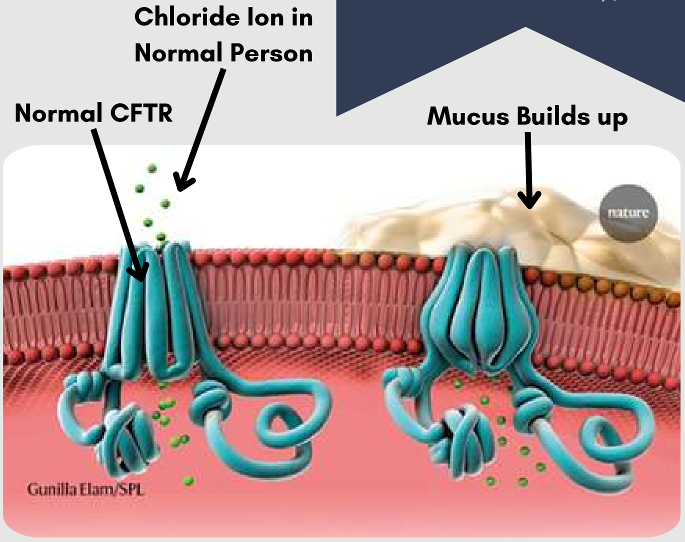

Figure 1: Pathophysiology of Cystic Fibrosis (Plackett, 2020)

The most common mutation causing cystic fibrosis is the Delta F508 mutation, where Phenylalanine (the 508th amino acid) is absent. Consequently, thick, sticky mucus (secretions) accumulates at the top of the CFTR channel, slowing the passage of chloride ions and water through it (Lukacs and Verkman, 2011) Furthermore, our body's defence proteasomes greatly worsen cystic fibrosis as they are programmed to degrade abnormal proteins. While this process is normally beneficial, in the case of cystic fibrosis, proteasomes degrade the CFTR proteins themselves. So, the impaired CFTR prevent any chloride ions passing through, leading to a formation of even thicker mucus, blocking the GI and respiratory tracts.

The opposite of this occurs with the bacteria the causes cholera (a serious infection of the bowels) where its toxin causes CFTR to open up more, causing excess chloride secretion, resulting in rice-water diarrhoea.

Symptoms

For newborns, CF is normally identified by meconium ileus (Figure 2). This is where the baby's first stool (its meconium) is too thick and sticky to pass through the gastrointestinal tract. As a result, the thick meconium obstructs the small intestine, forcing immediate surgery (Cleveland Clinic, 2022). As the baby grows into childhood with cystic fibrosis, it normally develops pancreatic insufficiency due to the thick secretions blocking the pancreatic ducts. The pancreas is the enzyme factory, and without it, proteins and fats are not absorbed. This often results in weight loss, steatorrhea (fatty stools) and a damaged pancreas. The damage usually causes acute pancreatitis or chronic pancreatitis in repeated cases, resulting in cysts (abnormal pockets of fluid) and fibrosis (thickening of the tissue) in the pancreas (giving the disease its name). Furthermore, it can cause endocrine (hormone) dysfunction in the pancreas which causes type 1 diabetes.

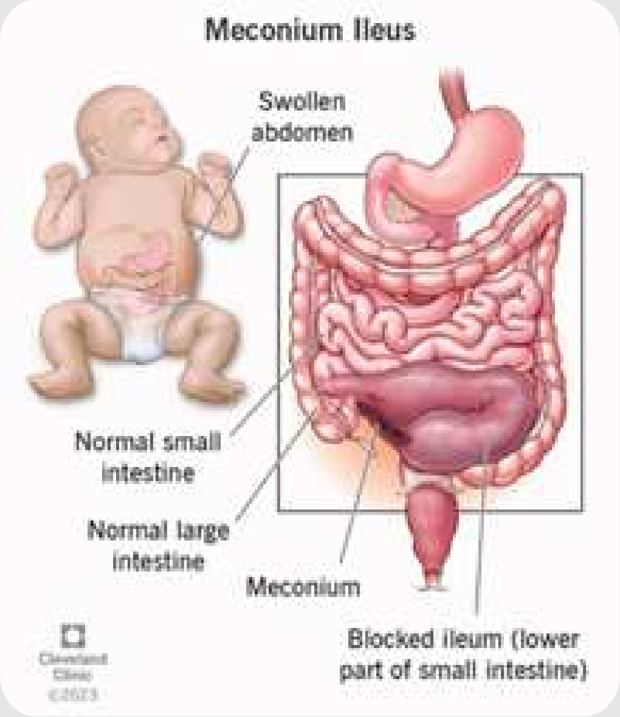

Figure 2 – Baby Suffering from Meconium Ileus (Cleveland Clinic, 2022)

Key Words:

Pancreatic Insufficiency (EPI): when the pancreas does not make enough of a specific enzyme the body uses to digest food in the small intestine

Pancreatitis: a condition that causes pain and swelling in the pancreas (= the organ in the body that produces insulin)

Pharnyx: the soft part at the top of the throat which connects the mouth and nose to the throat

While CF is commonly associated with the lungs, its effects only arise in late childhood. When we inhale, air enters our lungs and oxygen from the air diffuses into our blood. However, it is not just the oxygen in the air. Microscopic bacteria and debris can enter our lungs, but cilia (hair-like structures lining the airways) prevent them from diffusing into the bloodstream. The cilia move mucus (mucociliary action), which is sticky to catch bacteria, quickly towards the pharynx. However, in CF, given that the mucus is too thick and sticky, the mucociliary action is defective and slow (Figure 3).

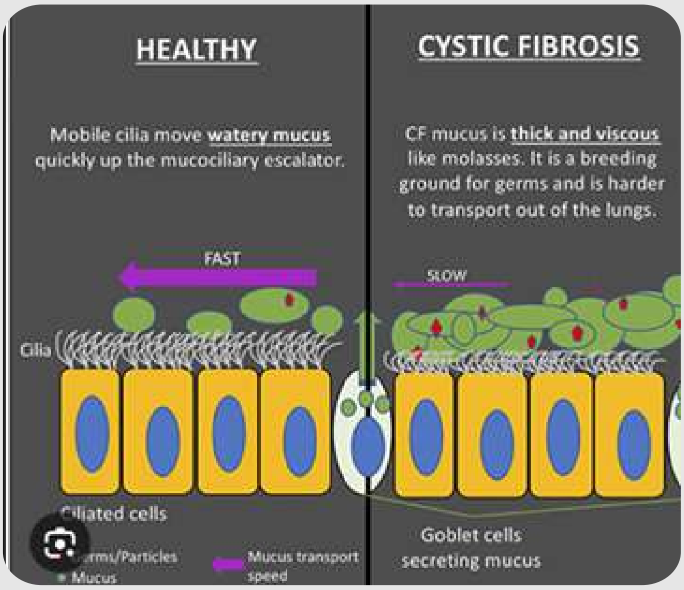

Figure 3 – Mucociliary Action in Normal vs CF Lungs (Weupe and Lever and Kennemur and Bono and Philips and Shei and Rowe, 2019)

Key Words:

Peripheral: at the edge of something

Bronchi: plural of bronchus (= one of the two tubes that branch from the trachea (windpipe) and carry air into the lungs

Chronic: continuing for a long time

Bronchiectasis: a condition where the lung airways become widened, leading to a build-up of excess mucus that can make the lungs more vulnerable to infection.

This allows bacteria to colonise the lung, and the increase in bacterial load causes excess coughing and fevers in attempt to move it out. These changes are known as CF exacerbation and prompt rounds of antibiotics. Repeated CF exacerbations can result in respiratory failure (when the blood doesn't have enough oxygen in it), which is the most common cause of death for cystic fibrosis.

CF also affects the lungs by decreasing lung capacity; it significantly lowers the FEV1/FEC ratio, the ratio of how much air you can exhale in 1 second to the total amount of air you can exhale forcefully in one breath (GPnotebook, 2021). As mucus clogs airways in CF, they naturally have a lower lung volume than normal. Thus, patients struggle to exhale air quickly, out of the clogged airways.

