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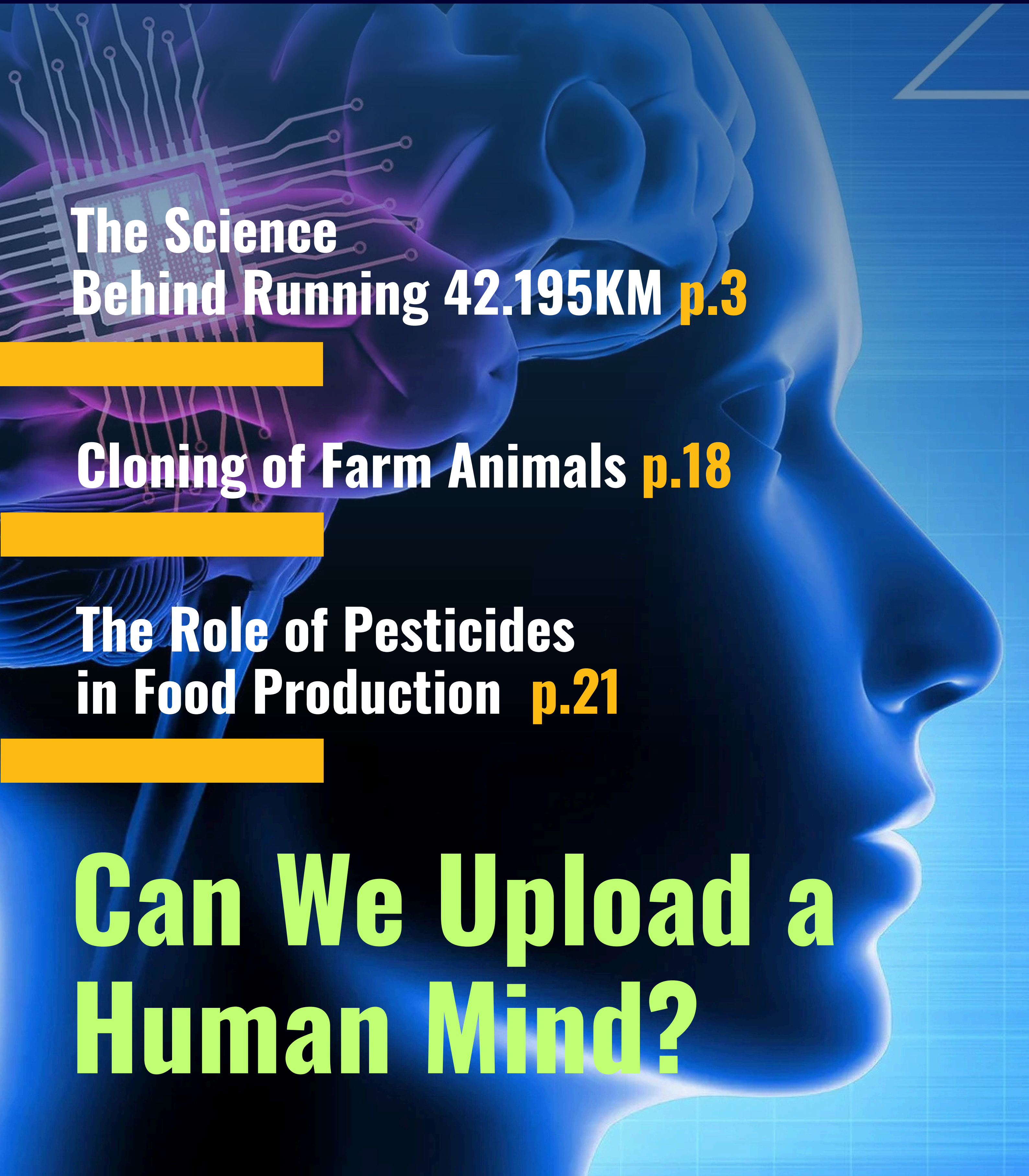
DragonScience

Edited by Yolcy Zhang, Claire Sun, Yolco Mao (G12), Rhema Hong, Tonya Liu (G11)



Can We Upload a Human Mind?

CONTENTS

The Science Behind Running 42.195KM

Akira Sugata Social Studies Teacher

Despite having been a runner for most of my student life, I had never run a marathon before. Forty-two point one ninety-five kilometers- that's the equivalent of running around the HIS campus about 42 consecutive times or, even worse, running around the HIS field 140.5 times. Challenging myself to run a marathon was something that my middle school and high school selves could have never imagined doing. I was always comfortable running a 5km race or maybe even a 10km. Last year, I stretched myself to run a half-marathon, and being luckily accepted into the Hangzhou Marathon this year felt, in a weird sense, like my calling to run the full one.

What I didn't know about running marathons was how much science and research were involved. One of the few topics I delved into while digging my hole of insanity during training was the fueling process with carbohydrates.

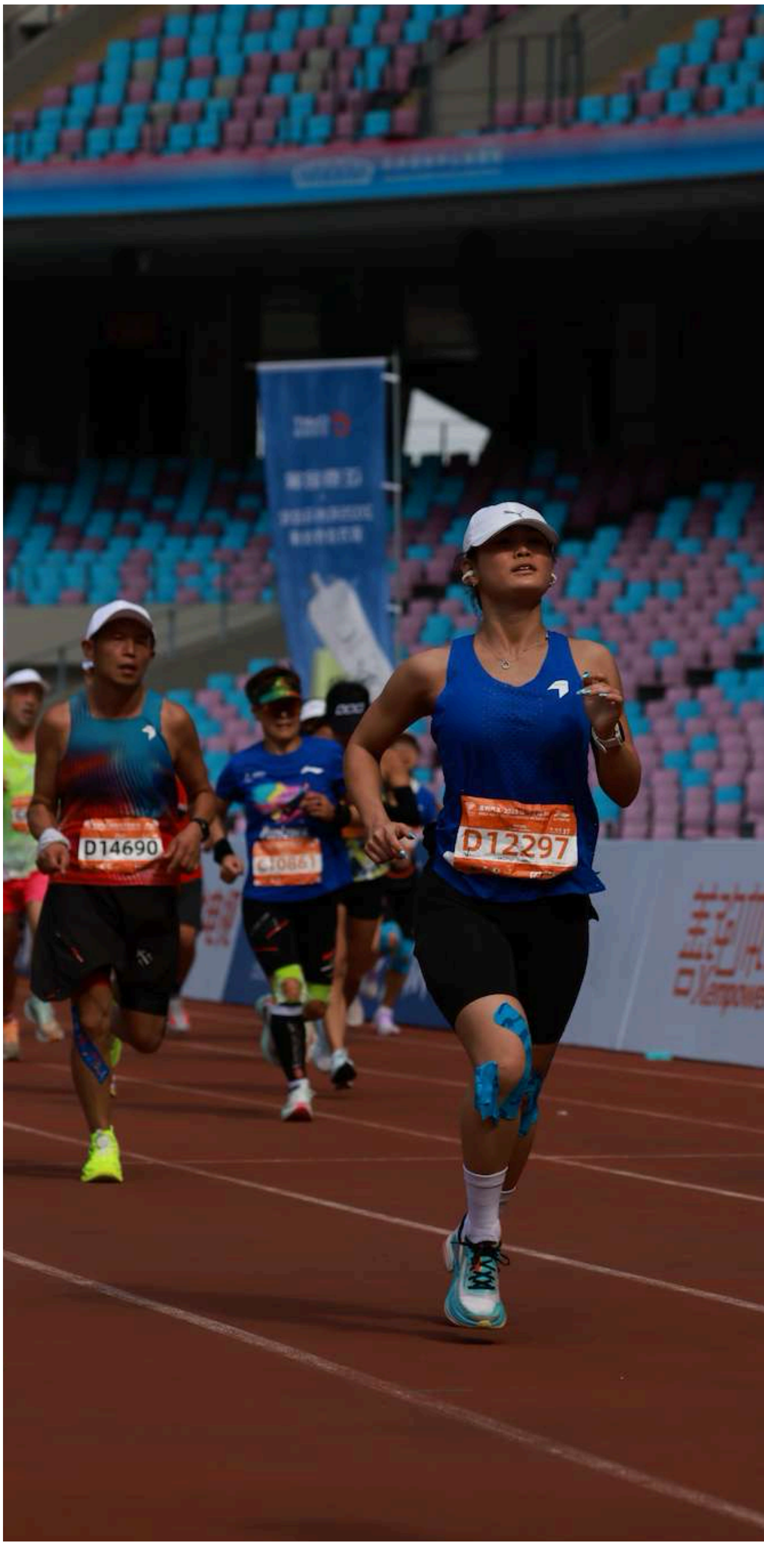
Whenever we eat carbohydrates- foods such as rice, bread, or pasta- our bodies store a macronutrient called glycogen in our muscles. During exercise, this is converted into a form of energy called glucose (Cleveland Clinic). When our body's glycogen storage runs out, we start to utilize fat, which is less efficient than using glycogen, thus making us slower during long-distance races like a marathon (Cleveland Clinic).

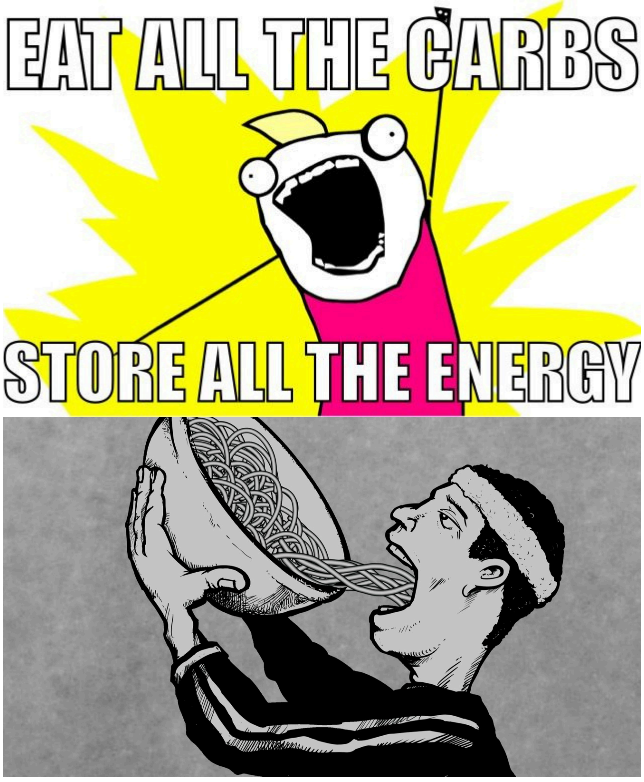
During a long-form exercise such as long distance running, our body will obviously use up the glycogen storage and start to use fat far quicker than any other form of exercise. This introduced me to a new concept: eating during a race. Fueling during a race was strange. Throughout my life as an athlete, it was always *"never eat during a race!" "You'll get stitches if you eat too much!"* Because of this, I was always a bit nervous about consuming food during a race, thinking it would inevitably make me slower. But under-fueling during practices and feeling like I could collapse after running more than 23 kilometers during my long-runs was definite proof, that my body was desperately asking me to fuel and eat more.

