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Contributions to this Issue:

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

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Editors' Note

Young Scientists' Journal

TRINITY EDITION 2024

We welcome you to the Trinity 2024 edition of the LGS Young Scientists' Journal! Our goal is to ignite curiosity and foster a passion for scientific inquiry among students at LGS.

We are thrilled to present a collection of thought-provoking articles written by our very own students. This edition covers a diverse array of topics, from microplastics to placebo and nocebo effects, to brilliant beetles! We hope that these articles spark your curiosity and encourage you to ask questions, explore new ideas, and engage in the scientific community. Finally, we hope that you enjoy reading the articles as much as we did!

Cover Images:

'Microplastic pollution in water' by SGS Digicomply

'Pills' by Daniel Kaesler

'Strong Stag Beetle' by WildMedia

'DNA Chromosome' by BlackJack3D

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

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TRINITY 2024

Bizarre Beetles

By Kumari Lad

Key Words:

Order: the fifth ranking in the classification system, between Class and Family.

Terrestrial: anything that grows or comes from Earth.

Aquatic: often or always growing or living in water.

Semi-aquatic: a creature that can survive on land and in water.

Beetles are an insect that belong to the classification order called Coleoptera. Currently there are approximately 300,000 individual species of beetles known to man-kind. (Mound, 2017) In the UK 40% of all discovered insect species are beetles. (Twinkl, 2023) Beetles are primarily terrestrial, however there are species that are fully aquatic or semi-aquatic. (Mound, 2017)

Figure 1: Nephanes Titan (Schmidt, n.d.)

The smallest beetle in Britain is ironically called Nephanes Titan despite it only growing up to 1 mm. (New Forest National Park Authority, n.d.) A beetle's diet can range from a wide variety of plants or unfinished or corpses of unfinished prey. (Mound, 2017)

Figure 2: Mandibles of a Giant Stag Beetle (Nichols, 2015)

Mouthparts

The majority of beetle species have a pair of sharp mandibles (jaws). If the mandibles are more than half the length of the beetle's head, then they are called antlers. Antlers are more commonly observed on larger specimens such as stag beetles. When such species are spotted, passers-by often misinterpret the mandibles with an intention of harm, when it is scientifically proven that they only use their mandibles during mating and defence. There have been no recent reports of stag beetles unreasonably attacking a human apart from when they threaten a chase in an act of defence. (Amateur Entomologists' Society (AES), n.d.)

Mating

During the mating season, sightings of dying beetles will be on the rise due to males fighting for females. Males will usually end with missing legs or broken mandibles. Male beetles will use their large antlers to push or lift their opponent off the ground. Beetle Battles normally contain several rounds, and a new round will start every time the two males lock antlers. The winner is decided when one of the males surrenders or is immobilised. (Mound, 2017) If one of the fighters is immobilised, it will either die from starvation and dehydration or become prey to other hungry insects. (Mound, 2017)

Figure 3: Stag beetles fighting (Mrocek, 2020)

Weevils (Curculionidae)

A common mistake that people make when seeing or hearing weevils is that most people do not relate weevils and beetles as they sound completely unrelated, when the truth is quite the opposite. Weevils and beetles are in the same Classification family of Coleoptera. One of the biggest weevil families has the name of Curculiondae. It contains around 40,000 different species. (Mound, 2017)

The difference between many weevils and beetles is that beetles have feathered antennae, whereas most weevils have long bent antennae. (Encyclopaedia Britannica, 1998) While beetles have large visible mandibles, weevils usually have microscopic mandibles at the tip of their elongated snouts. (Mound, 2017) The largest weevil can reach up to 8mm and the smallest is 6 mm. (Encyclopaedia Britannica, 1998) The most common colours for weevils are dull natural colours so they can camouflage in with their surroundings, whilst other species of weevil are more brightly coloured to ward off predators. (Mound, 2017) Even though beetles and weevils are in the same family, most weevil species lack a pair of wings, unlike beetles who always have a pair of wings. (Encyclopaedia Britannica, 1998)

Key Words:

Antenna: a thin sensitive organ on the head of an insect, crab, etc., that is used mainly to feel and touch things.

Larva: a form of an insect that has left its egg but has not yet developed into an adult.