There are three other serious effects CF can have on the body. Firstly, men with CF can have difficulty conceiving naturally due to the blockage of the vas deferens, the tube that transports sperm from the testes to the urethra. As mucus is thicker in CF, it clogs the vas deferens as it forms, causing sperm cells to die quickly.

Secondly, patients with CF often experience digital clubbing, where their fingernails become extremely large and curved, spooning around the finger (Figure 4). This occurs due to the CF's characteristic thick mucus which blocks the airways, effecting airflow. As a result, there is decreased oxygen exchange in the lungs, causing hypoxia, which is when not enough oxygen is available to the blood and body tissues (Cleveland Clinic, 2022).

Peripheral vasodilation is one of the results of hypoxia, where blood vessels in the fingers and toes may dilate (become wider) to enhance blood flow and oxygen delivery to the peripheral tissues. This dilation contributes to the swelling and rounding of the fingertips, a characteristic of digital clubbing.

Figure 4: Digital Clubbing (Cleveland clinic, 2022)

Lastly, CF can also cause Bronchiectasis (permanent dilation of bronchi walls). Since CF impairs mucociliary action, mucus accumulates in the airways of patients. The presence of thick mucus in the airways causes chronic inflammation and provides an ideal environment for bacteria to grow. The respiratory infections the bacteria cause further contribute to the inflammation of the airways which causes damage to airway walls and promotes enzyme release to break down tissues. Over time, this leads to dilation and scarring of bronchi walls, contributing to Bronchiectasis.

Treatment

Life expectancy after developing cystic fibrosis used to be just 10 years in the early 20th century, so how has it increased to 50 years and rising?

Despite it being an exceedingly rare disease (only around 160,000 patients worldwide), foundations consistently raise upwards of £200 million annually towards its research. As a result, Vertex Pharmaceuticals recently released a drug called Kaftrio (known as trikafta in the US) that has revolutionised modern medicine. It is a triple therapy, combining the three molecules: Ivacaftor, Tezacaftor and Elexacaftor (Figure 5).

Figure 5: Kaftrio Tablets Combining Ivacaftor, Tezacaftor and Elexacaftor (Merino, 2021)

While Ivacaftor prevents the degradation of CFTR channels, improving its activity, Tezacaftor and Elexacaftor increase the number of CFTR proteins on cell surfaces. In combination, they make the lung and digestive juices less thick, relieving the symptoms of Cystic Fibrosis and enhancing patients' quality of life (medlineplus.gov, 2023).

Over 90% of patients have experienced a huge transformation in their experience of cystic fibrosis including increasing their lung capacity from under 50% to over 80%; the performance of this drug is significant. Compared to other drugs on the market, like Orkambi and Symdeko, Kaftrio is unbelievable. Orkambi and Symdeko only offer under a 5% lung function improvement, whereas Kaftrio is just under 15%. Moreover, Kaftrio is being made more accessible; the age limit started off at 12 and up, but now children between 6-11 years can take it (mmu.ac.uk 2022). However, in this money-oriented world, nothing comes without a price tag.

Vertex Pharmaceuticals expect a total revenue of £10 billion this year, yet they still charge NICE (National Institute for Health and Care Excellence) £100,000 to £160,000, dependent on dosing, per patient, per year (Wise, 2023). To put this in perspective, with 11,000 patients suffering with cystic fibrosis in the UK, it would cost the NHS over £1 billion per year. At this steep price, Kaftrio will not be on the NHS for much longer due to its cost being well above its QALY gained, despite the severity of cystic fibrosis.

QALY is a measurement involving judging drugs based off their effect on improving quality and quantity of life. While Kaftrio does increase the quality and length of CF patients' life, the cost for just 11,000 patients makes it an unjustified expense. This also goes against utilitarianism, which states the best choice should produce the greatest good for the greatest number of people. Kaftrio is not accessible for everyone due to its excessive cost, therefore, its good does not help the greatest number it could. If Vertex Pharmaceuticals do not lower the prices of Kaftrio, so it is more sustainable for the NHS, the future of upcoming patients with cystic fibrosis will be dark and uncertain.

Moreover, only 12% of people in the world have access to Kaftrio, despite it working for 90% of patients suffering from CF.

While it was previously proposed that CF only affected white Europeans, recent evidence suggests it appears in the Middle East, Asia and Latin America. In addition, sufferers of CF in these less developed areas are thought to greatly increase the total amount of global CF patients, despite the fact that less than two thirds of those patients have been diagnosed (Inácio, 2022). The inflated cost of Kaftrio means that in these less developed countries, 'the medicines are so expensive they are essentially unavailable unless reimbursed by government or health system authorities.' (Guo, 2022).

Therefore, Kaftrio as it exists now, is exclusively available for high income countries. But even in Poland (a high-income country), the CFTR modulators are too expensive, so a CF patient's life expectancy sits at 24.5, compared to America's 46. So, it is clear that the distribution and sale of Kaftrio has been improperly managed .

In conclusion, Kaftrio shows great promise for CF patients as it relieves the symptoms of CF and betters patients' quality of life. It is clearly the best treatment for CF currently, increasing lung capacity by over 25% and lung function just under 15%. However, the problem is its cost and availability. Less developed countries don't have access to Kaftrio due to its price, and soon even higher income countries won't be able to afford the treatment at a base price of £100,000 per year. This can be improved by increasing funding and knowledge about the effects of CF, but also simply reducing its cost. Huge drug companies, like Vertex Pharmaceuticals, already turn over hundreds of millions, to billions of pounds per year. By reducing the cost of Kaftrio by a few thousand pounds, per patient, per year, many impoverished, sick patients can be helped to see adulthood.

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Key Words:

Narrowband: a signal over a small range of frequencies

Hypothesis: an idea or explanation for something that is based on known facts but has not yet been proved:

Extraterrestrial: in or coming from a place outside the planet Earth

ADVENT 2023

The Wow! Signal: A Cosmic Enigma

By Sehrish Malik and Khadijah Dudha

The universe is vast and filled with countless stars, planets, and galaxies. Whether other intelligent life exists beyond Earth has captivated scientists and dreamers for generations. One event in the summer of 1977 added an unexpected twist to this age-old question – the discovery of the Wow! Signal.

The Big Ear and its Discovery

The Wow! Signal is a powerful and enigmatic radio signal detected on August 15, 1977, by the Big Ear radio telescope. This massive radio telescope was located at Ohio State University's Perkins Observatory, near Delaware, Ohio, in the United States. The signal was named "Wow!" by astronomer Jerry R. Ehman because he was so impressed by the strength and unexpected nature of the signal that he wrote "Wow!" in red ink on the computer printout of the data.

A Cosmic Mystery

What made the Wow! The signal so intriguing was its characteristics. It was a narrowband radio signal, concentrating at a single frequency, like tuning into a specific radio station. Moreover, the signal was powerful, much stronger than the background noise typically observed in the universe. It lasted for 72 seconds and then disappeared, never detected again.

Figure 1: The Wow! Signal Constellation (The Planetary Society, 1977)

Possible Explanations

The Wow! Signal remains a mystery to this day. Many hypotheses have been proposed to explain its origin, but none have been proven definitively. Some scientists have suggested that it could have been a signal from an extra-terrestrial civilization, a notion that excites the imagination and sparks dreams of interstellar communication.

Others have proposed more mundane explanations, such as a passing satellite or a natural celestial phenomenon. However, these explanations have their challenges, and the Wow! Signal's unique characteristics make it difficult to attribute to known sources.

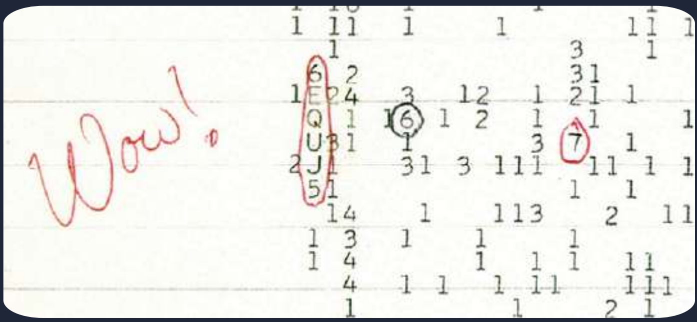

Figure 2: A Colour Scan of the Original Computer Printout of the "Wow!" Signal as Detected. (Big Ear Radio Observatory and North American Astrophysical Observatory (NAAPO), 1977)

The Quest Continues

The search for the origin of the Wow! The signal continues, with astronomers and scientists worldwide exploring various possibilities. Some researchers focus on re-examining the original data, hoping to uncover additional clues that might provide answers.

