YOUNG SCIENTISTS' JOURNAL

Advent/ Lent 2026

Edition 20

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Editors' Note

Young Scientists' Journal

ADVENT/LENT EDITION 2026

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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 delighted to share the Advent/Lent 2026 edition of the LGS Young Scientists' Journal. This marks the 20th edition of this periodical whihc enables students to investigate scientific concepts, present research, and take part in thoughtful dialogue, reflecting their commitment and passion.

In the past two terms we have received articles discussing a wide range of topics, from devastating sports injuries to insights in the wiring of our brains. A reminder that we accept articles from all year groups, regardless of whether pupils are currently studying a STEM subject. For a chance to see your article in the next edition do not hesitate to contact us!

Cover Images:

'Tigers edge past Bath with final kick of the game'
BBC

'How music touches the brain'
By Science Nordic

Neil A. Armstrong Flight Research Center of the United States National Aeronautics and Space Administration (NASA) under Photo ID: ED97-43968-1.

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IN THIS EDITION

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Key Words:

Laceration: a torn or jagged wound caused by blunt force or sharp objects, often leading to bleeding, pain, and possible nerve or tendon damage.

Brain Damage: The Neurological Consequences of Contact Sports

By Phillip Uhegwu (Year 12)

Repeated hits to the head in sports can result in a range of brain problems, from mild injuries such as concussions, to much more serious injuries like chronic traumatic encephalopathy (CTE), brain haemorrhages, dementia, and motor neurone disease (MND). Long term brain damage refers to the "long lasting, often permanent, functional or structural impairment of brain tissue." It may occur due to injury, disease, or a lack of oxygen supply, whilst a TBI happens when an external force, like a "forceful bump, blow, or jolt to the head or body" causes a brain injury. (NHI, 2025).

Boxing

In October 2015, Puerto Rican Professional boxer, Pritchard (Digget) Colon Melendez, suffered a severe brain bleed after multiple illegal blows to the back of his head. He was a respected boxer, having been an honorary WBC world champion and a gold medallist at the 2010 Pan American Youth Championship. It was the ninth round of a 10-round fight when Colon complained to the referee about being struck with multiple rabbit punches (blows to the back of the head). He continued the fight and finish the tenth round, but in the dressing room after the match, he experienced dizziness, nausea, and slurred speech. One of Colon's friends remarked that "he had one arm around his mother; his legs are becoming really shaky, and I could not understand it. I remember him collapsing in his own throw up and at that point he was trying to hold onto consciousness." (Brooks Rehabilitation, 2022)

He was then rushed to hospital where surgeons performed an emergency hemicraniectomy to remove the blood and relieve pressure on his brain. Colon would remain in a coma for 221 days following the incident (ESPN, 2017). Unfortunately, he suffered irreversible brain damage leaving him in a vegetative state, requiring a wheelchair and constant care. Fortunately, Colon has shown promising signs of recovery in recent years, being able to breathe independently and communicate with the help of a specialised computer (Brooks Rehabilitation, 2022).

The case of Pritchard Colon shocked the boxing world, reaffirming why back-of-the-head blows are illegal in boxing due to the severe brain injuries they could cause. Colon suffered an inter-cranial bleed - a "type of stroke" that causes bleeding inside the head (Cleveland Clinic, 2023), which occurs when blood collects inside the skull, putting pressure on the brain tissue. This reduces the supply of oxygen and nutrients to the brain (Aurora health Care, 2026).

A stroke occurs when a blood clot or ruptured blood vessel blocks blood flow to the brain. Strokes can be life-threatening and require

immediate medical attention. The brain relies on blood vessels, specifically two pairs of arteries: the internal carotid and the vertebral arteries. They merge at the base of the brain, forming a structure called the "Circle of Willis." Blood is sent to the brain tissues via these cerebral arteries, providing oxygen and nutrients that fuel metabolic activity whilst removing waste products from the body.

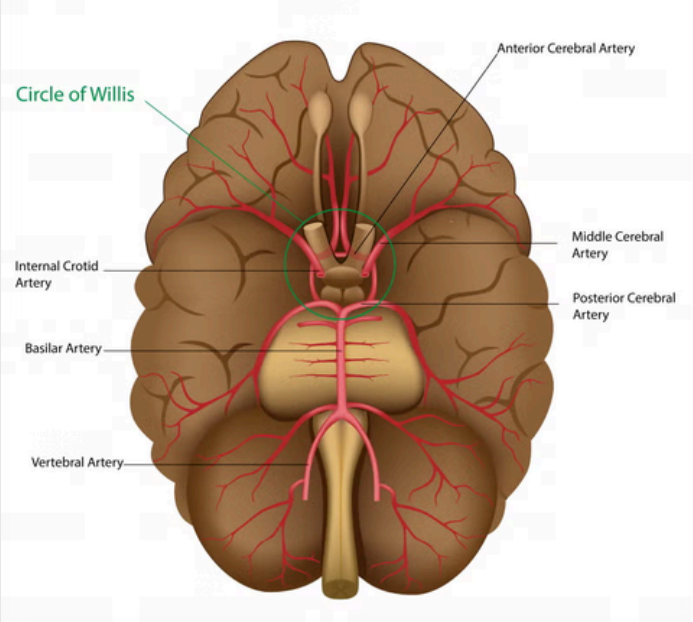

Figure 1. Blood flow through the circle of Willis (Innovation Space, n.d.).