What I consumed during my runs were little sachets of gooey gels called energy gels. Each sachet contained glucose and fructose, two essential carbohydrates to fuel the body, allowing me to continue running my marathon at a fast pace. One sachet of gel contained about 25 grams of glucose, which helped me maintain pace for 60-90 minutes (Wilson). However, after a mere hour and a half, I would start to feel a lack of energy and would slow down (Wilson). That could not happen

It all came down to this: Throughout the 3-4 hour timespan I was to complete my marathon, I needed to consume enough gels to ensure my glucose storage did not deplete and was constantly full or almost full to avoid impacting my performance. This led me to create a gel consumption schedule as follows:

Time	Distance	Gel Consumed
BEFORE RACE	0	1
20 minutes	4 km	2
50 minutes	10 km	3
80 minutes	15 km	4
110 minutes	20 km	5
140 minutes	25 km	6
170 minutes	30 km	7
200 minutes	35 km	8
230 minutes	39 km	9





Eating 9 packets of essentially just liquid sugar made me feel a bit like I had lost my mind, having left it somewhere between all the training I was doing at home and at the school gym. On top of this, to prepare my glycogen storage for race day, I participated in what runners call a "carbo load," or in other words, three consecutive days of eating so many carbohydrates that I never wanted to look at a bowl of pasta again.On a regular day, our bodies store about 19 grams of glycogen in our muscles, which gets used up as we move around. By carbo loading, this increased my body's glycogen storage to about 35-40 grams, making it perfectly ready for race day (HKSI). During these three days, I tried to consume about 9-10 grams of carbohydrates per kilogram of my body weight per day (HKSI). So, carbo-load I did. My diet before the race consisted of unseasoned pasta, lots of white bread and so so so many pretzels. It made me feel unsteady, bloated and heavy and I remember standing at the start line wondering if I had even done the right thing.

Having ran the marathon now, I can tell you that all this research prepared me well, as on race day, despite the horrible AQI and unexpectedly high temperatures, I ran a 3-hour 40-minute marathon with an average pace of 5 minutes and 14 seconds per kilometer. Although I did not achieve the 3-hour 30-minute pace that I was hoping for, my fueling strategies and carbo loading carried me through the 42.195 kilometers. Perhaps next time (if there even is a next time), with more experience and knowledge, I will be able to run a faster time!

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How do Rockets Work?

William C G9 Student

From launching satellites to sending astronauts to the Moon, rockets are how humans get to space. Unlike airplanes that need air to work, rockets can work even where there's no air, like in space. But how do they push heavy loads up against gravity? How do they get things to space? By using powerful fuel and breaking into parts during flight, rockets are built to overcome Earth's gravity. Let's look at the basics of these huge machines, exploring how they work, why they look the way they do, and how they help us explore space.

How do rockets move?

Newton's Third Law states that for every action, there is an equal and opposite reaction. In rockets, this means burning fuel to create high-pressure gas (the"action") generates a backward-facing force that pushes the rocket forward (the"reaction"). This force is called thrust. (Wikipedia Contributors,1-3)

Momentum conservation further explains this; the rocket's total momentum (mass × velocity) must remain constant. As the rocket expels mass (hot gas) at high speed backward, the remaining mass of the rocket accelerates forward to balance the equation . The efficiency of this process is measured by specific impulse, the thrust produced per unit of propellant consumed per second. Higher specific impulse means more efficient fuel use.(Physicsclassroom, 1-3) (Hall, 1-2)

The main parts that build up a rocket:

Payload: The "Cargo" of the Rocket

-The payload is the reason for the launch—it can be a satellite, a spacecraft (like Crew Dragon), a rover (e.g., Perseverance), or scientific instruments.

-To protect the payload during ascent, it's encased in a payload fairing—a cone-shaped shell made of lightweight, heat-resistant materials (like carbon fiber composites). The fairing shields the payload from aerodynamic pressure, friction heat (up to 1,200°C during atmospheric flight), and debris . (Hall, 1-2)

Propellant Tanks: Storing Fuel and Oxidizer

-Rockets cannot rely on Earth's atmosphere for oxygen, so they carry both fuel and oxidizer (collectively called "propellants") in separate tanks. These tanks are the largest and heaviest parts of the rocket—for example, SpaceX's Falcon 9 has two main tanks: one for liquid oxygen (LOX) and one for RP-1 kerosene fuel. (Hall, 1-2)

Engine System: Generating Thrust

-The engine system is the rocket's "powerplant," converting propellant energy into thrust. A typical liquid-propellant engine assembly includes:

-Thrust Chamber: Where fuel and oxidizer mix and burn at temperatures exceeding 3,000°C. The chamber is lined with a cooling system (e.g., "regenerative cooling," where cold fuel circulates through channels in the chamber wall to prevent melting).

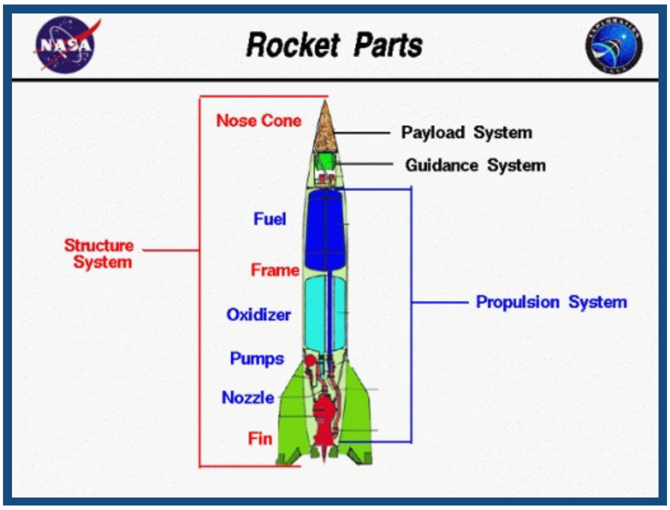
-Nozzle: A convergent-divergent (hourglass-shaped) tube that accelerates exhaust gas from subsonic to supersonic speeds (up to 5,000 m/s). The nozzle's shape is critical—too short, and thrust is wasted; too long, and it risks collapsing in the atmosphere. (Hall, 3-4)

Chemical Rocket Engines (Most Common)

Solid Propellant Engines:
Solid rockets use a pre-mixed "fuel-oxidizer paste" (e.g., polyurethane or nitrate-based compounds) stored in a rigid combustion chamber. Ignited by an electric spark, the propellant burns uniformly, producing hot gas that exits through a nozzle.

Solid propellant engines have a simple design, are reliable, and ready for immediate use (ideal for emergency systems or boosters).

Liquid Propellant Engines:
Liquid rockets store fuel (e.g., liquid hydrogen, kerosene) and oxidizer (e.g., liquid oxygen, nitrogen tetroxide) in separate tanks, pumping them into a combustion chamber at precise ratios. Liquid propellant engines have high specific impulse (250–500 seconds), adjustable thrust, and are restartable for future use. (Hall, 3-4)



Avionics: The "Brain" of the Rocket

-The avionics system is the rocket's navigation, guidance, and control center. It includes:

-Onboard Computer: A ruggedized computer (shielded from radiation and vibration) that runs pre-programmed flight plans and adjusts the rocket's trajectory in real time.

-Sensors: Gyroscopes (to measure rotation), accelerometers (to measure speed and acceleration), and GPS receivers (to track position relative to Earth). Some rockets also use star trackers (cameras that lock onto stars) for precise navigation in space.

-Communication Antennas: To send data (e.g., engine temperature, fuel levels) to ground stations and receive commands (e.g., "adjust thrust" or "separate stage").

Structural Frame: Holding It All Together

-The structural frame (or "airframe") is the rocket's skeleton, connecting all components and absorbing launch forces (which can reach 3–4 times Earth's gravity, or 3–4g). Short cylindrical sections that connect different stages (e.g., first stage to second stage). They include explosive bolts or separation motors to detach stages mid-flight (Hall, 3-4)

Conclusion

Rockets are feats of engineering that turn physics into exploration. As technology advances with reusable rockets (e.g., Falcon 9) and nuclear propulsion on the horizon, our access to space will become more accessible. Rockets are not just machines that send you to space; Rockets don't just defy gravity; they defy the idea that some frontiers are too far to reach. Sixty-three years ago, in 1961, Yuri Gagarin became the first human to orbit Earth, carried aloft by a Soviet Vostok rocket. That historic 108-minute flight wasn't just a milestone for space exploration—it was proof that rockets could turn "what if" into "what is." Gagarin's journey shattered the myth that humans were bound to Earth, inspiring generations to push further. In the end, rockets are the bridge between our world and the infinite possibilities of space, the connection and effort between rocket scientists. The next time you watch a rocket launch—whether it's a satellite heading to orbit or a massive rocket carrying astronauts to the Moon—pause for a moment. Look to the roar of the engines, watch as it climbs above the clouds, and remember: this is more than a launch. It's a continuation of Gagarin's legacy, a step forward for humanity, and a reminder that when we combine curiosity with innovation, there are no limits to what we can achieve.

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The Next Generation Cancer Therapy: Why Scientists Are Betting on Macrophages

Claire S G12 Student

Cancer is a thief. It steals lives, time, and peace of mind. For decades, our main weapons have been blunt instruments: chemotherapy that attacks all fast-growing cells, and radiation that burns through tissue. But what if we could train our own body's defenders, our immune cells, to become smarter, more precise assassins? That's the promise of CAR therapy, a revolutionary field that's rewriting the rules of oncology. Throughout my Grade 11 and 12 years, I have dedicated my IB Extended Essay research to a detailed comparison of these two therapeutic approaches.