Advances in technology have also expanded our ability to search for similar signals using more sophisticated telescopes and instruments. Projects like the Search for Extra-terrestrial Intelligence (SETI) continue to listen for potential signals from the cosmos.

The Wow! Signal is a captivating chapter in the ongoing quest to understand our place in the universe. While it has not provided definitive proof of extra-terrestrial life, it has inspired generations of scientists and space enthusiasts to explore the cosmos and search for answers to one of the most profound questions: Are we alone in the universe?

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ADVENT 2023

Rocket Science and Stability

By Aadil Seth

Key Words:

Lift: the force on the wing of a bird or aircraft that keeps it in the air as it moves forward

Drag: the force that acts against the forward movement of something that is passing through a gas or a liquid

Torque: a force that causes something to rotate

Rockets are notorious for their complexity: from the advanced mathematics behind them, to their stability.

During the flight of a rocket, small gusts of wind or instabilities can lead the rocket to steer off course or change its behaviours during its flight. Like most objects in flight, a rocket rotates along its height about its centre of gravity. The rotation causes the axis of the rocket to be inclined (angled) towards the flight path. Whenever the rocket is inclined in this way, a lift force is generated by the rocket body and fins, while the aerodynamic drag remains constant for small inclinations. Lift and drag both act through the centre of pressure of the rocket.

Rocket Body Stability

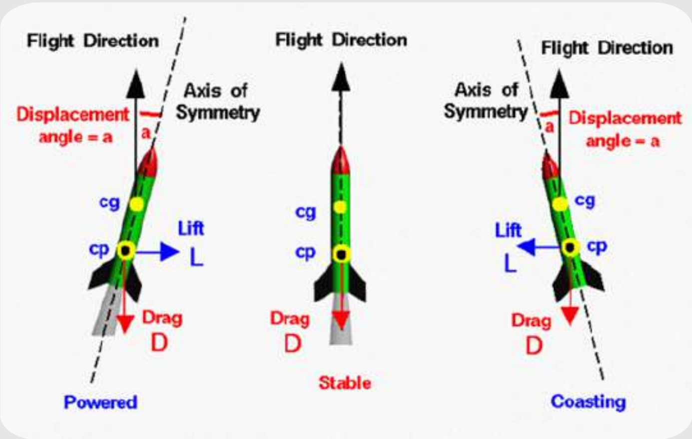

Figure 1: Rocket Stability (Nasa.gov, 2024)

In figure 1, three cases are shown for rockets for which their flight directions are vertical. The middle rocket is undisturbed, and its axis is aligned with the flight direction. The drag of the rocket acts along its axis and there is no lift generated.

The rocket on the left has its nose inclined to the right and the rocket on the right has its nose inclined to the left. The angle in both cases is denoted by a.

Considering the left-most rocket (inclined to the right), a lift force is generated and directed towards the right-hand side of the rocket. Thus, both the lift and the drag produce counterclockwise torques (moments), about the centre of gravity; the tail of the rocket swings to the left under the action of both forces, and the nose is pushed to the right. Oppositely, the right-most rocket (inclined to the left), lift is directed towards the left-hand side. Here, both lift and drag produce clockwise torques about the centre of gravity; the tail of the rocket swings to the right under the action of both forces and the nose is pushed to the left.

In both cases, the lift and drag forces push the nose back towards the flight direction. Some call this a 'restoring force' because the forces 'restore' the object to its initial condition and stabilise it. This is true if the rocket doesn't overshoot and oscillate, although in this case the rocket typically undergoes restoring force until it regains stability.

A restoring force exists for this model rocket because the centre of pressure (CP) is below the centre of gravity (CG), which are the conditions for a stable rocket (Hall, 2023).

If the CP is above the CG, the lift and drag forces maintain their directions but the direction of the torque generated by the forces is reversed. This is called a destabilising force.

Experimentation with Stability

There is a relatively simple test that can be done on a model rocket to determine its stability. First, a string is tied around the body tube at the location of the CG. Then, the tester must swing the rocket in a circle around them while holding one end of the string. After a few revolutions, if the nose of the rocket points in the direction of the rotation, the rocket is stable, and the CP is below the CG. However, if the rocket wobbles, or the nose points in another direction, the rocket is unstable. Stability can be increased by lowering the CP, increasing the fin area, or by raising the CG, by adding/shifting weight to the nose.

Determining the Effect of Fin Shape on Stability

Before physically experimenting with an actual model, I used a simulated model in Open Rocket – a free-to-use rocket modelling software wherein users can simulate rockets and commercial rocket motors (the part that contains the fuel).

After testing multiple cant angles (how angled left/right the fins are along the rocket's height), I found 45° to be the best theoretical angle, with the highest stability-to-speed-loss ratio. This was expected, as fins use drag to increase stability. Thus, by increasing the drag that acts on a fin, stability should increase. So, as angling the fins straight (relative to the height of the rocket) creates minimum drag (as less surface area faces the direction the rocket travels in), angling the fins perpendicular (90 degrees) to the direction of travel results in the maximum drag force. However, using the latter would slow the rocket down too much (not to mention that the fins may snap from experiencing such a large drag force).

Key Words:

Vane: a flat, narrow part of a fan, propeller, etc. that turns because of the pressure of air or liquid against it

Aerodynamics: the science that studies the movement of gases and the way solid bodies, such as aircraft, move through them

The solution is therefore to take the medium stance: 45°, the angle between horizontal and vertical. This angle also allows the rocket to spin, therefore further increasing stability.

However, what appeared to lead to the highest increase in stability was changing the rocket dimensions, specifically the ratio of the outer fin length (tip chord) to the inner fin length (root chord – attached to the body of the rocket). The larger the ratio, the higher the stability, as lowering the root chord shifts the CP lower down the rocket, if the lowest part of the root chord touches the base of the rocket body tube. This can be seen in figure.2. The fin is closer to the back of the rocket, so drag acts lower down the rocket, lowering the CP of the rocket further below the CG.

This only works when the fin is lightweight, if not, lowering the CP in this way would also shift the CG of the rocket downwards, negating the lowering of the CP.

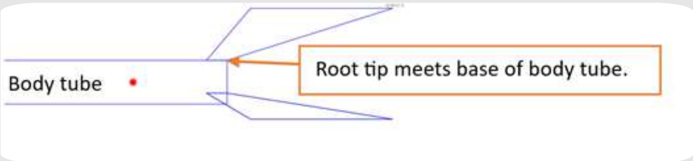

Figure 2: Diagram Showing Fins on Model Rocket

Computing the Centre of Pressure

For a more accurate assessment of the rocket stability, the CP and CG can be calculated using the Barrowman equations. The ratio of the positions of the CP to the CG shows the stability of the rocket; as said before, a lower CP and higher CG leads to more stability.

Specifically, the Barrowman equations allow you to determine the stability of a rocket by finding the location of the CP. The value calculated is the distance from the tip of the rocket's nose to the CP (Culp, 2008).

The CG can be found by simply finding the balance point of the rocket (where the rocket can be balanced along its length on your hand or finger without tipping to one side). The length from the tip of the rocket’s nose to the CG can then be measured. The calculated CP distance should be greater than the measured CG distance by one rocket diameter (calibre) to achieve stability. This is called "one-calibre stability" (Culp, 2008).

The Barrowman Equations

Terms in the equations are defined in the diagram (figure 4), and in the key (figure 3).