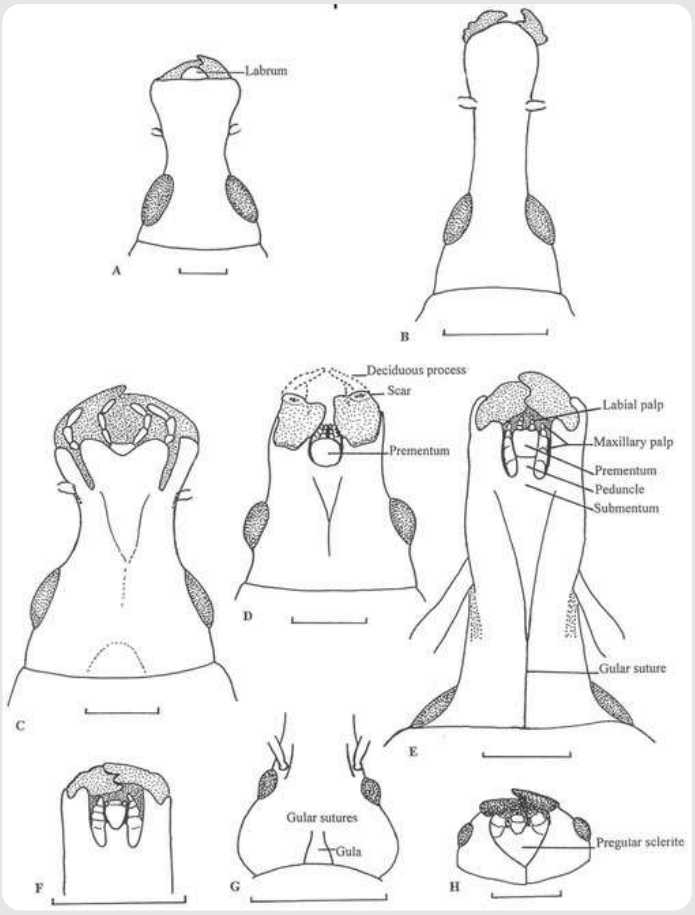

Figure 4: Characteristics of mouthparts of weevils (Marvaldi, 2005)

The diet of weevils only contains plant material. The larvae of weevils are legless and are just made up of flesh, they move around by elongating and then contracting their body. As larvae, certain species of weevil will feed on specific parts of the host plant. Weevil larvae will only eat either the seeds, the fruits, stems, roots, or the flower bud. Different people have different opinions on whether to call weevil larvae pests, as it can sometimes stop the plant from reproducing.

As an adult, a weevil will eat any part of a plant if the plant is a similar or closely related species to the host plant it feasted on when it was a larva. (Encyclopaedia Britannica, 1998)

Extra facts:

- Beetles and weevils have bad eyesight, so they communicate through touch, smell and sometimes vibrations! (Pest World for Kids, n.d.)
- Most beetles live up to a year. (Pest World for Kids, n.d.)
- Female weevils and beetles can lay twelve to hundreds of eggs. (Twinkl, 2023)
- All adult beetles have wings but, on some species, they don't work or are too short. (Twinkl, 2023)

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Key Words:

Chronic Obstructive Pulmonary Disease (COPD): a common lung disease causing restricted airflow and breathing problems. Also known as emphysema or chronic bronchitis.

Enzyme: proteins which speed up a chemical reaction.

Amino Acids: chemical building blocks which combine to create proteins

TRINITY 2024

Are Microplastics the Next Big Environmental Threat? What are the Possible Solutions?

By Muhammed Nasir

What Are Microplastics?

Microplastics are tiny plastic particles typically measuring <5mm (0.2 inches) in diameter. They are classified as either primary or secondary microplastics. Primary microplastics are intentionally manufactured for commercial use, such as those found in cosmetics and textiles like microfibre cloths or exfoliated scrub beads, as well as microfibres shed from clothing and fishing nets. On the other hand, secondary microplastics result from the breakdown of larger plastic items due to environmental factors like solar radiation and mechanical friction like ocean waves and car tires. Problems arise with microplastics for the same reasons as plastics of any size: they do not quickly break down into their monomers; rather, plastics can take hundreds or thousands of years to decompose. (Brown, 2023)

The Scale of the Problem

Due to the small size of these plastics, they are very easily ingested and inhaled, which can lead to their accumulation in organs via the respiratory, digestive, and circulatory systems.

In a recent study published in Environmental International, researchers developed a method of detecting microplastics in human blood. The researchers looked for particles that could pass across cell membranes.

To collect any plastic particles in the blood, they used a glass fibre filter to avoid any plastic contamination, collecting microplastic between 700 nanometres and 500,000 nanometres. (Leslie, et al., 2022) (Goodwin, 2022).