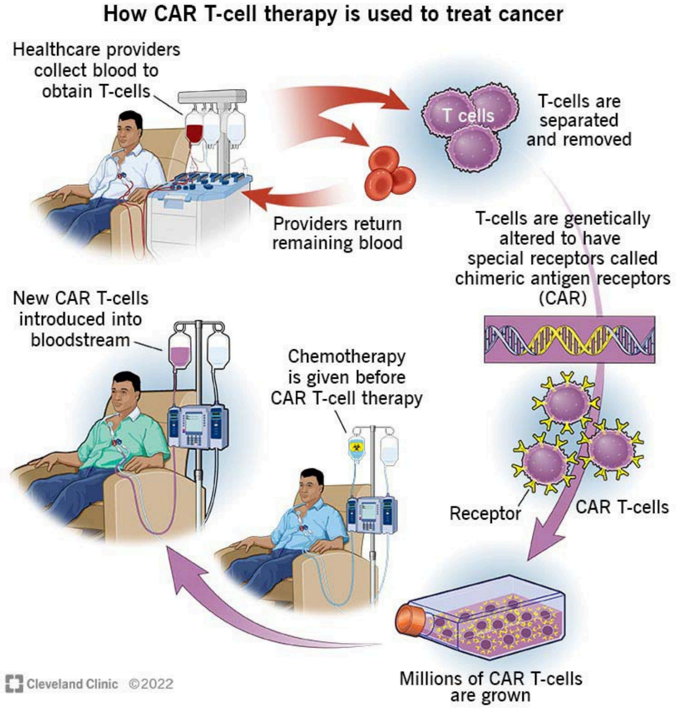


Figure 1: How CAR-T therapy work to treat cancer

The CAR-T therapy has already shown stunning results against multiple blood cancers. But for the solid tumors that make up most cancers, like those in the breast, lung, or pancreas, progress has been frustratingly slow. Now, scientists are exploring a new candidate in the cellular immunotherapy race: CAR-Macrophages. Instead of using T cells, they're engineering a different type of immune cell altogether.

What Is CAR Therapy?

CAR (Chimeric Antigen Receptor) therapy is about giving an immune cell better eyes. Normally, our immune cells recognize cancer through MHC complex, an often inefficient signals that could be hijacked by tumor cells. A CAR is a synthetic receptor that is genetically added to the cell. Once the CAR binds to its matching antigen on a cancer cell, it triggers the immune cell to attack.

CAR-T therapy uses T cells, the adaptive killers of our immune system. When it works, it can eliminate cancer completely using toxins. But solid tumors are protected by dense tissue, poor blood flow, and a highly immunosuppressive microenvironment that exhausts and deactivates incoming T cells (Beatty & O'Hara, 2016). They might be killed before infiltrating the tumors.

This is the central limitation that has kept CAR-T from revolutionizing solid tumor care.

The Macrophages

This is where macrophages come in. While T cells are the specialized killers, macrophages are the innate immune system's first responders. Their job is to engulf pathogens through a process called phagocytosis, and sound the alarm to recruit members of the adative immune system, like T cells.

Crucially, macrophages are naturally good at infiltrating tissues, including tumors. In fact, tumors are often full of macrophages, but cancer corrupts them, turning them into allies- the M2 macrophages, that are anti-inflammatory and promotes tissue repair- that suppress the immune response and help the tumor grow (Chen et al., 2023).

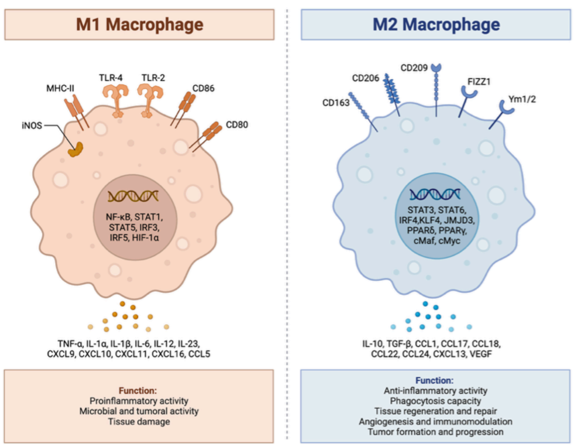


Figure 2: M1 Macrophage and M2 Macrophage. M1 are pro-inflammatory and engulf pathogen, whereas M2 are anti-inflammatory and promotes tissue repair. Macrophages hijacked by cancer usually becomes M2.

them. By adding a CAR, scientists aim to turn macrophages from M2 tumor supporters into M1 tumor destroyers, leveraging their natural ability to engulf cells and remodel their environment.

Why CAR-M Could Be a Game-Changer

Early research suggests CAR-Macrophages aren't just a copy of CAR-T with a different cell type. They work through fundamentally different mechanisms that might bypass some of CAR-T's biggest obstacles.

First, they can reshape the tumor microenvironment.

Solid tumors create a hostile, suppressive environment that shuts down T cells. CAR-M cells, however, have shown an ability to resist this suppression and remodel the tumor microenvironment. In a key 2020 study, CAR-Ms were shown to shift the environment from immunosuppressive to pro-inflammatory (promotes tissue breakdown) and even recruit other immune cells like T cells and natural killers to join the fight (Klichinsky et al.).

Second, they have a different safety profile.

One of the most serious risks of CAR-T is cytokine release syndrome (CRS), a systemic inflammatory reaction that can be life-threatening. It's common; in some trials, nearly all patients experience some form of it (Fu et al., 2023). The first reported human trial of CAR-M, however, observed no severe CRS or neurotoxicity (Reiss et al., 2025). While this is very early data, it points to a potentially safer therapeutic avenue.

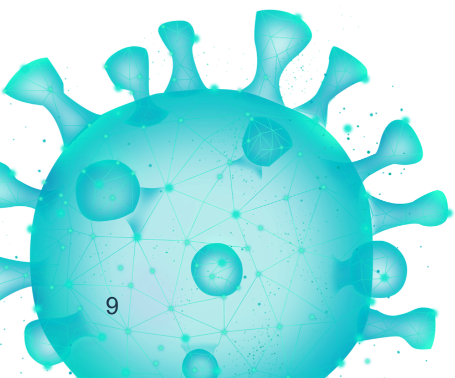
Third, they attack differently.

Instead of just killing a target cell, CAR-Ms engulf and digest it through phagocytosis. This process allows them to then present pieces of the tumor to the rest of the immune system and recruits other natural immune cells, potentially triggering a broader, longer-lasting adaptive immune response – something CAR-T cells struggle to do in solid tumors.

Unfortunately, Cancer is Not That Simple

For all their promise, CAR-Macrophages face significant unknowns. Most of the encouraging data comes from preclinical mouse studies. Human data is minimal, and key questions about long-term persistence and reliable tumor infiltration in patients remain unanswered (Zhang et al., 2019).

Furthermore, manufacturing CAR-M cells is a different challenge than growing CAR-T cells. Macrophages are harder to genetically engineer and expand in the lab at the scale needed for therapy.



Looking Ahead: Combination, Not Replacement

Personally after writing a 40 pages EE on comparing CAR-M and CAR-T, I believe the most realistic future for CAR-M may not be as a standalone replacement for CAR-T, but as a complementary partner. Given their respective strengths – CAR-M's ability to remodel the tumor microenvironment and CAR-T's ability to persist and kill tumor cells– a combined approach could be more effective than either alone.

Imagine using CAR-M first to break down the tumor's defenses, reduce immunosuppression, and recruit help. Then, follow with CAR-T cells to clean up. This could finally overcome the solid tumor barriers that have limited cellular immunotherapies for years.

The story of CAR therapy is evolving. It's no longer just about T cells. By recruiting the innate immune system's infiltrators, scientists are building a broader, smarter arsenal. The goal remains the same: to outsmart cancer. But now, they're sending in more than one type of soldier.

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The Scientific Exploration Behind the Pleasure of Song Yuqi's Radio

Elisa L G6 Student

The starting point of my exploration was the song Radio (Dum-Dum) by Song Yuqi. Every time this piece plays, my body unconsciously sways to the rhythm, I hum along with the melody, and I even set aside unfinished tasks. This phenomenon raised a core question: Why can specific music evoke such strong feelings of pleasure? Is there a scientific explanation behind this? With this question, I embarked on a scientific inquiry that lasted several weeks.

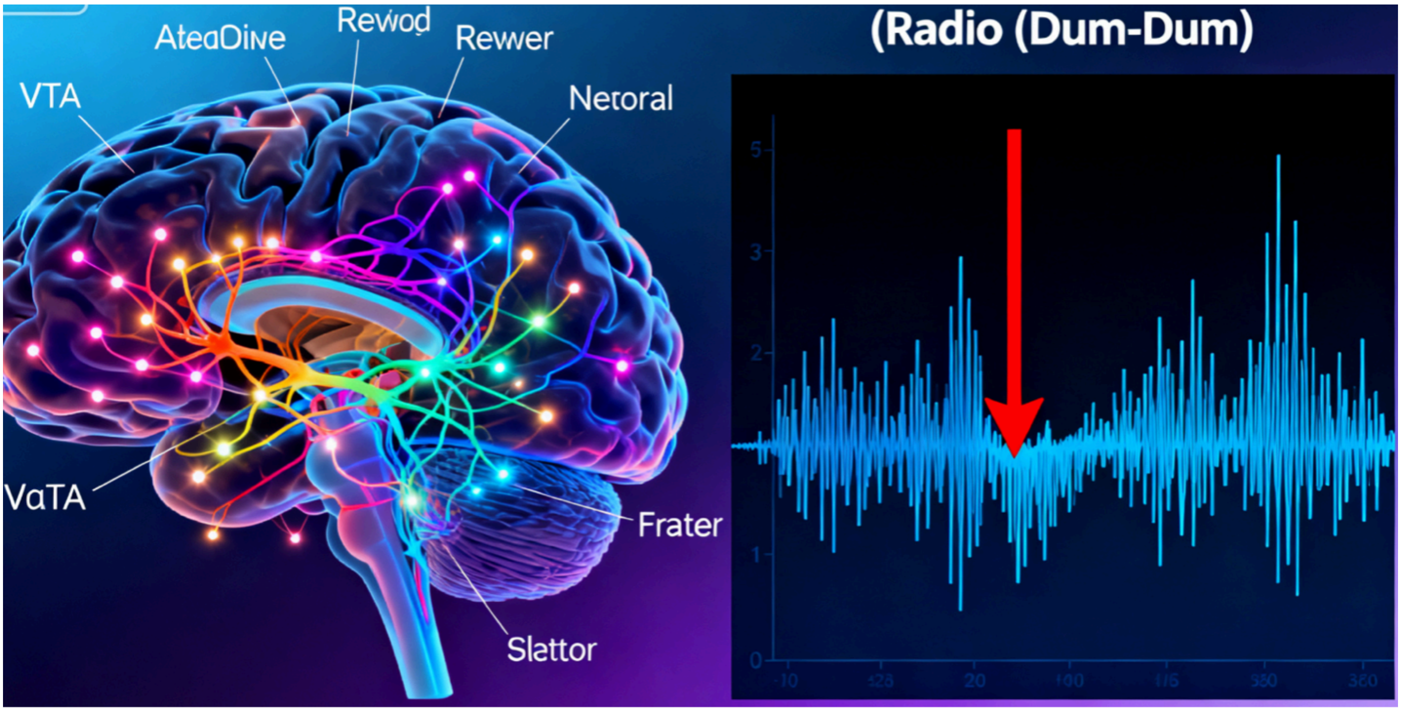
Initially, I hypothesized that pleasure came from the rhythmic qualities of the music. By analyzing the rhythm of Radio, I found its beat to be stable and highly regular. However, when I compared it to another song with a similar rhythm, the latter didn't elicit the same physical response. This suggested that rhythm wasn't the only factor. I then noticed a similar phenomenon: when watching variety shows, familiar theme songs would quickly capture attention and trigger singing along. This led me to speculate that after auditory signals enter the brain, there must be a specialized neural mechanism for processing music, which might be linked to memory and emotion.