L_N = length of nose
d = diameter at base of nose
d_F = diameter at front of transition
d_R = diameter at rear of transition
L_T = length of transition
X_P = distance from tip of nose to front of transition
C_R = fin root chord
C_T = fin tip chord
S = fin semispan
L_F = length of fin mid-chord line
R = radius of body at aft end
X_R = distance between fin root leading edge and fin tip leading edge parallel to body
X_B = distance from nose tip to fin root chord leading edge
N = number of fins

Figure 3: Key of Rocket Dimensions (Culp, 2008)

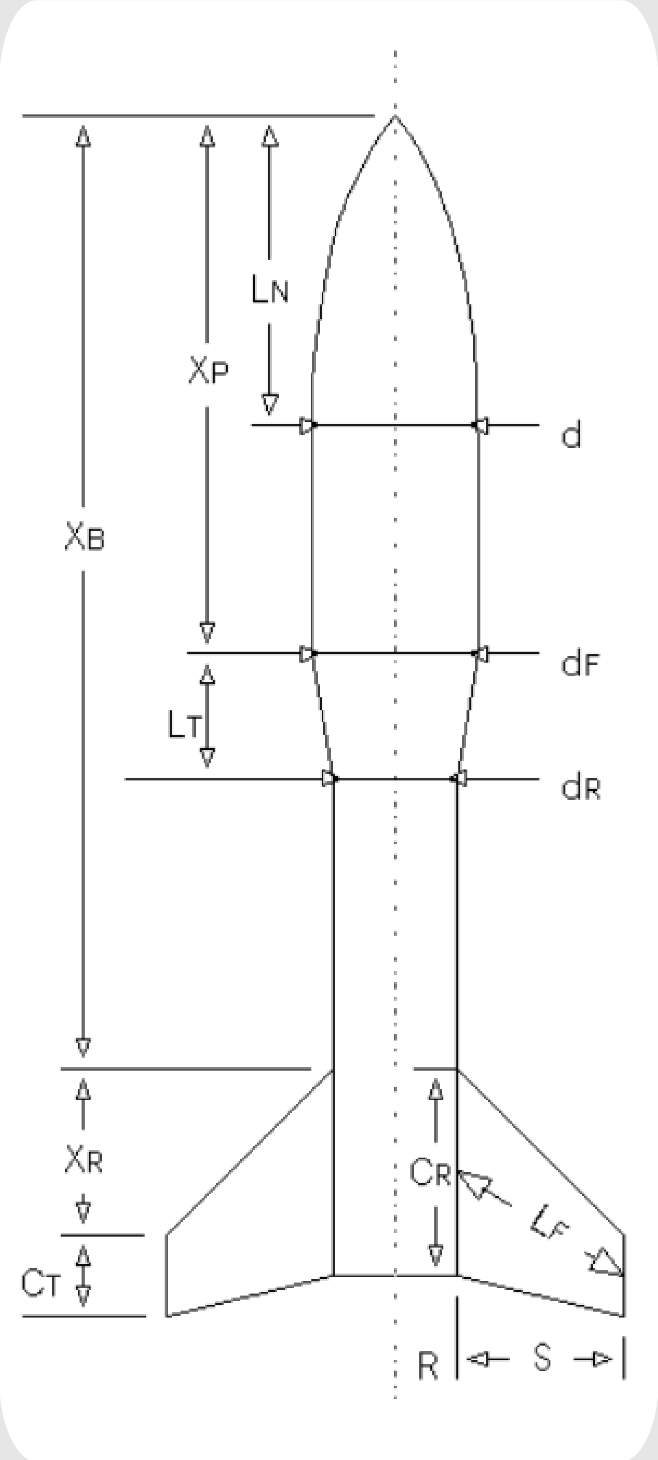

Figure 4: Diagram of Rocket Dimensions (Culp, 2008)

Nose Cone Terms

$(C_N)_N = 2$
For Cone: $X_N = 0.666L_N$
For Ogive: $X_N = 0.466L_N$

Conical Transition Terms

$$(C_N)_T = 2\left[\left(\frac{d_R}{d}\right)^2 - \left(\frac{d_F}{d}\right)^2\right]$$

$$X_T = X_P + \frac{L_T}{3}\left[1 + \frac{1 - \frac{d_F}{d_R}}{1 - \left(\frac{d_F}{d_R}\right)^2}\right]$$

Fin Terms

$$(C_N)_F = \left[1 + \frac{R}{S+R}\right]\left[\frac{4N\left(\frac{S}{d}\right)^2}{1 + \sqrt{1 + \left(\frac{2L_F}{C_R + C_T}\right)^2}}\right]$$

$$X_F = X_B + \frac{X_R}{3}\frac{(C_R + 2C_T)}{(C_R + C_T)} + \frac{1}{6}\left[(C_R + C_T) - \frac{(C_R C_T)}{(C_R + C_T)}\right]$$

Finding the Center of Pressure

Sum up coefficients: $(C_N)_R = (C_N)_N + (C_N)_T + (C_N)_F$

Find CP Distance from Nose Tip:

$$\bar{X} = \frac{(C_N)_N X_N + (C_N)_T X_T + (C_N)_F X_F}{(C_N)_R}$$

Figure 5: Barrowman Equations (Culp, 2008)

Why is the Centre of Gravity so Important?

If a rotating force is applied to a free body in space, it will cause it to rotate around its centre of gravity. For example, after throwing a wooden dowel or uniform stick of length 2' into the air, an 'end over end' rotating type motion can be observed (see figure 6, example A).

It is apparent that regardless of how the stick is thrown, it will always rotate about its CG. However, if a weight is then attached to one end of the stick and it is thrown into the air, it will rotate about a new location (figure 6, example B).

This time the point about which it rotates will be closer to the weighted end. If this weighted stick is then balanced on top of a sharp edge, the point about which it balances (its CG) is the same point about which it had been rotating when tossed into the air (Figure 6, example C).

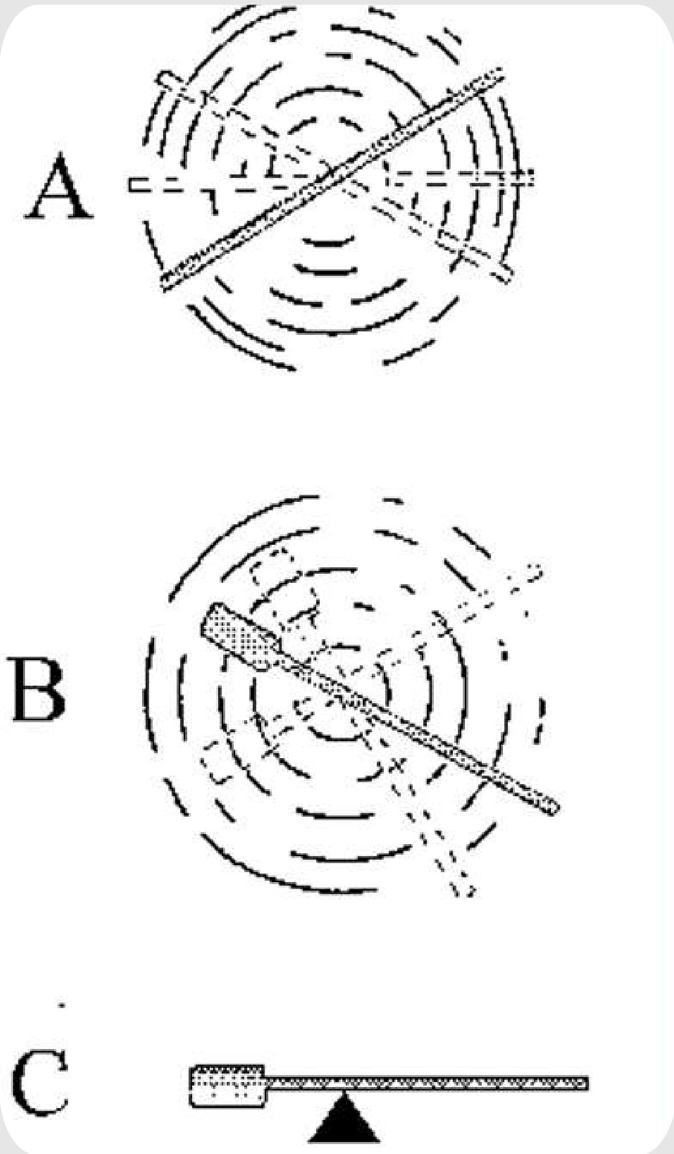

Figure 6: Diagram Showing the Correlation Between Rotation and the Centre of Gravity (Estes, n.d.)

This simple explanation explains why a model rocket in flight, which is also a free body in space, always rotates about its CG if a suitable force is applied to it (Estes, n.d.).