The brain also controls all conscious and subconscious actions including heart rate, breathing, digestion, and thermoregulation. Colon specifically suffered from an acute subdural left-sided hematoma, which is a type of brain bleed that takes place when "blood collects beneath the dura matter" - which is the "outermost membrane surrounding the brain" (Cleveland Clinic, 2023). This type of bleed develops rapidly, with symptoms appearing within hours of injury. Symptoms may include severe headaches confusion, weakness, numbness on one side of the body, drowsiness, speech, comprehension problems, dizziness, nausea, vomiting, and seizures (Aurora Healthcare, 2023). This type of haemorrhage can be diagnosed by CT or MRI scans, allowing doctors to first find, then figure out the severity of the bleed, to see if surgery is needed to drain it.

Key Words:

Gastrostomy tube:
a medical device inserted directly into the stomach via the abdominal wall. It provides long-term nutrition, fluids, and medications for individuals unable to take enough by mouth.

Embolisation:
a minimally invasive, image-guided procedure that blocks abnormal blood vessels or stops active bleeding by injecting agents - such as coils, particles, or glue - via use of a catheter (a flexible tube inserted through a narrow opening into a body cavity to remove fluid)

Medications which control "blood pressure, seizures, or headaches" can be used to treat smaller subdural hematomas (Aurora healthcare, 2026), but prompt medical care is essential to prevent complications caused by larger subdural haemorrhages such as repeated bleeding and brain herniation, which could prove deadly. Doctors are making progress to prevent the need for multiple surgeries following brain bleeds. One treatment: middle meningeal artery (MMA) embolisation consists of the guiding of a "thin, flexible tube" through a blood vessel to seal off the MMA, which "feeds blood to the membrane around the hematoma" (Aurora healthcare, 2026). Studies suggest it can reduce the need of a repeat surgery or reduce the occurrence of further problems by approximately 63%.

Another treatment is Atorvastatin: a cholesterol drug that may help to shrink hematomas by reducing inflammation and supporting "vascular repair." A study suggested that taking 20mg of atorvastatin daily for 8 weeks can absorb the clot (Aurora healthcare, 2026).

Safety measures are also enforced by governing authorities in boxing to prevent serious head injuries. Headguards are mandatory for amateur boxers (aged 11-18), while heavier gloves (16-18oz rather than 8-12oz) are often used in sparring to absorb impact and reduce the risk of injury. These rules, however, are not always enforced in professional bouts.

Rugby

Alix Jon Popham is a former professional rugby player who played as a flanker for teams including Wasps and the Wales national team, earning 33 international caps. In an interview, he explained that "Jerseys and medals" are now the only reminders of major matches he has no "recollection of." He has since been diagnosed with dementia and CTE with his neurologist estimating that he had sustained over 100,000 sub-concussive hits to the head in his playing career (BBC, 2025).

CTE is a progressive brain condition thought to be linked to repeated head injuries. It can lead to dementia, but the symptoms can be managed with treatment (NHS, 2022). The brain contains specialised cells called neurones that send electrical signals responsible for thought, sensation, and movement. The neurones are joined by pathways called axons, which extend from the nucleuses of the cells, allowing the transmission of signals throughout the nervous system. Axons are structurally vulnerable and must rely on a microtubule scaffold stabilised by a protein called "tau" (Brain injury group, 2026).

Repeated head impacts, like the ones sustained during rugby careers, can damage axons by stretching, twisting, or even physically breaking them. The microtubules are especially vulnerable to such impacts (Brain injury group, 2026). As rugby is a sport where frequent unprotected collisions occur, players are especially vulnerable to repetitive head injuries. Unlike in American football, helmets are not worn, and play is continuous, so there is less time to recover between impacts (Brain injury group, 2025).

CTE symptoms are commonly grouped into four categories: Cognitive, Behavioural, Motor, and Functional. Cognitive effects may include memory loss, confusion, headaches, difficulty concentrating, and a reduced processing speed. Meanwhile, irritability, anxiety and depression are behavioural symptoms most common in people under the age of 50. Motor symptoms can include problems with co-ordination, balance, and speech. Whilst functional symptoms may affect employment, relationships, and independence, as well as causing social withdrawal. The seriousness of these effects has led to legal action being taken by over 400 former rugby players, who claim that authorities have failed to protect them from repeated head injuries (Brain injury group, 2025). In response to the need of raising awareness to such problems, Alix Popham founded the charity "head for change" to campaign further for safer protocols in the sport.

Lewis Moody is also a former professional rugby player who played for Leicester Tigers and Bath and was part of the England squad that went on to win the world cup in 2003. He was diagnosed with motor neurone disease in October 2025, a rare and fatal neurodegenerative condition that damages motor neurones in the brain and spinal cord, leading to progressive muscle weakness, and difficulties with speech, movement, breathing, or swallowing (NHS inform, 2024).

Research has suggested that professional rugby players have a higher risk of developing MND than the general population (Green, E, 2022). A study of 412 former Scottish international professional rugby players found a "two-fold increase in the risk of dementia, and a 15-fold increase for MND" when compared to 1236 members of the Scottish public.

However, because MND is not a common condition, the overall risk is low, with other factors - genetic or environmental - likely to be involved.

Although there is no current cure for MND, treatments can manage symptoms, such as the use of regular physiotherapy to help with muscle cramps and stiffness. Some medications such as quinine and baclofen have shown promise in treating muscle cramps too. Patients having trouble with communicating can receive support from speech and language therapists, whilst dysphagia (difficulty swallowing) can be treated via a surgically implanted gastrostomy tube.

Safety measures may also be enforced in rugby, such as lowering the legal tackle height to below the sternum, as well as the use of scrumcaps by all ages. However, it is worth noting that scrumcaps are not designed to prevent head injuries or concussion, but rather to protect the user against face, ear, and scalp lacerations.