To test this, I systematically observed the specific reactions Radio triggered: the singer's pitch changes would draw clear auditory attention, while the repeated chorus sections would quickly form memories, making it easy to sing along upon a second listen. Further research revealed that the nerve cells responsible for transmitting and processing sound signals in the brain are called neurons. A neuron consists of dendrites, a cell body, and an axon—dendrites receive input signals, the cell body processes them, and the axon transmits signals to other neurons. Neurons that recognize pitch become active when the singer changes tone, while those responsible for memory storage record the repeated melodic fragments. This is the physiological basis for quickly becoming familiar with music, essentially the same mechanism by which variety show theme songs trigger memory.

The album cover of Radio (Dum-Dum) also carries unique symbolic meaning. It is designed with a red rabbit as the core element, which Song Yuqi said represents herself—she was born in the Year of the Rabbit, and red is her favorite color . This warm and vivid design resonates with the cheerful rhythm of the song, adding an emotional layer to the auditory experience.

But a new question arose: Why does the sudden drop in volume during the instrumental bridge enhance the sense of pleasure? Pondering this, I discussed it with friends and found that most people engage in repeated listening to their favorite music and experience emotional pleasure. Together, we consulted academic resources and found a key explanation: the brain secretes a neurotransmitter called dopamine, whose core function is to transmit pleasure signals . The brain's dopamine reward pathway mainly originates from the ventral tegmental area (VTA); dopamine produced here is released to the nucleus accumbens and prefrontal cortex, forming a loop that perceives and amplifies pleasure . When music presents unexpected changes—like the volume drop in Radio's instrumental bridge—it stimulates this pathway to secrete more dopamine, thereby intensifying the sense of pleasure and encouraging repeated listening .

This exploration deeply impressed me that science isn't confined to laboratories or astronomy—it exists in the subtleties of everyday life. Now, when I listen to Radio, I don't just perceive the melody; I also understand the underlying physiological mechanisms. In the future, I plan to further explore animals' sound responses, such as whether my cat's avoidance of loud Radio plays is related to differences in animal brain sound-processing mechanisms. The journey of scientific exploration is endless, and every unresolved question is the starting point for a new inquiry.



To verify this, I played the instrumental bridge for my younger brother, who showed a clear desire to listen again, consistent with the theory.

Additionally, I observed that listening to Radio while fatigued could alleviate irritability. Research indicates this is related to the amygdala, the brain's emotional regulation center. The amygdala is closely connected to the brain's reward circuit and receives glutamatergic inputs that influence emotional responses . When exposed to pleasant music like Radio, the amygdala suppresses anxiety-related neural activity, helping to calm emotions . This explains why the song can soothe irritability and bring emotional comfort during moments of tiredness.

Later, I surveyed my friends and found that different music evoked varied emotional responses. After explaining the functions of neurons, dopamine, and the amygdala, most gained a new understanding of the connection between music and the brain.

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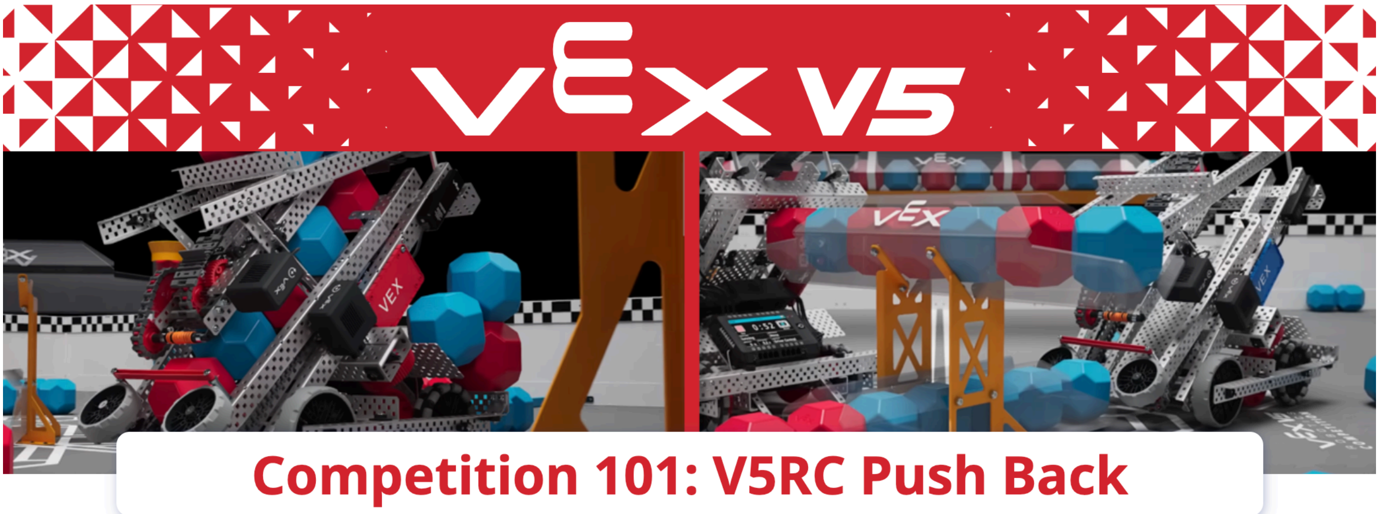
Building the Future: Hangzhou International School's Robotics Team

Jia Chen Q G12 Student

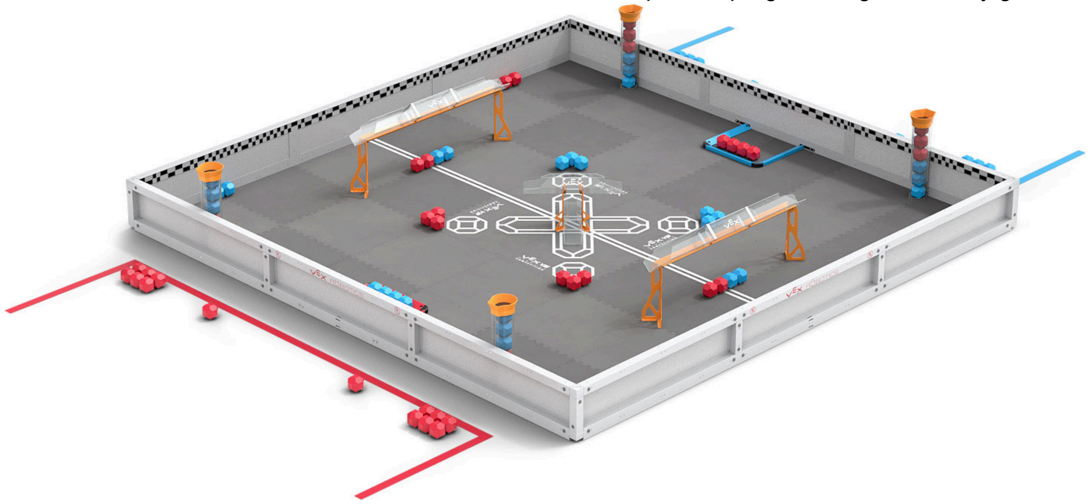


Beneath the ordinary veneer of metal parts, wires, and motors, something extraordinary is taking shape after school at Hangzhou International School (HIS). The varsity **robotics team** isn't just a club; it's a dynamic group of dedicated high school engineers working collaboratively to design, construct, and program complex machines. Every week, the students gather to test theories, troubleshoot designs, and meticulously build their robots from the ground up, turning metal pieces and motors into competitive machines.

The Challenge: VEX V5 Robotics Competition

The HIS high school division competes in the rigorous **VEX V5 Robotics Competition**, which challenges students to solve a specific engineering problem presented as an annual game. The current game for the 2025-2026 season is called **"Push Back."**

"Push Back" is played on a 12' x 12' square field by two alliances, each composed of two teams. Matches consist of a **15-second autonomous period** where robots operate purely on pre-programmed code, followed by a **one-minute and 45-second driver-controlled period**. The primary objective is to score **Blocks** (small cube-like objects) into various **Goals**—two Long Goals and two Center Goals—to earn points. Each scored Block is worth **three points**. Additional points are awarded for **Controlling Zones** within the Goals and for **Parking** robots in designated zones at the end of the match, providing a significant bonus for alliances that can coordinate both robots to park. Teams also vie for an **Autonomous Bonus** of 10 points for the alliance that scores more points in the initial 15 seconds, and a crucial **Autonomous Win Point** which both alliances can earn by completing specific pre-assigned tasks. This multi-layered scoring system demands a blend of reliable robot design, precise programming, and savvy game strategy.



Teamwork and Competition

The HIS varsity program currently features **four separate teams**, each working independently on their own robot design and strategy to maximize their competitive edge within the "Push Back" challenge. This structure fosters a healthy internal competition that drives innovation and excellence.