Rotating Forces in Rockets

Rotating forces applied to rockets in flight can arise due to a multitude of reasons, such as lateral winds, air resistance on the nose cone, air resistance on launch lugs, crooked fins, exhaust gases being emitted at an angle, the motor being mounted at an angle, unbalanced drag on fins, unequal streamlining, etc. Given that many of these factors are going to be present in all rockets and thus rotating forces will be present, rockets must be designed very carefully. If not, the rocket could take an erratic path but end up not covering much distance. However, nearly all model rockets can be stabilised (all rotating forces are counteracted or overcome) by air currents. This means that for each force trying to make the rocket rotate, an equal and opposite force (via. air currents) must be set up (using the structure of the rocket) to counteract it. (Estes, n.d.)

The Importance of the Centre of Pressure

The following experiment should clarify why the centre of pressure is so important in rockets.
The same piece of dowel used in the previous experiment is placed on a low-friction pivot as shown in example A of figure 7. Then suppose the dowel is held in a uniform air current of 10-15mph. If the pivot has been placed in the physical centre of the dowel and if the dowel has a uniform cross-sectional area, the forces exerted by the air pressure will be equal on the dowel on both sides of the pivot, and the air current will produce no rotating effect.

If, however, a 3″ x 3″ piece of cardboard is glued to one end of the dowel, creating a vane, when the dowel is reintroduced into the air stream with the pivot in the same position, the moving air current will apply a greater force against the end of the dowel which has the vane attached to it. (See example B, figure 7) The larger the surface area, the greater the force applied will be. (Estes, n.d.) This will cause the dowel to rotate so that the opposite end of the dowel to the vane points into the source of the air current.

If the pivot is moved closer to the vane, it is possible to locate a point along the dowel where equal air pressure will be applied to both ends and the air current will no longer cause rotation. This point is called the lateral centre of pressure, which correlates only to the forces applied by air currents.

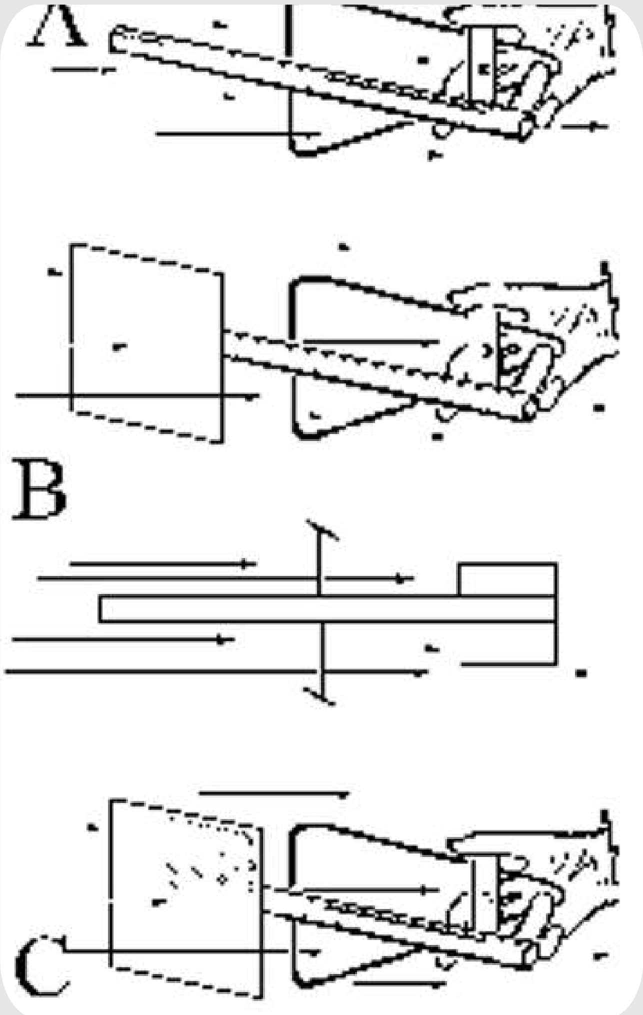

Figure 7: Diagram Illustrating the Effect of Centre of Pressure in an Air Current (Estes, n.d.)

Relating the Centre of Pressure and Centre of Gravity

Suppose a model rocket starts to rotate in flight. It will rotate around its CG and the air rushing past it will then hit the rocket at an angle. If the CP is behind the CG on the rocket, the air resistance will exert the greatest force against its fins. This will then counteract the rotational forces and the rocket will continue to fly straight. If, on the other hand, the CP is ahead of the CG, the air resistance will exert a greater force against the nose end of the rocket. This will cause it to rotate with greater magnitude and lose its stability in the air (Estes, n.d.).

However, it must be noted that modern full-scale rockets do not typically rely solely on aerodynamics for stability. Instead, they pivot their exhaust nozzles to provide stability and control. That's why fins aren't seen on a Delta, Titan, or Atlas Booster rocket (Hall, 2023).

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Key Words:

Beneficiaries: a person or group who receives money, advantages, etc. as a result of something else.

Automate: to make a process operate by machines or computers, in order to reduce the amount of work done by humans and the time taken to do the work.

ADVENT 2023

Artificial Intelligence (AI) - Friend or Foe?

By Aryan Gopal

The History of AI

AI was the brainchild of John McCarthy, Yoshua Bengio, Geoffrey Hinton, Yann LeCun and Alan Turner in 1948, all of whom contributed to the foundations of the technology, which has recently skyrocketed in its awareness and applications. AI stands for 'artificial intelligence' and is quoted to be 125,000 times faster than the human brain. Some regard it as one of our most significant technological advances since the dawn of the internet; the speed of its revolution has left many speculative about the technology. So, the question we are left with is, is AI a friend or a foe?

Figure 1: (KiboShib, 2023)

What is AI?

AI is the science of making machines that can think like humans. It can do things that are considered "smart." AI technology can process large amounts of data in ways that are unlike humans. The goal for AI is to be able to do things such as recognize patterns, make decisions, and judge to carry out tasks such as having human-like conversations.

Figure 2: (Academy, B., 2023)

How Could We Benefit From AI?

AI could benefit the human race in various ways across our everyday lives in industries all around us, like criminal justice, manufacturing and medicine, to name a few. Examples of technological advancements are as follows:

- AI has been used to advance diagnoses and illnesses based on previous data to save lives worldwide. This use alone has predicted to save 250,000 lives a year, just in the NHS.

- AI is allowing new technological breakthroughs quicker than ever before.
- AI is speculated to automate jobs that humans have previously completed.

The possibilities are endless, from what can be created to what can be achieved.

The Disadvantages of AI

Although AI has many beneficiaries, many factors could create setbacks and a sense of worry within the public. This is because AI is programmed with information that could lead to potential bias, dependent upon the data source. This leads to problems in areas such as the criminal justice system.

The recent advancements and mass circulation of AI has also highlighted enormous problems for the education sector, with students using technology to automate assignments and tasks. This has recently been discussed in the media with ChatGPT.

Moreover, questions around the future of the employment landscape are another huge concern, with speculations that by 2030, 40% of all jobs in the UK will have been replaced by AI technology.

Figure 3: (Ingham, L., 2019)

Figure 4: (Ingham, L., 2019)

Conclusion

AI has the potential to be a revolutionary advancement, or an uncontrollable force based on the empowerment of humanity. What are your thoughts? Is AI a friend or foe?

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ADVENT 2023

Oblique Wings - A Radical Solution to Supersonic Flight?

By Isaac Chi

Key Words:

Aerofoil: a structure with a curved surface designed to give the best lift to drag ratio.

AOA: 'angle-of-attack', the angle the chord makes with the horizontal. (Higher AOA means the plane is going up at a steeper angle).

Bernoulli: a Swiss mathematician and physicist (1700-1782).

Since the dawn of time, humanity has been fascinated by the ability to fly, yet the first successful recorded flight was not until the 17th of December 1903, when the Wright brothers revolutionised aviation with their Wright Flyer.