Overall, the evidence clearly shows that repeated head impacts in contact sports such as boxing and rugby carry substantial risks of long-term neurological damage. The tragic cases of athletes like Pritchard Colon, Alix Popham, and Lewis Moody illustrate how even routine sub-concussive blows can accumulate into serious, life-altering conditions including intracranial haemorrhages, CTE, and MND. Scientific research continues to deepen our understanding of how these injuries develop, highlighting the structural and biochemical changes that occur in the brain because of repeated trauma. Although both sports have introduced safety measures aimed at reducing these risks, the extent and severity of the long-term consequences suggest that far more must be done to protect athletes at all levels. Ultimately, ensuring better education, updated rules, improved medical protocols, and a stronger commitment to player welfare is essential if these sports are to remain both competitive and safe for future generations.

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ADVENT/LENT 2026

What happens when we sleep?

By Avá-Mai Sandhu
(Year 10)

Key Words:

Hippocampus:
a region of the brain vital for memory, where neurons activate during learning or experiencing new things (Mackenzie, 2024)

NREM sleep:
non-rapid eye movement sleep

Sleep is something all humans must do. It is part of our evolved architecture. No-one can function properly without it. Adults tend to need between 7-9 hours of sleep per day, and children even more (Suni, 2025). We all know that once we go to bed, we close our eyes...but then what? This article explores what happens within our bodies once we fall asleep, as well as addressing why sleep is so important.

Sleep's Two 'Sub-sections'

Once you fall asleep, there are various stages of sleep you will go through. This is known as the sleep cycle. These stages are divided into two main categories: NREM, non-rapid eye movement, and REM, rapid eye movement. Each stage helps your body and brain to function. During the NREM sleep stages, the brain replays and reinforces neural connections associated with recent experiences (Biology Insights, 2025). When we first learn or do something new, neurons are activated in the hippocampus (Technology Networks, 2024).

These neurons then repeat the same pattern of activity as we sleep, known as memory consolidation (Tuhin, 2025). Both NREM and REM sleep helps us to enforce new memories, while NREM also focuses on physical repair. However, the REM sleep stage contributes to cognitive processes such as memory consolidation and emotional processing (Sleeping Institute Review Team, 2025). When in the REM sleep stage, emotional centres, such as the amygdala and prefrontal cortex, interact to "work" through emotional memories.

This is why when you wake up in the morning, you can feel more grounded (Chong, 2024). While these are the two main categories that the sleep cycle is divided into, there are 3 NREM sleep subsections, known as N1, N2 and N3, and a REM sleep stage towards the end of the sleep cycle.

The Stages of NREM Sleep

N1, the first stage of NREM sleep, is the transition from being awake to falling asleep. This is the time when some people may experience abnormal sensations, a common one being falling down into a dark abyss. The N1 stage only lasts for a few minutes (Zwarensteyn, 2024). Brain waves can be recorded when someone is asleep, they indicate what sleep stage a person is in by showing the electrical activity of the brain. The transition to from consciousness to sleep can be detected by alpha waves, showing that someone is relaxed, yet still awake. However, as you move on in N1, theta waves are also detected. These brain waves have low frequency, theta more so than alpha waves, and high amplitude patterns (University of Central Florida, n.d.).

Once you have entered the second NREM sleep stage, N2, your body temperature will drop, and your breathing and heart rate will decrease and become more regular. This stage lasts for about half the time you are asleep (Holland, 2024).

Brain waves recorded in this sleep stage are now dominantly theta, though these are now briefly interrupted by bursts of activity, known as sleep spindles (University of Central Florida, n.d.).

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The REM Sleep Stage

The REM sleep stage is the stage of dreams. When you are dreaming, voluntary muscles are found to be temporarily paralyzed, so that you do not physically act out your dreams. Breathing also becomes faster and irregular; heart rate and blood pressure increase to levels comparative to those whilst awake (Sleeping Institute Review Team, 2025). Brain waves recorded are also similar to those recorded when a person is conscious (University of Central Florida, n.d.). This is when information is moved from a temporary memory store, to a permanent memory store.

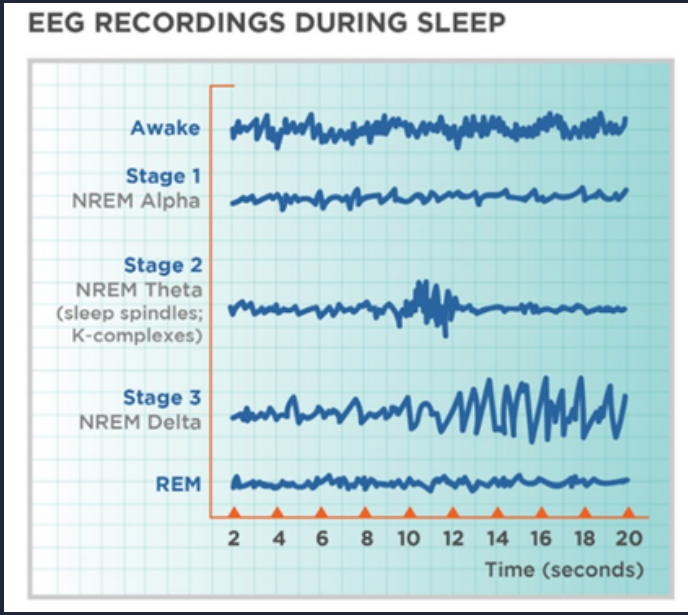

Figure 1. Brain waves recorded in different sleep stages and when awake (University of Central Florida, n.d.).

What Happens with a Lack of Sleep?