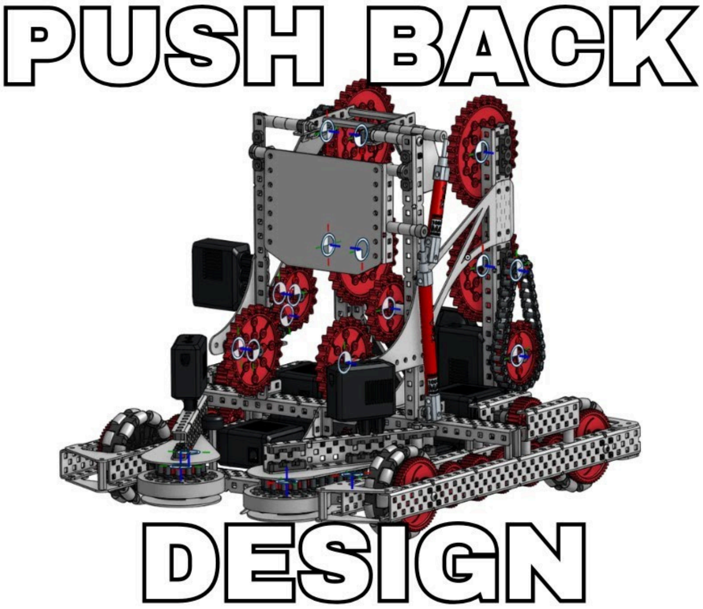
The teams don't just compete against each other; they test their mettle against some of the best international school robotics teams across China. This competition circuit provides invaluable experience against rivals from institutions like the Nanjing International School (NIS), Shanghai American School (SAS), and Hong Kong International School (HKIS).

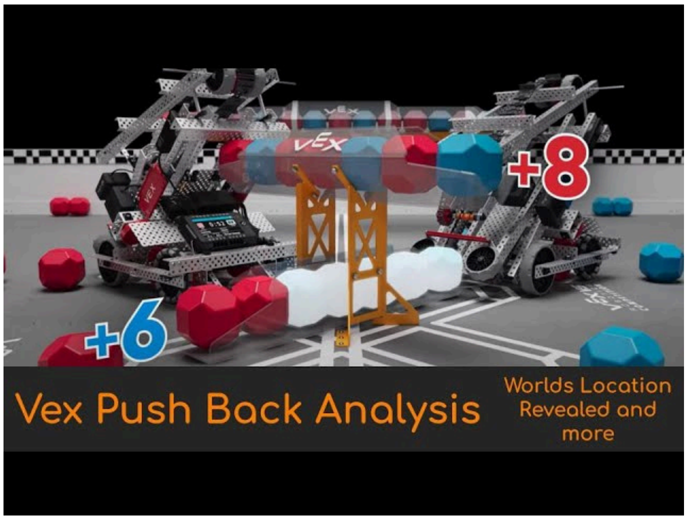
The season kicked off with the **first major competition** taking place in early November at the Nanjing International School. This initial event served as a crucial learning experience. The intense, real-world pressure of the tournament highlighted immediate areas for improvement—from reinforcing structural weaknesses under stress to refining collaborative strategies during the alliance matches. The teams walked away with an enhanced understanding of **game strategy** and the importance of **cooperation** both within their individual teams and when paired with an alliance partner.

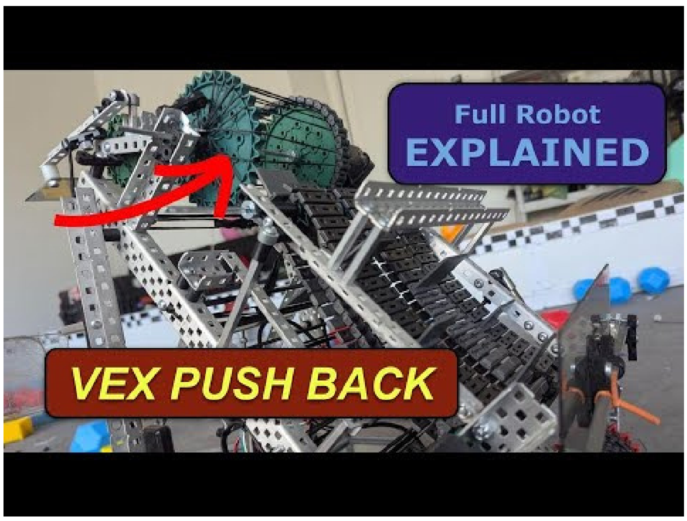
Looking Ahead

With the first competition behind them, the HIS robotics teams are now in a phase of intensive **iteration and improvement.** Their sights are set on the next major event scheduled for **early January**. This upcoming competition is critical, as the results will count toward the **qualifiers for the prestigious ACAMIS (Association of China and Mongolia International Schools) robotics competition**.

Success at the ACAMIS level is the ultimate goal, representing the pinnacle of international school robotics in the region. The students are working diligently to implement the lessons learned in Nanjing, fine-tuning their robot designs to be faster, more robust, and more efficient at scoring and parking. The January competition will be a true test of their engineering prowess and their ability to execute a winning strategy under pressure. For the HIS robotics team, this journey is about much more than just metal and motors—it's about learning the core principles of engineering, teamwork, and persistence that will serve them long into the future.





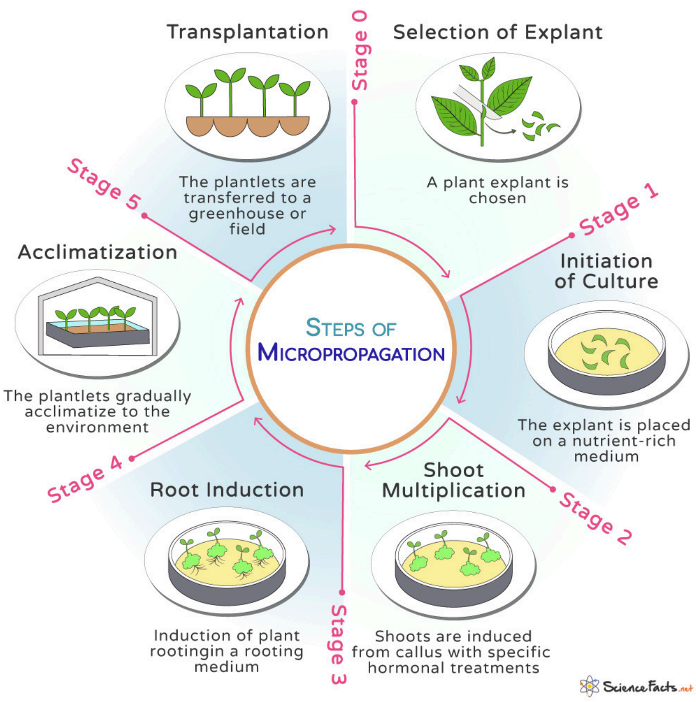


The Role of Micropropagation in Food Production and Recent Technological Advances

Melanie Z G10 Student

What is Micropropagation?

Micropropagation is a technique used to grow small plantlets from tissue samples, known as “explants,” in sterile laboratory conditions (tissue culture). This method relies on nutrient media, controlled light, and temperature to produce genetically identical plantlets from a single parent plant, allowing for the rapid multiplication of desirable species (ScienceDirect, 2009). Recent technological advancements have made micropropagation more efficient, cost-effective, and beneficial for food production.



Latest Technological Advances

Recent innovations have significantly improved micropropagation techniques. One major advance involves the use of low-cost gelling agents, which are essential for converting liquid cultures into semi-solid media for explant growth. Traditional gelling agents like agar, derived from seaweed, have been costly, especially for developing countries. In contrast, alternative agents such as mung bean flour and Isabgol powder are effective and can reduce costs by up to 60% while supporting plant growth equally well (Opata and Hegele, 2022; Ebile et al., 2022).

Another breakthrough is the integration of nanotechnology, which addresses issues like contamination and low chemical yields (Guru, 2025). Contamination from bacteria and fungi can kill up to 30% of cultures, while traditional sterilizers may damage plants. Silver nanoparticles, for example, can destroy harmful microorganisms without harming the plant tissue (Gerasene et al., 2024). Tests have shown that silver nanoparticles can reduce contamination rates by 90%, enhancing overall plant propagation efficiency (Shahzad, 2024).

Automation and artificial intelligence (AI) are also transforming micropropagation by minimizing labor costs and improving consistency. Labor accounts for 80% of micropropagation expenses due to manual handling. Robots, such as RoBoCut, can laser-cut explants and transfer them, reducing human error and contamination by up to 70% (Lee et al., 2019). AI systems can evaluate plantlets for size, color, and health much faster than humans, enhancing monitoring efficiency. Additionally, technologies like the Certhon Control System (CCS) regulate environmental factors such as temperature, humidity, and CO_2 levels, promoting uniform growth. Temporary Immersion Systems, like RITA®, allow for brief dips in nutrient solutions to optimize nutrient absorption while preventing waterlogging (Singh, 2025).

Contribution and Advantages of Micropropagation in Food Production

Micropropagation addresses critical issues in food production, including slow growth rates, diseases, and seasonal limitations, which are vital for ensuring food security. Since the 1970s, micropropagation has revolutionized agriculture by enabling rapid and large-scale plant production. For example, traditional potato farming produced only 10–20 plants per parent annually, which could not meet growing demands. Micropropagation can generate over 10,000 plants from a single explant, dramatically increasing supply (Hajare et al., 2021). By the 1980s, this technology became standard in potato nurseries, doubling production in countries like the Netherlands (Pierik, 2025).

In places like Kenya, micropropagation has accelerated banana production. Seedlings grown through this method mature in 12-16 months, yield heavier bunches (30-45 kg), and achieve much higher yields (40-60 tonnes/ha) compared to conventional methods (15-20 tonnes/ha) (Isaaa, 2025).

Additionally, micropropagation plays a crucial role in disease control by combating viral diseases that affect staple crops. The cassava mosaic virus, which reduces yields by 30-50%, has threatened food security in sub-Saharan Africa. By using explants from virus-free “mother plants,” micropropagation has successfully produced clean, healthy seedlings, significantly lowering the prevalence of cassava viruses in Nigeria by the 2000s (Alabi et al., 2011; Maruthi et al., 2018). Similarly, potato farmers in India have reported fewer virus-related crop failures since adopting micropropagation techniques (KaurJalandhar, 2025).

Micropropagation also facilitates year-round production and ensures uniform quality of crops. The technique allows countries with harsh climates to avoid seasonal gaps in production. The U.S. started commercially producing plants via micropropagation with orchids around 1965, leading to constant availability of pathogen-free plants that can be applied to various fruits and vegetables (Zimmerman and Jones, 1991). The uniformity achieved through micropropagation has boosted trade; for instance, Peruvian farmers using micropropagated asparagus can meet international export standards, significantly increasing their income (CIP, 2021).

Limitations

Despite its advantages, micropropagation has limitations, especially for small-scale farms in developing regions. The initial costs for setting up small labs range from $50,000 to $100,000 for necessary equipment and trained staff—expenses many small farmers cannot afford (Farrelly Mitchell, 2025). Automation, while improving efficiency, can lead to high electricity consumption, which may be unreliable and costly in poorer areas (Farrelly Mitchell, 2025).