Modern-day commercial planes are powered by jet engines, cruising at approximately 880 to 926 kmh-1 (475-500 kn or 547-575 mph), yet only three decades ago, flights on the Concorde were flying significantly faster at speeds of up to 2172 kmh-1 (1173 kn or 1350 mph), holding the record for the fastest trans-Atlantic flight from New York to London in 2 hours, 52 minutes, and 59 seconds. Modern-day jetliners complete the journey in 7 hours, over two times longer. So, why are we flying more slowly?

Firstly, we need to understand how conventional planes fly. In order to fly, a plane must have a lift force greater than the weight of the plane, and so aerofoils have been designed to generate lift. The popular explanation of how lift is generated utilises the equal-transit time and longer path arguments. People assume that the air that hits the leading edge of a plane wing must meet its trailing edge at the same time. The longer path argument states that the upper surface of an aerofoil is longer than the lower surface. Therefore, to meet up at the same place, the air above the wing must travel faster to cover more distance in the same amount of time.

$$P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g h_2$$

P = Static Pressure of the Fluid

ρ = Density of the Flowing Fluid

v = Velocity of the Fluid

h = Height

Figure 1: Bernoulli's Equation

Bernoulli's principle states that 'an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy' (i.e. a point with higher fluid speed will have lower pressure than a point with lower fluid speed). In other words, because the air is faster above the aerofoil, it must have a lower pressure, so there is a relatively high pressure on the lower surface. This difference in pressure generates lift.

However, the flaw in the argument is the equal transit time principle, which has been proven to be incorrect. If the principle of equal transit times is true, the wing of the plane would be an absurd shape. For example, a small plane typically has a top surface that is 1.5 to 2.5% longer than the bottom, however, if we assume the equal transit times principle, the actual distance above will need to be around 50% longer than the bottom. (Anderson, D. and Eberhardt, S., n.d.)

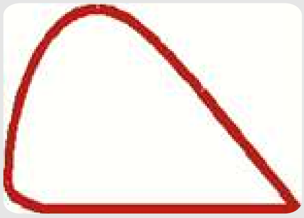

Figure 2: Predicted Wing Shape with Equal Transit Time (Anderson D. and Eberhardt S., n.d.)

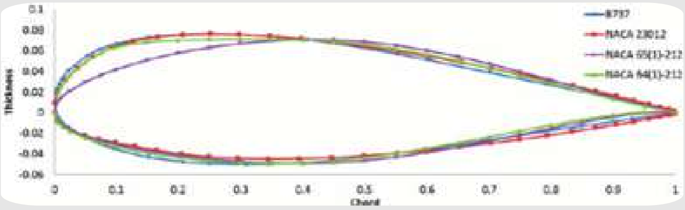

Figure 3: Comparison of Aerofoil Sections (Anon.,2014)

By assuming that air from both directions meets at the trailing edge at the same time, we invalidate the application of Bernoulli's Principle. Tests show that air on the upper surface of a wing reaches the trailing edge first (before the air underneath the surface).

So, how do conventional planes *actually* fly? There are multiple theories about how lift is generated. One approach to explaining lift simply is by using Newton's laws of motion. A plane flying with a positive AOA will fly through a certain mass of air each second (m/dt). Newton's second law can be expressed as: F = ma. As the wing attacks the air, it is displaced, accelerating the air downwards, which thus creates a downward force. And, as stated by Newton's third law (colloquially, every action has an equal and opposite reaction), the air exerts a reactive force on the wings, which acts upwards. This upward force is lift. (Landell-Mills, N., 2021).

However, the drawback of attempting to use either the Newtonian argument or the pressure argument (Bernoulli's principle) is that they only consider lift from one side. To form a better understanding, we can combine the two principles.

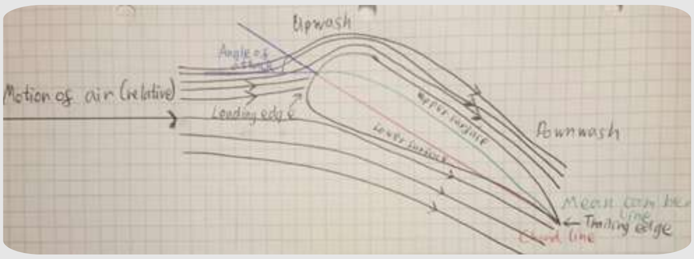

Figure 4: Aerofoil Diagram

Key Words:

Chord Line: the straight line between the leading and trailing edges.

Leading Edge: the front end of the aerofoil.

Trailing Edge: the rear end of the aerofoil.

Static Pressure: the pressure exerted by a fluid when it is at rest.

When an aerofoil with some AOA flies through air, the air is diverted downwards as shown. As previously mentioned, Newton's Third Law dictates that an 'equal and opposite reaction' be made, in the form of lift. However, some air is diverted above the wing. As air is a fluid, the air almost 'sticks' to the upper surface of the aerofoil, following its shape (on the diagram, you can see the lines above showing the flow of air staying close to the aerofoil).

This can be explained by the Coanda effect, which is where a fluid along a solid surface tends to follow the curvature of the surface rather than separating. (The Coanda effect can be seen at home using a mug with a lip and gently pouring water out of it. Some water 'sticks' to the mug and flows down the sides).

Wings with a positive camber also benefit from the geometry of the wing to an extent (but not due to the fact that the distance is longer but rather the slight curve), which generates further lift because when air flows along the surface of the upper surface, it is compressed, meaning it flows faster. Now, we can apply Bernoulli's principle without assuming the equal transit time principle. Bernoulli's principle states that an increase in pressure accompanies a decrease in fluid (air) speed and the inverse is also true. Thus, the upper surface with a now higher speed is accompanied by a lower pressure. This creates a pressure difference, generating further lift.

On the other hand, supersonic jets have a drastically different wing form to conventional planes. At subsonic speeds, the optimal wing design is long and straight, whereas at supersonic speeds, it is ideal for a wing to be thin or sharply swept. For example, the Concorde had an ogival wing design, a variation of the delta wing. These delta wing-derived designs performed poorly at subsonic speeds, as they struggled to generate lift. Equally, planes designed to cruise at subsonic speeds were not built for flying at speeds beyond the speed of sound as the delta wing was a better-optimised design for generating lift when in supersonic flight.

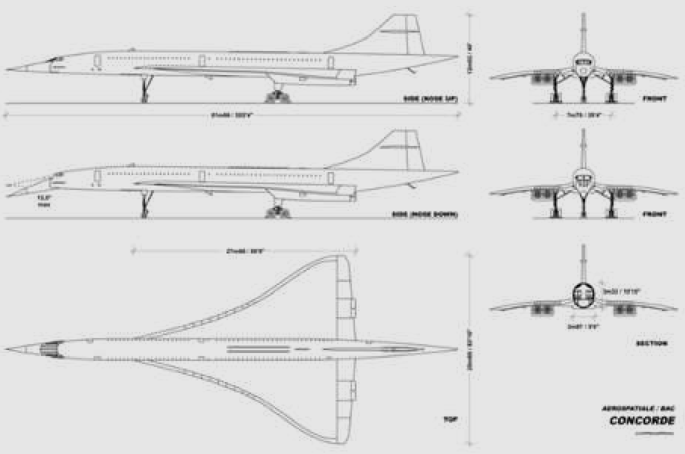

Figure 5: Concorde (Scavini, J., 2012)

Initially, engineers came up with the variable-sweep wing; the logic behind the design is simple. At low speeds, the plane has a long, straight wing, the optimum for subsonic flight. At higher speeds, the shape of the wing is changed to favour supersonic speeds by ‘sweeping’ back. While the concept seems intuitive, the wingspan would need to be significantly shortened to accommodate this mechanism, sacrificing cruising efficiency as well as higher take-off and landing speeds. Moreover, the complex mechanisms of the sweep wings add significant weight to the plane when compared to conventional wings, affecting the lift and speed of the jets, as well as having to counter immense forces when changing wing angles.

Key Words:

Camber: the asymmetry between the two acting surfaces of an aerofoil. Zero camber means the camber line is the same as the chord, positive camber means the camber line is above the chord line and negative camber means the camber line is below the chord line.