A lack of sleep can cause serious problems, including depression, anxiety, and bipolar disorder (Chong, 2024). This correlation between a lack of sleep and said disorders indicate how insubstantial sleep may have detrimental effects on mental health. Depression is caused by a lack of REM and NREM sleep, which helps to regulate emotions. Anxiety symptoms are often heightened by chronic sleep deprivation, and bipolar disorder can be connected to irregular sleep cycles (Chong, 2024). A complete lack of sleep has even worse effects. Once a person has not slept for 24 hours, they become irritable, and decision-making skills and concentration begin to wane (Weekly Recess, 2025). After 48-72 hours without sleep, people may experience hallucinations, a distorted perception of reality and may become paranoid (Weekly Recess, 2025).

Sleep as a Torture Method!

Sleep is so important to the human body, that it has even been used as an effective torture technique. During the 16th century, the importance of sleep was beginning to become very well known. During the 'Witch Trials', those accused of witchcraft were often deprived of sleep for many days, in order to induce hallucinations and feelings of being disoriented. This led to many genuinely believing that they were guilty, and confessing to the false accusations (Weekly Recess, 2025). Japanese war camps in WWII had cruel schedules, designed to break the wills of war prisoners, by combining sleep deprivation with starvation and beatings (Weekly Recess, 2025). The European Court of Human Rights has now declared that sleep deprivation, when applied severely or systematically, is a form of torture, violating human dignity. (Weekly Recess, 2025)

Key Words:

REM sleep:
rapid eye movement sleep

Sleep cycle:
sleep is composed of several different stages, with deeper NREM sleep occurs early on in the night, while the duration of REM sleep increases as the night progresses (University of Central Florida, n.d.), and is often repeated on ~90-minute cycles.

Notorious Investigations Of Sleep

Before Eugene Askerinsky and Nathanial Kleitman (American scientists) discovered REM sleep in 1953, many believed sleep to be a passive, coma-like state. However, this extraordinary discovery was an unexpected observation: in the early 1950s, Kleitman told his graduate student Askerinsky to observe infants falling asleep, in order to study correlations between different behaviours and falling asleep. He noticed that some infants moved their eyes substantially when asleep and, wanting to see whether this was unique to infants, he did an experiment with his 8-year-old son, measuring his eye movement as he slept. Aserinsky found that he had observed the same eye movements in the infants, as well as his 8-year-old son (Liu, 2024).

Kleitman also figured out that sleep is divided into different stages which cycle, and each cycle lasts around 90 minutes. These cycles consist of both REM and NREM sleep stages. Kleitman was able to find out that sleep is an active process with complex brain activity, rather than a passive state. He also discovered ultradian rhythms, biological cycles which mostly last for less than 24 hours. These rhythms are known to be what effects the duration and timing of sleep stages, and by aligning your sleep with these rhythms, you can increase the quality of your sleep (Unplugged Psych, 2025)

In 1964, 17-year-old high school student Randy Gardner attempted to stay awake for 11 days straight, this experiment unknowingly yielding amazing discoveries. Beginning as his high school science fair project, Gardner voluntarily subjected himself to 264 consecutive hours with no sleep, and experienced a wide range of physical and cognitive effects. As the experiment went on his speech became slurred, he found difficulty in remembering a recent event and showed signs of mental fatigue. Physically, Garnder's appetite changed, and his sense of smell and taste grew worse. Sometimes he even reported to feeling cold when in a warm environment. By the fourth day Gardner had auditory and visual hallucinations. In the end, his experiment helped to demonstrate how important sleep is for the human body, and the physical and mental effects sleep deprivation can have on a person. (Neurolaunch, 2024)

Conclusion

Ultimately, it is evident that sleep is an essential requirement, for various reasons, the main being to aid your immune system, to grow, and to help with memory and emotional processing. If you do not sleep enough, there can be severe effects, such as mental health disorders and even hallucination, so always make sure to get plenty of sleep every night! Sweet Dreams.

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ADVENT/LENT 2026

Wired for sound: The Neuroscience of the Musical Mind

By Lucía Powell (Year 12)

Key Words:

Dopaminergic system:
a network of neurons in the brain that produce, release and respond to the neurotransmitter dopamine

Caudate nucleus:
region of the brain that is involved in habit learning and prediction

Nucleus accumbens:
brain region central to motivation, reward and pleasure

Neuroplasticity:
the brain's ability to reorganise itself in response to experience and learning something new

From the oldest known instrument of the Old Stone Age, the bone flute, to intricate, modern-day digital compositions, music has remained the universal constant within human civilisation. Often characterised as 'purely cultural' or a 'creative endeavour', modern advancements in neuroimaging have revealed that music is a profound biological phenomenon. When we listen to or create music, the brain does not just 'hear' sound; it engages a sophisticated, multi-system workout that incorporates both hemispheres and thedeep subcortical structures (Collins A., 2013). As researchers uncover the neural pathways responsible for processing rhythm, melody, and harmony, it becomes evident that music is deeply embedded in the evolved architecture of the human brain. This essay explores the neurobiology of music, exploring how it triggers the brain's reward systems, eases structural neuroplasticity, and serves as a powerful therapeutic tool for cognitive and physical rehabilitation.

The 'Chills' Study: Dopamine and Reward

The emotional impact of listening to music is primarily rooted in the brain's reward circuit, specifically the **dopaminergic** system. Unlike stimuli such as food, which provide many biological advantages, music is an abstract stimulus that nonetheless triggers the same 'happy' neurotransmitters. According to a study conducted by Valore N Salimpoor et al. in 2011, the brain's response to music occurs in two distinct phases: the **anticipatory** stage and the **peak-emotiona**l stage. During the anticipatory phase, the c**audate nucleus** (brain regioninvolved in habit learning and prediction) releases the neurotransmitter **dopamine** as the listener expects a musical resolution. When the 'climax' of the music finally occurs, the **nucleus accumbens** (brain region central to motivation, reward, and pleasure) releases a surge of dopamine, often resulting in the physical sensation of 'chills' or 'goosebumps'. This reveals that the brain reacts to a perfectly timed melody as not only entertainment, but as a significant neurological reward, reinforcing our underlying urge to seek out and create complex auditory patterns ourselves.