Moreover, there is a shortage of skilled labor in developing countries, limiting the effective application of micropropagation technology (Amare and Dugassa, 2022). Another significant drawback is the loss of genetic diversity; uniformity in propagated crops may make them more vulnerable to new diseases. If a new disease arises, it can potentially decimate an entire batch of genetically identical plants, leading to significant losses (Farrelly Mitchell, 2025).

Additionally, the delicate nature of plant tissue used as explants makes it sensitive to lab conditions. Minor fluctuations in nutrient media, light, or temperature can adversely affect growth or even kill the plantlets (Singh, 2021). Some species, especially certain woody plants, are particularly challenging to propagate using this method.

Conclusion

In conclusion, while micropropagation has considerable limitations, its benefits continue to outweigh them by providing innovative solutions to agricultural challenges. This technology has revolutionized food production since the 1970s, enabling the mass propagation of disease-free plants and addressing critical issues like food security in the face of a rising global population and climate change (Rabobank, 2019). Recent technological advances, such as low-cost gelling agents and the integration of nanotechnology, are making micropropagation more accessible and efficient. As we move toward a future where sustainable food production is increasingly vital, micropropagation remains an essential tool in agriculture.

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Cloning of Farm Animals

Jason G G10 Student

Introduction:

Cloning of farm animals is a biological process that creates genetically identical copies of animals through techniques like somatic cell nuclear transfer (SCNT). This method involves removing the nucleus from a somatic cell and implanting it into an egg cell that has had its original nucleus removed (Gootwine).

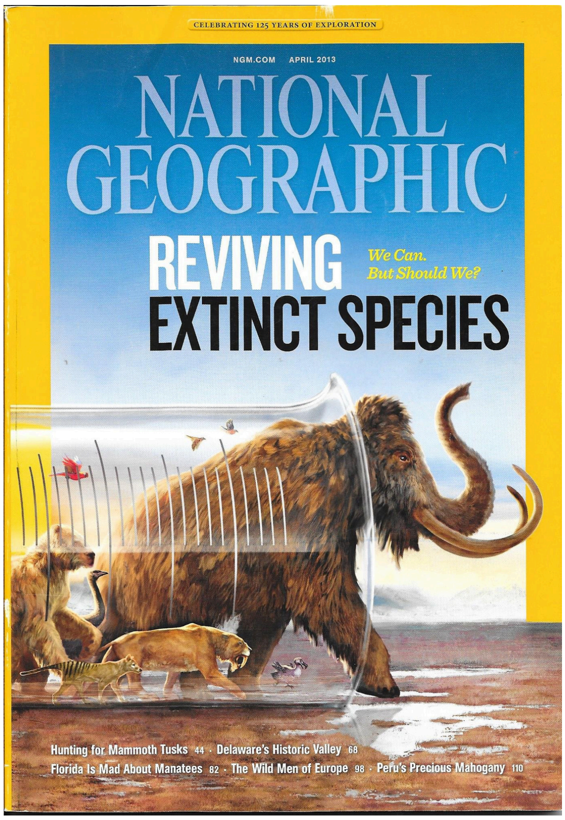
Latest Technology in SCNT:

As of 2025, SCNT remains the primary technique for cloning farm animals. It begins with collecting a tissue sample to create a genetic preservation cell line or tissue bank. This allows for cryopreservation and the later cloning of valuable genetics in pigs and horses (Stocum).

Pros and Cons of SCNT:

The advantages of SCNT technology include the ability to replicate animals with superior genetics, enhancing livestock productivity and preserving valuable traits from elite or infertile animals. SCNT also has applications in medical science, where cloned animals can serve as disease models and help produce pharmaceuticals. Additionally, it holds potential for conserving endangered breeds and possibly reviving extinct species (Kober).

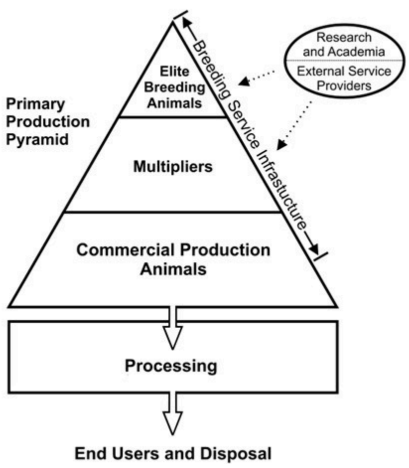
However, SCNT comes with significant drawbacks. The technology raises environmental concerns due to its low efficiency and the substantial resources required, often resulting in many surrogate mothers. Cloned animals frequently experience health issues, leading to increased pharmaceutical use and raising risks related to contamination. Furthermore, reduced genetic diversity may make livestock populations more susceptible to disease, posing long-term ecological threats (INOUE).



Impact of SCNT on Food Production:

SCNT enhances food production by creating genetically identical copies of high-quality livestock. However, cloned animals are often too expensive for direct food use. This method accelerates genetic improvement over traditional breeding and facilitates genetic modifications through tools like CRISPR-Cas9, promoting disease resistance and muscle growth. SCNT also enables the creation of transgenic livestock that can produce valuable pharmaceuticals in their milk (Ormandy et al).

Idealised Breeding and Production Pyramid



Problems Associated with SCNT:

Several issues complicate SCNT, including organ defects, immunodeficiency, low success rates, Large Offspring Syndrome (LOS), and abnormal DNA methylation. The low success rate of SCNT is a significant challenge affecting scientific progress and ethical considerations. Reprogramming somatic cell nuclei to a totipotent state is technically complex and results in many embryos failing to develop or dying before birth (FDA Center).

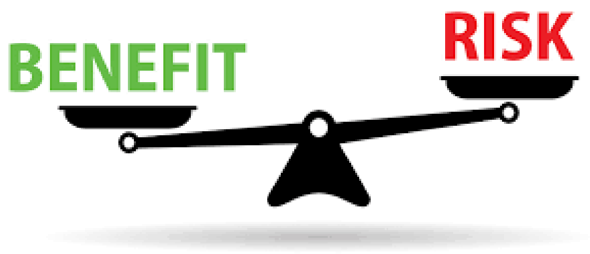
The success rate typically ranges from 1–5% because reprogramming failures occur during the process, complicating further advancements (Gouveia et al.)

Three Major Impacts of Success Rates:

1. Reprogramming Failure: This occurs when egg cytoplasm cannot erase the donor nucleus's differentiated memory, leading to developmental abnormalities or nonviable embryos (Mauer et al).

2. Embryo Turnover and Loss: Many embryos are generated, but only a small fraction survive viability, raising ethical concerns about resource use and animal welfare (Kidder and Pedersen).

3. Species and Protocol Dependence: Efficiency varies widely among different species and laboratories, complicating predictions and safety when translating results to humans (Akhtar).



Importance of Risk-Benefit Analysis:

Understanding the risks and benefits is crucial as it impacts foundational decisions in SCNT research, influencing policies and oversight efforts. This analysis drives the quest for safer, more efficient alternatives, such as induced pluripotent stem cells, which could enhance regenerative medicine, disease modeling, and reproductive biology in future applications (Gouveia et al).

Enhancing the success of SCNT involves three main strategies: improving reprogramming to reset donor nuclei to an embryo-like state; reducing embryo loss by optimizing activation and growth conditions for better survival rates; and standardizing protocols across species to ensure consistent results. Researchers are exploring ways to adjust genomic chemical markers, enhance egg activation, precondition donor cells for easier reprogramming, and potentially incorporate stem-cell approaches to avoid ethical concerns while advancing biological research (Liao et al).

Economic Issues Related to SCNT:

SCNT presents economic challenges, including high production costs per unit due to low success rates, which necessitate more eggs, oocytes, and surrogate mothers. This increases operational costs, ultimately raising the prices of cloned animals or their products. The variable quality of products from cloned livestock can undermine consumer trust, further influencing economic viability (Czernik et al).

The costs for cloning vary significantly by species. For instance, commercial pet cloning can range from $50,000 to $100,000, while cloning a cow costs approximately $15,000—well above the typical market value of a cow. Similar high costs exist for cloning other farm animals like pigs, sheep, and goats, limiting widespread use in agriculture (Galli and Lazzari).

Conclusion

Somatic Cell Nuclear Transfer (SCNT) is a transformative yet challenging technology in animal agriculture. It offers significant promise for improving food production and replicating superior genetics, but faces major technical hurdles including low efficiency, animal welfare concerns, and high economic costs. These challenges create a complex risk-benefit analysis that influences policy and drives the need for alternatives. The future of SCNT hinges on overcoming these limitations through improved efficiency and responsible oversight, ensuring the technology's applications are both viable and ethical.

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The Role of Pesticides in Food Production

Joanna Y G10 Student

Basic Introduction to Pesticides

Pesticides are essential chemicals designed to prevent, control, or eliminate pests that threaten crop production. Composed of various chemical compounds such as organophosphates, carbamates, and pyrethroids, they help farmers manage harmful organisms, including insects, weeds, fungi, and diseases (Editors). By protecting crops, pesticides play a critical role in ensuring food security and supporting agricultural productivity. However, their use raises concerns about potential environmental impacts and health risks, including respiratory issues and skin irritations from prolonged exposure (World Health Organization).

Most Commonly Used Pesticides

The most commonly used pesticides include glyphosate, chlorpyrifos, and neonicotinoids. Glyphosate, a widely used herbicide, inhibits processes essential for plant growth and effectively manages many weeds with less risk to animals. Chlorpyrifos is an insecticide that disrupts the nervous systems of insects but has faced criticism for potential health risks to humans and wildlife. Neonicotinoids, another class of insecticides, target the nervous systems of pests, causing paralysis and death (providenceri.gov). These compounds bind to nicotinic acetylcholine receptors, effectively controlling pests while minimizing harm to beneficial organisms (Ihara and Matsuda).

Most Up-to-Date Science

RNA interference (RNAi) pesticides represent a breakthrough in pest control technology. Published in May 2025, this method uses double-stranded RNA (dsRNA) to turn off essential genes in target organisms, disrupting their life processes without harming the environment. The specificity of RNAi minimizes adverse effects on non-target species like bees and beneficial soil microbes (BIS Research). By reducing the risk of pests developing resistance, RNAi technology offers a sustainable solution amid rising regulations and challenges in agriculture.