The variable-sweep wing design also changes the balance of the plane as when the wings sweep forwards and backwards, this changes the centre of lift of the plane. Thus, variable-sweep wings have only been applied in a few military aircraft designs, including the Mig-27, Tupolev Tu-22M and Grumman F-14 Tomcat. (Inamdar, A. et al, 2021)

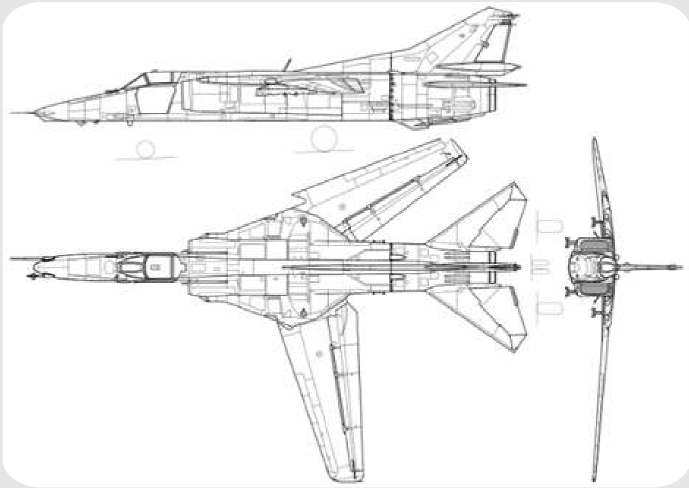

Figure 6: MiG-27 (Kaboldly, 2012)

Note that there are other variations of the variable-sweep wing, including those seen on jets such as the XB-71 Valkyrie which folds the wing by the wing tips downwards to attempt to counter the issues associated with its short wingspan.

Although, why is there a need for bilateral symmetry? In the 1950s, Robert Thomas Jones, an aeronautical engineer working at NASA (who had also worked on the delta wing) challenged aircraft design and pushed forward the concept of oblique wings.

Jones had proven using wind-tunnel tests and radio-controlled prototypes that an oblique-winged aircraft could fly stably, despite the design implying that it would be impossible.

Oblique wings have the same basic concept as variable sweep wings. The idea is to change the profile of the wing to better suit different cruising speeds. They are designed to have a wing that rotates on a central pivot, so that they can have a conventional wing geometry, however they can also be swept at an angle such that one side of the wing moves behind while the other side of the wing moves in front of the pivot, creating an unsymmetrical shape.

After the Second World War, classified German documents containing designs for oblique-winged aircraft were uncovered. These included the Blohm and Voss P.202, indicating that engineers may have been considering oblique designs back in the 1940s.

NASA would then go on to invest in the AD-1 (Ames Dryden-1), the first tested and piloted prototype, built on a shoestring budget (the original budget being $240,000). The test was conducted at NASA Dryden (now NASA Armstrong), demonstrating that the plane could fly with an oblique wing, varying the angle of rhe wings from the horizontal from 0 to 60 degrees, with its first flight in 1979 and final flight in 1982. Built with no computer assistance and mostly of fibreglass (having a mass of 900 kgs), the AD-1 flew at a maximum speed of 322 kmh-1, only 26% of the speed of sound. (NASA, 2015)

Figure 7: NASA AD-1 In Flight (NASA, 1980)

Key Words:

Mach: the ratio of a speed of an object to the speed of sound in the surrounding medium. Mach 1 is the speed of sound, Mach 2 is twice the speed of sound etc.

After the AD-1 tests, Ilan Kroo, an aeronautical engineer, determined the primary advantages and disadvantages of the oblique-wing design. He found that, due to the increased length of the oblique wing when compared to a symmetrical wing, the design had a reduced supersonic wave drag, meaning the aircraft flew more efficiently. Moreover, he noted that the elimination of the 'kink' at the wing centreline further reduced wing wave drag. The single pivot system is also lighter, reducing the weight of the plane. When the oblique wing is swept, the centre of lift also remains in a more central region when compared to the variable-sweep wing design (like those in the MiG-27). (Larrimer, B., 2013)

It was concluded that the sonic boom level of oblique wing configurations was lower than that of a similar, symmetrical swept wing design. A sonic boom is produced when an object moves faster than sound. When this happens, as an aircraft flies through the atmosphere, air-pressure waves are created, faster than the speed of sound. These pressure waves then combine to form shockwaves, creating the sonic boom. In fact, the sonic boom created by Concorde was so disruptive that many countries restricted or banned it from flying over their land (hence, Concorde was primarily used for trans-Atlantic flights between Europe and New York). Studies conducted by Boeing had reported that oblique wings could theoretically fly at Mach 1.2 without generating a sonic boom (Mach 1.2 is generally considered the boundary for supersonic flight). (Ven der Velden, A., Kroo, I., 1994)

Ilan Kroo also remarked on some drawbacks to oblique wings. For example, as the design is extremely unconventional to the public eye, there may be a perception of high risk, and even if the concepts are proven to be safe and efficient, there may be a negative public portrayal of the design. However, arguably, the largest drawback is the reduced control of the plane. Conventional planes with a symmetrical design are much simpler and more logical to fly - the oblique wing has some further complexities (for example, when the AD-1 flew, pilots had to constantly bank right to correct for a swept wing at 60 degrees). However, modern aircraft already have autopilot and are largely computer-controlled, and thus the oblique-winged planes could also feature autopilots and computer programs to fly the plane as efficiently and quickly as possible. (Larrimer, B., 2013).

In the late 1900s, a partnership between NASA, the US Navy and Rockwell International gave rise to the F-8 OWRA (Oblique Wing Research Aircraft) Programme. The programme determined that an oblique wing configuration would be well suited for a Navy fleet defence mission and supersonic transport at speeds below Mach 1.6. Unfortunately, after extensive research, NASA ran into issues with project funding. After the US Navy withdrew funding, NASA's attempts to receive funding from DARPA and the Air Force failed, leading to the termination of the programme. (Gilyard, G., n.d.)

The F-8 OWRA Programme did however have many experimental findings. The programme confirmed that the variable geometry that the oblique-winged design brought benefited performance, with tests up to sweep angles of 60 degrees at Mach 1.40. The F-8 OWRA used the F-8 Crusader as its foundations, which has a top speed of Mach 1.20. Moreover, the directional stability of the F-8 OWRA when the wing was swept back was only said to be slightly decreased when compared to the configuration with zero sweep. NASA noted that the overall drag was high, but this was mostly due to the large, blunt fuselage with an abruptly faired-over engine inlet. (Kennelly, R. et al., 1999)

The notion of supersonic flight making a return for commercial passengers is polarising. Some argue that the convenience and time saved from flying supersonic are extremely beneficial, whereas others may argue that supersonic planes have disruptive sonic booms and fuel-hungry engines, posing a threat towards the environment and global warming. Thus, the design of oblique wings on the commercial stage may never be revived. Perhaps consumers' fear of new, unconventional designs may lead to any hope of seeing them being within the military. Yet, hope is not completely lost, as Boom Supersonics' Overture jet design, powered by symphony engines, may be able to spark another age of supersonic flight.

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Figure 5: Scavini, J. (2012) Concorde v1.0[Photograph] Available at https://commons.wikimedia.org/wiki/File:Concorde_v1.0.png [Accessed 14 January 2024].

Figure 6: Kaboldly (2012) Mikoyan MiG-27 3-view[Photograph] Available at https://commons.wikimedia.org/wiki/File:Mikoyan_MiG-27_3-view.svg [Accessed 14 January 2024].

Figure 7: NASA (1980) NASA AD-1 in flight [Photograph] Available at https://commons.wikimedia.org/wiki/File:NASA_AD-1_in_flight.jpg [Accessed 14 January 2024].

Key Words:

Superorder: a category of biological classification ranking below a class and above an order.

Moult: to lose skin as a natural process at a particular time of year so that new skin can grow.

Aphids: any of various small insects that suck the juices of plants for food

ADVENT 2023

Mysterious Mantises

By Kumari Lad

Introduction: What are Mantises?

Mantises (Mantodea), commonly known as praying mantises, are an invertebrate that can grow up to 18 inches long and have a life span of up to 1 year. Mantids are insects, scientifically known as Mantidea. 1800 species of mantids can be found across the world. Most gardeners and farmers will accept mantises on their land, as their diet consists predominantly of pests that damage crops and other plants. (National Geographic Kids, 2014).