The Musician's Brain: Strucutural Plasticity

Because music requires the simultaneous processing of pitch, timing, and motor coordination, it acts as one of the most powerful drivers of **neuroplasticity**- the brain's ability to reorganise itself in response to experience and learning something new. The nervous system can change its activity in response to intrinsic or

extrinsic, as in this case, stimuli by reorganising its structure and neural connections (Puderbaugh and Emmandy, 2023). This structural adaptation is most evident when comparing the brains of musicians to those of non-musicians. Research by Christian Gaser and Gottfried Schlaug in 2003 revealed that individuals with long-term musical training often possess a significantly larger corpus callosum, the bundle of nerve fibres that facilitates communication between the left and right cerebral hemispheres. This increased connectivity is likely a result of the intense coordination required to translate sheet music into fine, bimanual motor movements. Furthermore, the auditory cortex in the brains of musicians often shows increased grey matter density, allowing for a more refined 'tuning' to frequencies and timbres. These evident changes suggest that the brain is not just a 'static' organ, but a dynamic system that physically expands its processing capacity to meet the demands of musical performance. These changes in structure are most profound if training begins before the age of seven, as the young brain is extremely flexible and adaptable, though the brain does remain plastic throughout adulthood (Harvard University, 2024).

The Shared Syntax of Music and Language

Beyond its emotional and structural impacts, music shares a profound neurological relationship with human language. Both systems rely on 'syntax', a set of rules for organising elements, such as words or notes, into meaningful sentences. Neuroimaging studies have shown that the brain processes musical disharmony, for example dissonant chords, in the same regions used to detect grammatical errors, specifically Broca's area in the left hemisphere – the region crucial for speech production and language processing. This overlap suggests that musical training can enhance linguistic abilities, such as phonological awareness and reading fluency. Moreover, the 'OFC' (Overlap, Sharing, Enhancement) hypothesis suggests that because music and speech share these neural resources, the brain's ability to process the modulations of pitch in a melody directly translates to a better understanding of tone and emotion in human speech. This connection reinforces the idea that music is not a separate 'artistic' module of the brain but is fundamentally woven into the very circuits that allow us to communicate (Patel, A. D., 2003).

Key Words:

Corpus callosum:
bundle of nerve fibres that facilitates communication between the left and right hemispheres

Auditory cortex :
region of the cerebral cortex responsible for processing sound information including pitch, volume, rhythm and speech

Bronca's area:
region in the left hemisphere crucial for speech production and language processing

Ventromedial prefrontal cortex:
area in the brain often spared by the first stages of dementia

Music as Medicine: Rhythmic Auditory Stimulus (RAS)

The intersection of music and neuroscience is perhaps most impactful in the field of clinical rehabilitation, where music is used to bypass damaged neural pathways. For patients recovering from a stroke, Neurologic Music Therapy (NMT) uses the brain's natural synchronisation with rhythm, a process known as entrainment (for example, people subconsciously synchronise tapping their feet whilst listening to a catchy tune). Research led by G C McIntosh and S H Brown in 1997 demonstrated that rhythmic auditory stimulation can significantly improve gait and motor control by providing an external 'metronome'; something that the motor cortex can use to stabilise movement. The study found that stroke patients who struggled to walk were able to improve their stride and speed by walking

to a steady rhythmic beat (a 50ms square wave tone embedded in instrumental music from the Renaissance period).

Beyond physical recovery, music serves as a strong anchor for those with neurodegenerative diseases like Alzheimer's. Musical memories are often stored in the ventromedial prefrontal cortex – an area often spared by the first stages of dementia. Patients who have lost the ability to speak may still be able to perfectly recall lyrics and melodies (Cuddy and Duffin, 2005). This reveals how music is not merely a hobby, but a vital mental base that can sustain human connection and function, when traditional medical treatments reach their limits.

To conclude, the relationship between music and the brain is a far more than simple interaction between listener and sound; it has a deeper biological meaning that shapes the architecture of the human mind. From the immediate dopaminergic rewards, processed in the nucleus accumbens, to the longer-term structural changes to the corpus callosum, music acts as a powerful stimulus that engages multiple cognitive systems. Music bridges the gaps between emotion, motor control, and language, providing a resilient framework for not only developmental growth, but also in a clinical context, such as rehabilitation. Advancements in neuroscience continue to map these intricate pathways, and it becomes increasingly clear that our aged affinity for melody is not a cultural accident, but a central feature of human evolution. Music is not something just to listen to – it is a fundamental lens through which the brain interprets, organises, and heals itself.

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Key Words:

Prebiotic:
a substance, usually fibre, that feeds beneficial bacteria in the gut.

Atherosclerosis:
the build-up of fatty material inside arteries, which can reduce blood flow.

ADVENT/LENT 2026

Does an Apple a Day Really Keep the Doctor Away?

By Bilal Khatri (Year 12)

The proverb "An apple a day keeps the doctor away" suggests that regular apple consumption prevents illness. While evidently exaggerated, modern research carried out by nutritional scientists provides compelling evidence that apples can contribute to disease prevention. However, no single food can completely eliminate the need for medical care. This essay argues that the statement is directionally true, in a preventative sense, but overstated when interpreted literally.

Apples are low in calories but are nutritionally dense. A medium apple provides around 4 grams of fibre, in particular soluble fibre (pectin), alongside vitamin C, potassium, and polyphenols, such as quercetin and chlorogenic acid (USDA, 2023). These components contribute to several physiological benefits, and are shown to majorly boost cardiovascular and metabolic health.