Pros and Cons of Pesticides

Pesticides address significant agricultural challenges by controlling pests that threaten crops and increasing yields. This enables farmers to produce more resources and reduce losses from weeds, insects, and diseases (pesticidefacts.org). For instance, fungicides prevent fungal infections in crops like wheat and corn, protecting incomes and ensuring food availability (Brown). While pesticides enhance agricultural productivity and help control disease-spreading pests, they also present drawbacks. Pesticide use can contaminate soil and water, negatively affecting beneficial insects like bees and posing risks to human health, including respiratory problems and potential cancer risks. Moreover, pests may develop resistance over time, leading to increased chemical use and costs, ultimately reducing productivity (Sharma).

Environmental Factors

The environmental impact of pesticides in food production raises concerns about their effects on ecosystems and agricultural sustainability. Pesticide runoff can contaminate soil and water, adversely affecting non-target organisms vital for healthy crop production. For example, runoff from agricultural lands in the Chesapeake Bay has led to harmful effects on aquatic ecosystems, disrupting fish populations (epa.gov) (Johnstone). Pesticide use also contributes to the decline of pollinators. Studies show that beetle-pollinated crops yield higher quality produce (Bahgat), and neonicotinoids have been linked to impaired bee behavior and reproductive abilities, reducing crop yields (van der Sluijs et al). Excessive use of pesticides can encourage harmful algal blooms, depleting oxygen levels in water bodies and creating "dead zones" where aquatic life cannot thrive (Narayanan et al). Furthermore, pesticides harm soil organisms vital for nutrient cycling and soil fertility, essential for sustainable agricultural systems (Donley).

Conclusion

In conclusion, pesticides play a crucial role in food production by managing pests and enhancing crop yields. However, they also present significant environmental and health challenges that must be addressed. Emerging technologies like RNAi pesticides offer promising alternatives that could reduce negative impacts while maintaining agricultural productivity. Balancing the benefits and risks associated with pesticide use remains essential for promoting sustainable agriculture and food security in the future.

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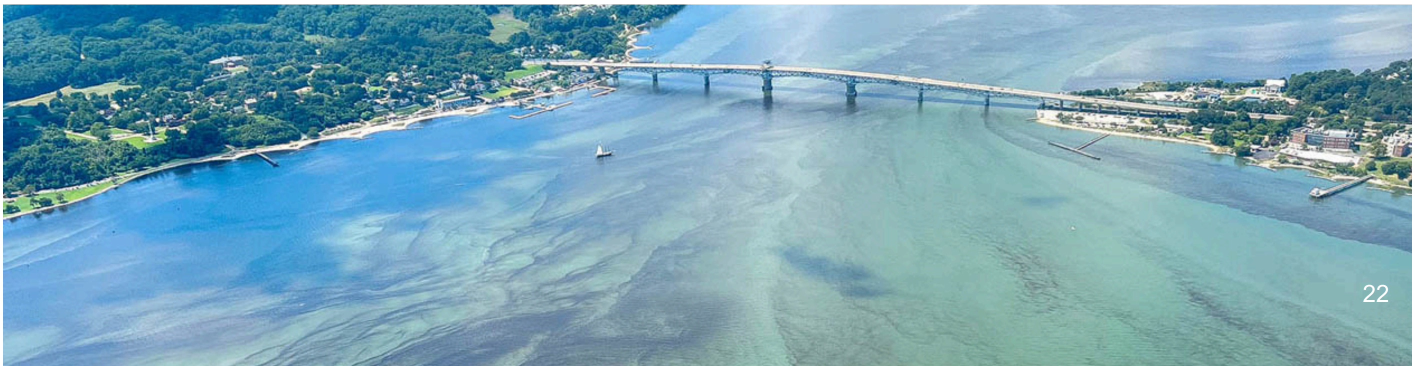
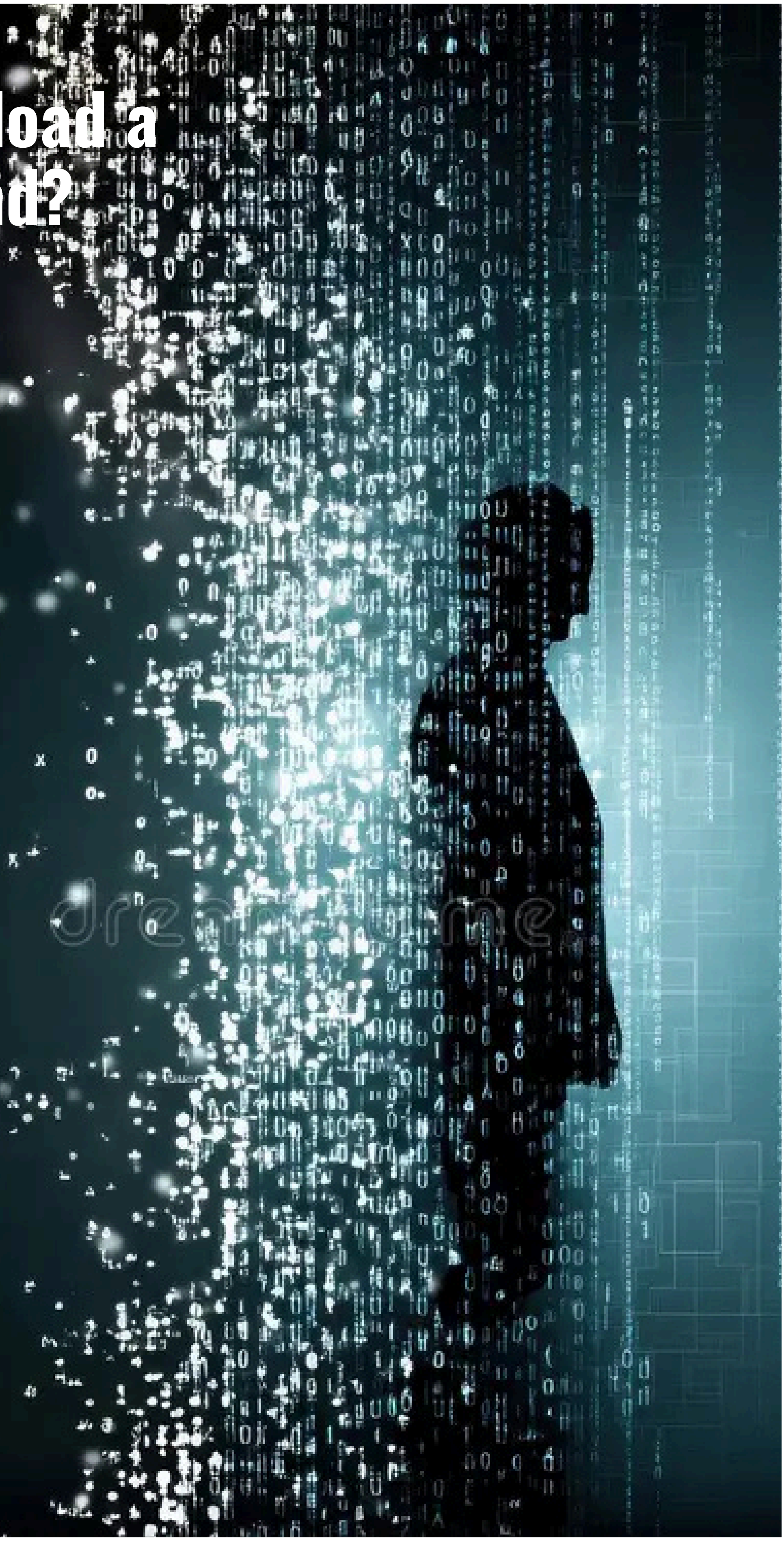


Can We Upload a Human Mind?

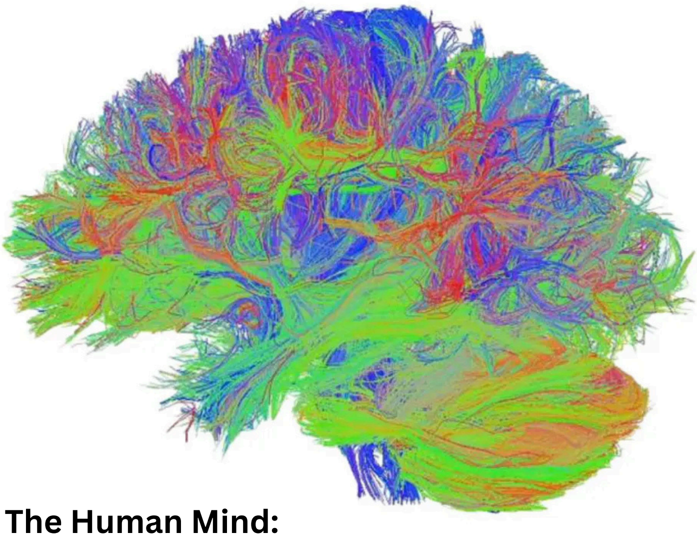
Kingsley C G8 Student



Exploring how AI and supercomputers might one day capture consciousness

Imagine waking up and finding yourself inside a computer — not your physical form, but you: your thoughts, your memories, your way of thinking. The world outside your screen continues, but “you” now exist in lines of digital code, speaking through a machine. It seems like the plot of a futuristic film, yet scientists, philosophers, and engineers are asking a real question: could we one day upload the human mind?

The idea of transferring consciousness into a computer — sometimes called whole brain emulation — sits at the edge of neuroscience, artificial intelligence, and philosophy. Once seen as pure science fiction, it’s slowly creeping toward scientific possibility. The combination of supercomputers, advanced brain scanning, and machine learning means we are, for the first time, beginning to understand how this could work.



The Human Mind:
A Biological Masterpiece

To imagine uploading a mind, we must first ask: what is a mind?

Your mind is not a single organ, but the pattern of connections and electric signals among the brain's **86 billion neurons**. Every memory you hold, every decision you make, every moment of emotion — all of it is coded in these connections. Scientists call this map of links the **connectome**.

In theory, if we could copy your connectome perfectly — every neuron, every connection, and the precise strength of each signal — we could reproduce your mind in another medium, such as a computer. But there's one problem: we're nowhere near being able to do this.

Current brain imaging can map small sections of the brain with stunning detail, but only at microscopic scales, and often by destroying tissue in the process. Mapping even one cubic millimetre of brain tissue can take months. For a full human brain, we'd need unimaginable computing power, storage, and precision.