Having no pests allows plants and crops to grow in vast amounts. Consequently, farmers and gardeners can maintain the quality and production rate of their crops to profitable standards.

A biological classification system groups organisms that are living or extinct by their characteristics. These classifications are used to identify whether a species is stable, endangered, or a new species. The classifications are as follows: kingdom, phylum, class, order, family, genera, and species. Mantids belong to the superorder Dictyoptera, which is a branch of order classification. Superorder is not on the official list because it is not a common classification. (Britannica Kids, n.d.) The superorder Dictyoptera only includes Termites (Isoptera), mantids and Cockroaches (Blattodea). (Legendre et al., 2015)

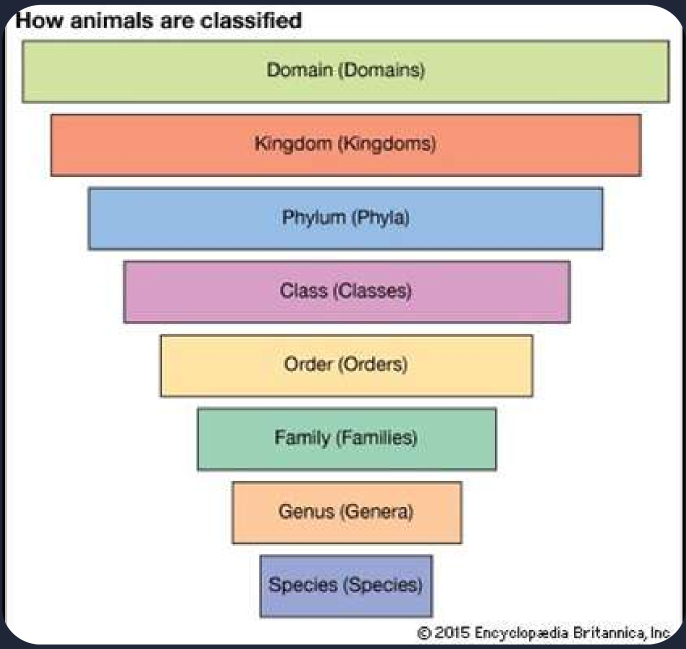

Figure 1: Animal Taxonomy (Encyclopaedia Britannica, 2015)

Disguises

Disguising is the act of having an appearance that allows organisms to blend into their surroundings. Mantises primarily disguise as plants and leaves to hide from predators and prey (Cmnh.org, 2015).

The African Spiny Flower Mantis (Pseudocreobotra Wahlbergi) is able to change its colour to match its surroundings after each moult. Some species of African mantises have evolved to look like leaves or flowers to attract prey, whereas other species of African mantises have developed to look like twigs or bark. (Gardenia, n.d.)

Disguise Examples

If mantids live in trees, it is more than likely that the mantids may have a mossy or leafy disguise. A great example is the Giant Moss Mantis (Majangella Moultoni) (iNaturalist, 2014).

Walking leaf mantises (Phylliidae) and Dead Leaf mantises (Extatosoma tiaratum) disguise as leaves. To complement their disguise, when the wind blows, mantises sway as if they are a real leaf. Leaf mantises have ridged edges with uneven holes on the top of their body that give them the appearance of an eaten leaf.
(www.buglogical.com, n.d.)

To conclude, mantises disguises vary, dependant on their habitat or life style. The ability to camouflage enhances its success rate in hunting and hiding. (Insektenleibe, n.d.). Every mantis needs a good disguise; without disguises mantises would die!

Mantis Colour Palette

As plants return with colour during spring, green, pink, and white, mantises can be found. As the year goes by, plants die and turn brown, and so will majority of the mantises. Exceptions can be found for species like the orchid mantis (Hymenopus coronatus) who remain a pale pink colour.

Defence

It is mandatory for insects to have a defence mechanism because 80-99% of insects do not live long enough to reproduce. Around 50% of these deaths are caused by predatory hunting (www.buglogical.com, n.d.).

Not being able to reproduce indicates that the population of that species will decrease which could lead to their extinction.

A popular defence pose can be described as when the mantis stands horizontally, fans out its wings and bares its spiked forearms, thus prolonging its life.

Figure 2: Praying Mantis Horizontal Stance Defence Pose (Dillon, J., 2023)

A less commonly used pose is described as simply raising its arms at the threat, seen in figure 3.

Figure 3: Praying Mantis Raised Arm Defence Pose (www.buglogical.com, n.d.)

Mating

Mating is the act of reproducing. Mantises and many other animals such as spiders, fish, spotted hyenas and blue whales, feature females who are are notably larger than the males.

After successfully mating with the female mantis, the male will have to escape immediately. The reason for this action is because the female will attempt to eat him to gain strength and nutrients to lay her eggs.

The female has no other reason to eat her mate other than the fact it is part of the mating ritual. (www.pbs.org, 2001).

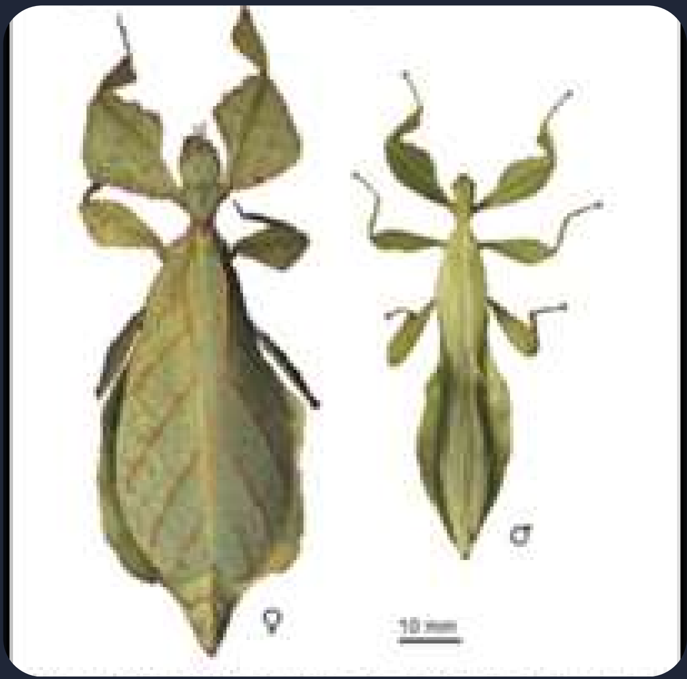

Figure 4: A Comparison of the Sizes of Female (left) and Male (right) Mantises (www.buglogical.com, n.d.)

To lay her eggs, the mantis will find a secure and hidden place that she will encase in a substance called an ootheca. The female can produce many oothecae after one mating. In a single ootheca there can be from 100 to 200 babies inside. (Cmnh.org, 2015).

Figure 5: Mantis Egg Case (ootheca) (Markopoulos, S., 2007)

Carnivorous Mantids

All species of mantises are carnivores, meaning they they feed on insects and even small mammals and reptiles. (National Geographic Kids, 2014).

Adult mantids can eat organisms as large as themselves. When young, mantises will eat various aphids, leafhoppers, mosquitos, caterpillars, and other soft skinned, slow creatures. In fact, on average, adults mantids eat 1-3 large prey per day. (www.buglogical.com, n.d.).

Despite the fact that predators of mantises are noticeably larger than the mantis itself, mantises have no fear attacking their hunters. For example, it is not uncommon for mantises to attack animals such as lizards which have tried to eat them.

Figure 6: A Praying Mantis Attacking a Lizard Mantis (Dillon, J., 2023)

Other Facts:

- Mantises are the only known insect that can rotate their heads 180 degrees. This gives them almost full 360 degree vision. (National Geographic Kids, 2014).
- Mantises have ONE ear that enables them to pick up sounds far past the range of human hearing. (www.buglogical.com, n.d.)
- The Giant Papuan Mantis *(Hierodula)* is naturally green or blue. (Britannica Kids, n.d.)

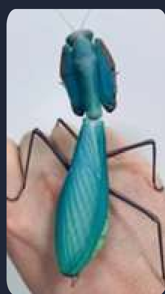

Figure 7: An Giant Papuan Mantis (www.buglogical.com, n.d.)

- When threatened, some mantises will produce a hissing noise in an act of defence. (www.buglogical.com, n.d.)

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