Apples also support metabolic health. Observational research indicates that whole fruit consumption correlates to lowering the risk of type-2 diabetes (Muraki et al., 2013). Fibre slows down the rate of glucose absorption, improving glycemic control and insulin sensitivity.

Importantly, these benefits apply to whole fruit rather than fruit juice, which lacks fibre and can cause rapid blood sugar spikes. This distinction highlights that it is the structure of the whole apple, not simply its sugar content, that provides the benefit.

Furthermore, gut health is also positively influenced by frequent apple consumption. Apple pectin acts as a prebiotic, stimulating many beneficial gut bacteria which aid in digestion, immune system regulation, nutrient production and protection against pathogens (Koutsos et al., 2015). Fermentation of fibre produces short-chain fatty acids, which support immune function and reduce inflammation. As chronic inflammation underlies many non-communicable diseases, it strengthens the idea that apples contribute to long term health.

There limited evidence suggesting protective effects against certain cancers, particularly colorectal cancer, due to fibre increasing stool bulk and reducing exposure to carcinogens (Boyer and Liu, 2004). However, most cancer research is observational, therefore cannot prove

direct causation. People who eat apples regularly may also engage in other healthy behaviours, such as exercising and avoiding smoking. This confounding makes it difficult to attribute reduced disease risk to apples alone.

Despite these benefits, the proverb becomes inaccurate when taken literally. A cross-sectional study investigating healthcare usage found that daily apple eaters were not significantly less likely to visit a doctor after adjusting for lifestyle factors (Davis et al., 2015). While apple eaters were found to have slightly lower prescripted medication use, the difference in doctor visits was statistically insignificant. This demonstrates that health outcomes depend on multiple factors, including genetics, environmental factors, and the overall dietary pattern of an individual.

Furthermore, focusing on a single food risks nutritional reductionism. Disease prevention is associated with overall healthy dietary patterns, for example, leading a diet rich in fruits, vegetables, whole grains, and healthy fats, such as olive oil. Apples contribute to this pattern, but cannot compensate for a poor diet or an unhealthy lifestyle. The proverb simplifies a complex reality.

It is also important to consider the contextual factor. Apples are affordable, accessible and easy to incorporate into daily life. Public health messaging often relies on simple, memorable phrases to encourage behaviour change. In this sense, the saying functions as more a 'motivational guidance' than scientific claim. Encouraging daily fruit consumption aligns with NHS recommendations of at least five portions of fruit and vegetables per day.

In conclusion, the statement "An apple a day keeps the doctor away" is proven to be partially true, but exaggerated. Apples contain fibre, antioxidants and bioactive compounds that support cardiovascular, metabolic and gut health.

Epidemiological evidence links fruit intake with lower chronic disease risk. However, apples alone do not eliminate the need for medical care, and health outcomes are influenced by broader lifestyle and socioeconomic factors. The proverb captures an important preventative principle, but it should be understood metaphorically, rather than literally.

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ADVENT/LENT 2026

Engineering the Hypersonic Regime: How Flight Changes Above Mach 5

By Preston Gakuya (Year 11)

Introduction

Mach 5, defined as five times the speed of sound, marks the transition into the hypersonic regime. Above this threshold, flight is no longer governed by the assumptions that underpin conventional aerodynamics (Anderson, 2006). Air behaves less like an invisible, passive fluid and more like a reactive medium, undergoing extreme compression, rapid heating and, at higher velocities, chemical change. These effects make hypersonic flight one of the most demanding challenges in modern aerospace engineering, with implications for defence systems, space access and future high-speed transport.

Compressible Flow Physics

At hypersonic velocities, airflow becomes strongly compressible. Density variations dominate the flow field, producing highly non-linear relationships between pressure, temperature and velocity. Shock layers form extremely close to the vehicle surface and merge with thickened boundary layers to create a viscous shock layer. Under these conditions, real-gas effects such as molecular dissociation and ionisation begin to appear, invalidating many classical aerodynamic assumptions and necessitating advanced numerical modelling (Anderson, 2006). As a result, simplified analytical approaches are replaced by computational fluid dynamics and high-enthalpy wind tunnel testing.

Shockwaves

Shockwaves are a defining feature of hypersonic flight. Normal shocks, which form perpendicular to the airflow, generate abrupt increases in pressure and temperature and are therefore highly undesirable on vehicle surfaces. Oblique shocks, produced by angled geometries, are less severe but still contribute significantly to heating and drag. Particularly problematic are shock-boundary layer interactions, which can trigger flow separation and intense localised heating. To mitigate these effects, many hypersonic vehicles adopt blunt leading edges, creating a detached shockwave that keeps the hottest air away from the structure, a strategy long employed in atmospheric re-entry systems (NASA, 2007).

Aerodynamic Heating

Thermal effects dominate the hypersonic regime. As airflow decelerates at stagnation points, kinetic energy is converted directly into heat, producing temperatures exceeding 1,000°C even

at Mach 5 (Anderson, 2006). Additional heating arises from viscous friction within the boundary layer, while at higher velocities radiative heating becomes increasingly significant. Conventional aerospace materials rapidly lose strength or melt under these conditions, meaning thermal management is not a secondary consideration but a primary design constraint.

Materials Engineering

Surviving hypersonic flight requires materials capable of withstanding extreme temperatures and severe thermal gradients. Ablative materials are commonly used in re-entry vehicles, intentionally eroding to carry heat away from the structure. Reinforced carbon-carbon, famously employed on the Space Shuttle's leading edges, offers excellent thermal resistance but is costly and structurally fragile. More recently, ceramic matrix composites and ultra-high-temperature ceramics such as hafnium diboride and zirconium diboride have attracted attention for their ability to withstand temperatures exceeding 3,000°C. In many designs, these materials are integrated into layered thermal protection systems, sometimes supplemented by active cooling techniques.