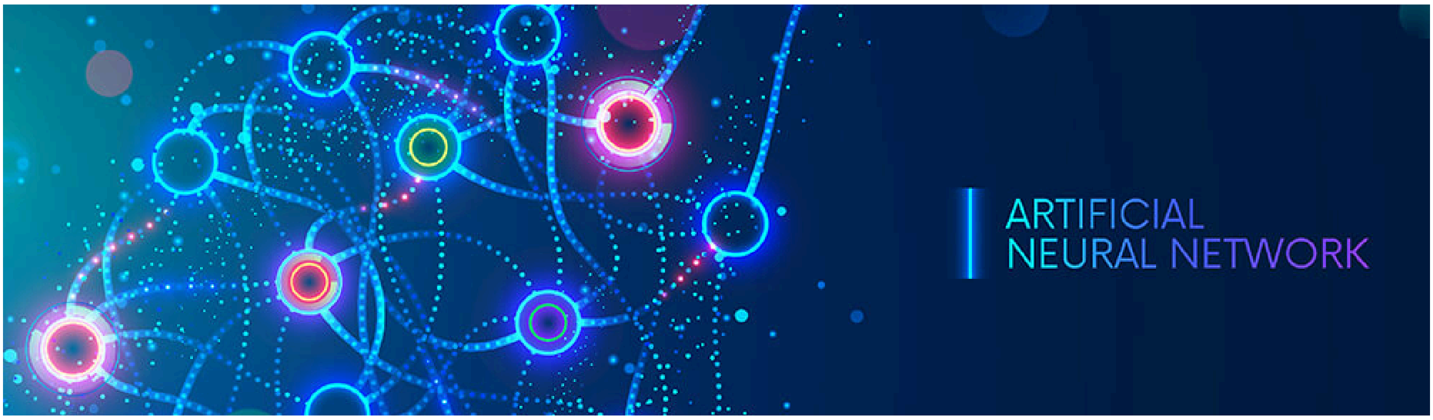
Still, the theory stands. If one day, technology could safely scan and replicate the entire connectome, a digital version of your mind could — at least in theory — come alive.

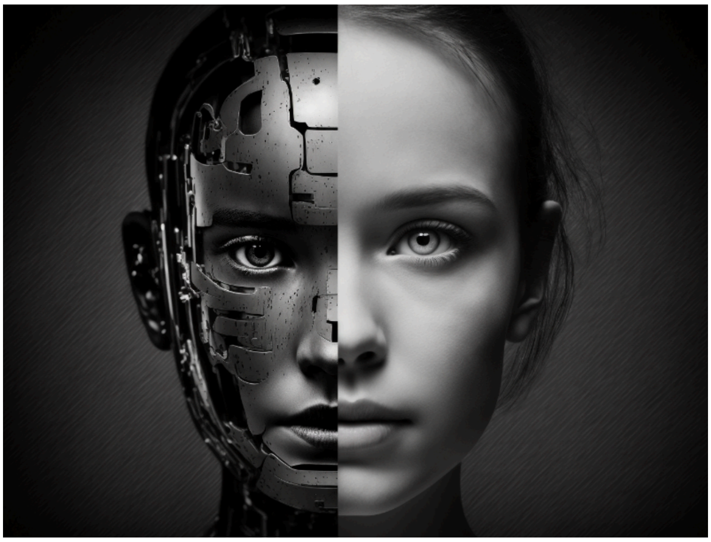
Supercomputers and AI:
Machines Which Think

Enter the supercomputers. These machines, capable of performing quadrillions of calculations per second, are humanity's best attempt at mimicking nature's complexity. Projects like the **IBM's Blue Brain Project and the Human Brain Project** are already trying to simulate small parts of the human brain digitally.

To understand how this works, think of **artificial neural networks** — the AI systems behind modern tools such as ChatGPT and self-driving cars. They're called "neural" because they're inspired by the structure of the human brain. Instead of real neurons, they use mathematical ones, arranged in layers that "learn" from data by adjusting the strength of their digital connections.

AI can already perform tasks that once required human intelligence — recognising faces, understanding language, generating art, and even composing music. Yet, despite their power, these systems don't actually understand what they're doing. They process patterns; they don't experience meaning.
This is the key difference. Even the most powerful AI doesn't have consciousness. It doesn't feel emotions, self-awareness, or pain. To upload a mind, we'd need not only a machine that thinks like a human but one that feels like one too.





Could AI Ever “Feel” Like Humans Do

This is where the debate begins. Suppose we could build a perfect digital model of your brain, complete with all its electrical impulses and memories. Would that model be you — or just a very accurate imitation?

Philosophers call this the **“copy problem.”** If we copy your brain into a computer, the digital version might think it’s you, but you — the original — are still sitting there, unchanged. You’d have created a second consciousness, not transferred your own to another medium.

Others argue that if the copy has all your memories, feelings, and sense of self, it’s essentially the same. After all, your brain is constantly changing and replacing its cells, yet you still feel like “you.” Maybe identity isn’t about the matter you’re made of, but the pattern of information that defines you.

Still, many scientists caution that consciousness might depend on biological processes we don’t yet understand. Some theories suggest that feelings and self-awareness emerge from the brain’s unique chemistry — something that can’t simply be copied into silicon.

The Ethical and Moral Dilemmas

Even if mimicking were possible, it would open a sea of ethical questions.

Would a digital mind have human rights? Could it own property, make decisions, or feel pain? What happens if the power goes out — would this count as death?

There’s also the question of control. Who owns your digital self? Could a company edit your memories or duplicate you a thousand times?

The possibilities are thrilling — and terrifying. Some dream of achieving digital immortality, living forever as code

How Close Are We, Really?

Despite what science fiction suggests, mind uploading is still a long way off. The main barriers are both **technical and philosophical.**

Technically, we can’t yet map the human brain with enough precision. Even if we could, storing all that information would require computing power far beyond what currently exists. A single human brain contains about 2.5 petabytes of information — equivalent to nearly 3 million gigabytes.

Philosophically, we still don’t know what consciousness truly is. If we don’t understand what makes us aware, how can we hope to recreate it?

We are making progress in smaller but significant steps. **Brain-computer interfaces**, like those developed by Neuralink, already allow paralysed patients to control devices with their thoughts. AI systems can mimic certain brain functions, and brain-mapping projects continue to improve their accuracy.

We might not upload a mind anytime soon, but we are certainly learning to understand it.

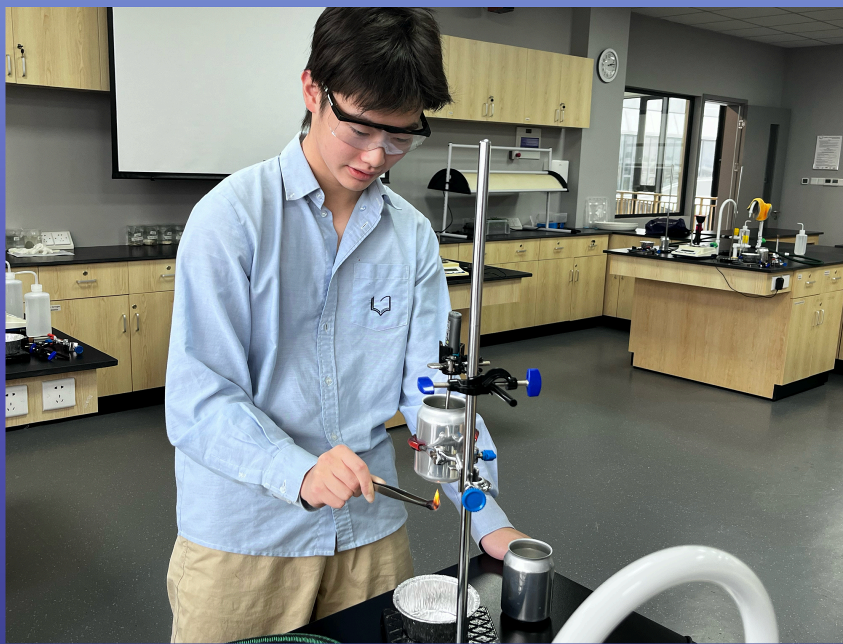
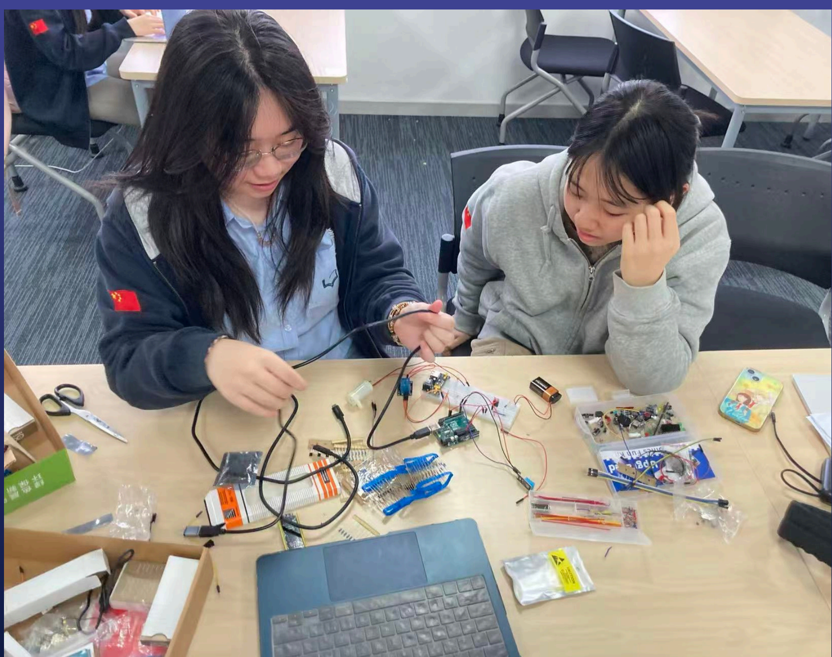
Why It Matters

So why does any of this matter if we’re still centuries away? Because the journey toward understanding the brain will reshape every aspect of our world — from medicine to ethics to what it means to be human.

Studying how the brain stores thought could help cure Alzheimer’s and mental illness. Developing AI which models human reasoning could revolutionise education and technology. Thinking deeply about identity might help us understand ourselves in ways we never have before.

In the end, perhaps the question isn’t whether machines can become human — but whether humans can use machines to become something more.


MARS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Hangzhou International School

2190 Xiangbin Road, Binjiang District, Hangzhou 310052
+86 571 8669 0045
info@hisdragons.org.cn
www.his-china.org

For further inquiries, please contact the Admissions Department
admissions@hisdragons.org.cn

Founded in 2002, Hangzhou International School was the first international school in Hangzhou and remains the only non-profit, WASC accredited, IB World School in Zhejiang province.