Propulsion in the Hypersonic Regime

Propulsion presents one of the greatest barriers to sustained hypersonic flight. Turbojet and turbofan engines are incapable of operating at the extreme inlet temperatures encountered above Mach 3. Ramjets eliminate rotating machinery but rely on subsonic combustion, limiting their effectiveness beyond approximately Mach 5. Scramjets, or supersonic combustion ramjets, overcome this limitation by allowing combustion to occur in supersonic airflow. Experimental vehicles such as NASA's X-43A and and the United States Air Force's X-51A have demonstrated scramjet-powered flight beyond Mach 5, although challenges in ignition, stability and efficiency remain unresolved (NASA, 2025; United States Air Force, 2013).

Stability and Control

Maintaining stable flight at hypersonic speeds is exceptionally challenging. The centre of pressure can shift rapidly with changes in speed and altitude, producing destabilising moments. Traditional control surfaces lose effectiveness due to shock interference and reduced atmospheric density at high altitudes. To compensate, many hypersonic vehicles rely on reaction control systems using small thrusters, particularly during near-space or exo-atmospheric flight. These systems are integrated with advanced flight-control algorithms capable of responding to rapidly changing aerodynamic conditions.

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Key Words:

Quadricep:
a muscle at the front of the thigh, helping extension at the knee and flexion at the hip.

Tibial tuberosity:
the bump you feel just below your kneecap

Avulsion fractures:
twhere small pieces of bones are pulled away by the patella fragment

ADVENT/LENT 2026

The Physical Cost of Competition: Trends in Lower Limb and Ligament Injuries

By Adhidev Ghosh (Year 12)

Sport continues to act as a dominant force in the world, providing entertainment and thrills to households worldwide. The globalisation of sport has helped influence hundreds of millions to become fit and healthy whilst socialising.

As a performer develops, more training is required, which can be rigorous at times, especially if there is little chance of making it to the next level. At a young age, this is as a problem, because this puts stress on the body whilst growth is still occurring. For example, Osgood-Schlatter's disease is a common cause of knee pain in adolescents, due to constant running and continuous usage of the quadricep. The quadricep muscle inserts into the patella, which transmits force into the tibial tuberosity (YouTube, n.d.-a). People with Osgood-Schlatter's disease experience minor avulsion fractures, where small pieces of bones are pulled away by the patella ligament. Due to the space created after the small bone breakage, the tibial tuberosity grows, resulting in a lump just under the knee. Swelling may also occur (Bradford Teaching Hospitals NHS Foundation Trust, 2025).

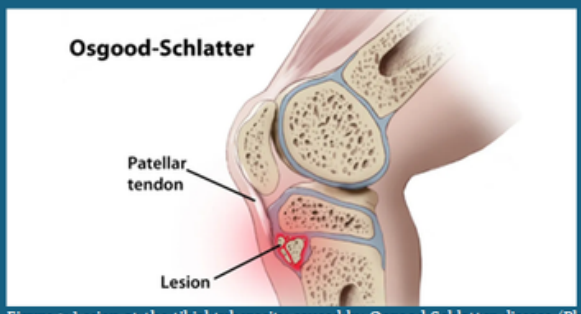

Figure 1: Lesion at the tibial tuberosity caused by Osgood-Schlatter disease (Physis, n.d.)

It is widely known that professional athletes – especially footballers – must adhere to compact fixture schedules, with the inclusion of more competitions and changes to events, such as the reinvention of the FIFA Club World Cup, and the introduction of a League Phase in the already-existing UEFA Champions League. As expected, this requires players to train and play more often, with less recovery time for muscles. As a result, more soft tissue injuries occur. For example, out of all the injuries suffered in the Premier League from the last twenty years, the proportion of hamstring injuries has doubled. The high intensity of the Premier League places a higher workload on the hamstrings, accumulating fatigue. In particular, the muscles in the hamstring are the most injury prone due to how they control acceleration and deceleration while running. Hamstring injuries occur when the muscle fibres are stretched beyond their limit or overworked. The two main types of injuries are proximal and distal (YouTube, n.d.-b), with the former being

Key Words:

ACL (anterior cruciate ligament:
a ligment which stabilises the knee joint

close to the hip and the latter being closer to the kneecap. Hamstring tears are most common in the proximal zone where the muscle meets the tendon (musculotendinous junction). They are classified into three grades. Grade 1, the least serious grade, consists of mild pain or swelling. Grade 2 includes a minor tear, leading to a loss of function. Finally, Grade 3, the most serious grade, involves a complete tear with severe pain and swelling.

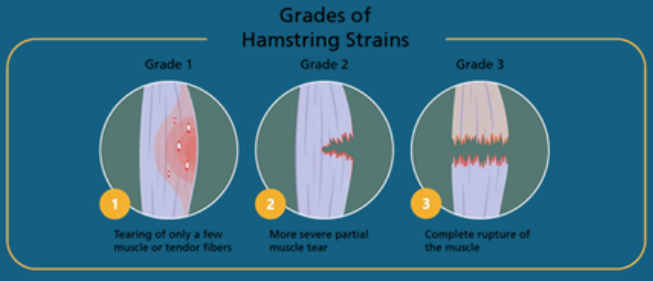

Figure 2: Illustration of hamstring injury treatment using the R.I.C.E. method (Sterosport, n.d.).

Perhaps the most troublesome and challenging injury an athlete may face is an anterior cruciate ligament (ACL) injury, due to its strenuous and lengthy rehabilitation process. This injury is common in sports with a sudden change in direction, such as basketball. In Australia, the number of ACL reconstructions carried out by surgeons has risen by more than forty-three percent (Zbrojkiewicz, D., Vertullo, C. and Grayson, J. E., 2018).

ACL injuries occur due to sudden changes in direction during movement. They are highly common in sports such as basketball and hockey, which involve random changes in both speed and direction, as performers 'cannot predictably plant their foot'. Again, ACL injuries are categorised into three grades, with Grade 1 being the least severe, as the ACL is overstretched a little, but not torn. Grade 2 involves a partial tear, hence the knee could feel unstable and give way. Grade 3, the most severe, involves a complete rupture. Surgery is often required in this case.

Interestingly, women are two to eight times more likely to suffer an ACL injury than men. The reason for this is yet to be discovered, but there are some theories as to why this is. For example, it is scientifically proven that women are more flexible than boys, and as a result are more likely to carry out hypermobility (where joints can carry out an unusual amount of movement). Alternatively, there are points in the menstrual cycle where women find themselves more injury-prone to men, due to fluctuating levels of different hormones, which can have the effect of temporarily weakening muscles (OneWelbeck n.d.) For instance, peak oestrogen results in high ligament laxity, increasing the likelihood of an ACL tear.

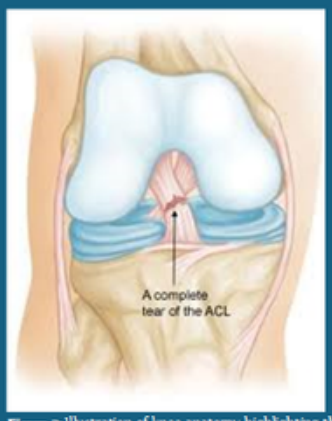

Figure 3: Illustration of knee anatomy highlighting the anterior cruciate ligament (AAOS, n.d.).

Despite sport being able to provide physical, global and social benefits, the increasing demands put athletes in a more vulnerable position. Even at a young age, it is possible to become injured through natural growth, via diseases such as Osgood-Schlatter's, whilst there has been a rise in soft tissue injuries amongst some of the world's most famous athletes. Anterior-cruciate ligaments also continue to hinder progress, in the men's game as well as the women's. Appropriate recovery and injury-prevention strategies are essential to protect

athletes and maintain participation.

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ADEVENT/LENT 2026

Impacts of stress: Why are young people getting grey hair?

Jaia Ramji (Year 10)

Key Words:

Norepinephrine: As a neurotransmitter, it's a chemical messenger that helps transmit nerve signals across nerve endings to another nerve cell, muscle cell or gland cell. As a hormone, it's released by your adrenal glands, which are hat-shaped glands that sit on top of each kidney.

Melanocyte stem cells: Specialized melanin producing cells, and are responsible for skin, hair, and eye pigmentation in vertebrate organisms.

Why are so many more young people getting grey hair? Shouldn't this be a problem linked with aging, or can other factors contribute to the grey hue?

It is often believed that grey hair is a common sign of aging and, although it is, seeing it in younger generations can raise concerns, leaving many confused. However, research has shown that high levels of stress can affect young people, causing them to slowly lose their natural hair colour.

Teenagers have been reported to have higher levels of stress, anxiety and depression than all other age groups. These results have shown to be consistent with other surveys too. At least 40-60% of college students were shown to have significant mental health issues, and an analysis (by Jean Twenge) has shown that teenagers from 2005 and 2017, have experienced a significant rise in mental distress and depression, further causing an increase in suicide rates amongst young teens. (APA survey, 2018)

So how is this affecting their hair?

Researchers have linked this problem to the sympathetic nervous system (the system responsible for the body's fight or flight response). These sympathetic nerves branch out to each hair follicle, and stress can cause these nerves to release a chemical, norepinephrine. In healthy hair, stem cells that live in the base of the hair strand produce the pigment, melanin.

These stem cells produce pigments, which give the hair it's colour. As we age, these stem cells gradually disappear. However, when acted on by norepinephrine, they can act excessively, depleting the store of pigment producing cells too early. This results in a loss of colour in the hair, irreversibly turning it into a streak of grey. (The Harvard Gazette, 2020).

Researchers initially suspected either the immune system or the stress hormone cortisol as the cause, but experiments ruled both out. This led to the discovery that norepinephrine might be responsible - yet the finding came with a puzzle: while the adrenal glands produce norepinephrine, mice that had their adrenal glands surgically removed still experienced greying caused by stress. The research team, led by Dr. Ya-Chieh Hsu of Harvard University, used mice to examine stress and hair greying. The mice were exposed to three types of stress involving mild, short-term pain, psychological stress, and restricted movement. All caused noticeable loss of melanocyte stem cells and hair greying. This suggests that norepinephrine is also produced from the sympathetic nerve system, resulting in the change of hair colour. (Chemical & Engineering News, 2020)

This issue is not uncommon; it has happened to many well-known people. Marie Antoinette hair has been rumoured to have turned white overnight, whilst awaiting her execution during the French revolution, and Sen. John McCain, a Navy pilot during the Vietnam war, lost the colour in his hair when he was suffering multiple serious injuries and beatings in North Vietnam, as a prisoner of war. These examples can be linked to high levels of stress affecting the stem cells in the hair follicle, causing these wonders. (The Harvard Gazette, 2020)

In summary, the evidence proves that there is a connection between elevated stress levels in young people and the premature appearance of grey hair. Stress triggers norepinephrine that affects pigment-producing cells, accelerating hair greying even at an early age. Understanding this link not only highlights how emotional well-being influences physical health but also emphasizes the importance of supportive environments for children. By addressing stress early, we can help protect both their mental health and natural development and can overall improve confidence with their appearance.

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