The researchers observed five common plastics:

- Polyethylene (PE): the most widely used plastic, most commonly used for carrier bags but often used in many other appliances.
- Polyethylene terephthalate (PET): heavily used in textiles and food and drink containers.
- Poly(methyl methylacrylate) (PMMA): used in dentistry and other clinical applications.
- Polypropylene (PP): commonly used for packaging and textiles.
- Polymerized styrene (PS): used for lightweight packaging.

The researchers' main conclusions:

- The researchers found that more than three-quarters of the blood samples contained a quantifiable mass of plastic particles.

- The researchers found PET — which most drink bottles are made from — in the blood of more than half of those tested but did not detect PP in any of the samples.
- Researchers found at least three different types of plastic in some blood samples. (Leslie, et al., 2022)

In another study conducted by researchers from the Medical University of Vienna and presented at the United European Gastroenterology Week, researchers examined stool samples from eight individuals residing in locations including Finland, Italy, Japan, the Netherlands, Poland, Russia, the United Kingdom, and Austria. Over the course of one week, each participant maintained a food diary, after which stool samples were collected for analysis. Remarkably, microplastics were detected in every single stool sample examined. The investigation revealed the presence of up to nine distinct types of plastics in each sample, with particle sizes ranging from 50 to 500 micrometres. Polypropylene and polyethylene terephthalate were the most commonly observed plastics. On average, researchers identified 20 microplastic particles per every 10 grammes of stool. (Philipp Schwabl et al., 2019)

However, the collection of microplastics in large amounts is mainly found in the ocean, with one study estimating that 15-51 trillion particles, weighing between 93 and 236 thousand metric tonnes, entered the ocean in 2010 (Erik van Sebille et al., 2015). This sheer amount clearly shows the scale of the ubiquitous nature of microplastics.

Do Microplastics Actually Cause Harm?

While it's widely believed that microplastics pose harm to the body, there remains insufficient evidence to support these claims indisputably. However, given the potential risks involved, it's imperative to take steps to mitigate their possible impact in the future.

An increasing amount of research relating plastics to various health issues, such as lung diseases, including asthma, chronic obstructive pulmonary disease (COPD), and cancer, is being carried out. The American Lung Association's report highlighted COPD as the fourth leading cause of death in the United States, underscoring the seriousness of finding possible links between respiratory ailments and plastic pollutants.

Humans encounter foreign particles daily, triggering the body's defence mechanisms to remove them. While larger particles are typically coughed out, smaller ones may accumulate in the respiratory tract, potentially leading to inflammation, infection, or even cancer over time.

Studies such as the U.K. Lung Study, have identified plastic particles known to be toxic to humans, raising concerns about their health impacts. Symptoms associated with exposure to these plastics include lung irritation, dizziness, headaches, asthma, and cancer. However, the extent of harm caused by plastic particles in the lungs remains uncertain, necessitating further investigation (Parker, 2023). A study on rodents (which is not always applicable; for example, 94% of drugs that pass animal trials fail in human trials) shows microplastics can accumulate in testes, risking reproductive health and sperm quality (Liu W, Zhang B et al., 2023).

However, a 2019 Australian study on Japanese quail chicks challenged this. Despite being deliberately fed these microplastics, the chicks experienced minor growth and maturation delays but did not show an increase in reproductive issues (Lauren Roman et al., 2019). This unexpected finding underscores the complexity of assessing the impact of plastic exposure and the need for cautious interpretation of research findings.

Key Words:

Pre-emptive: done before other something can happen.

Optical Proterties: how it looks eg. gloss, colour, transparency.

Barrier Properties: how easily substances can get through the plastic i.e. permeability.

Inert: chemically unreactive.

Aromatic: a type of structure in chemistry which is stabilised due to the presence of (a) ring(s) of specially bonded atoms.

Why Is It So Difficult to Draw Conclusions?

Measuring the impact of plastic on human health is difficult, especially compared to animals (we cannot just feed people plastic). Also, current research has only been undertaken with small sample sizes and limited data. Furthermore, in one plastic product, there can be thousands of chemicals, making it difficult to pinpoint which are harmful. Also, microplastics may be coated with bacteria or other pathogens, which may cause adverse symptoms.

Albert Rizzo, from the American Lung Association, has drawn parallels between the uncertainty surrounding microplastics and the historical struggle to prove the link between smoking and cancer. He emphasises the importance of pre-emptive action to ensure public health, suggesting efforts to make plastics safer while awaiting clearer evidence. Overall, while concerns about the potential harm of microplastics persist, ongoing research is essential to fully understand their implications and inform effective strategies to mitigate risks to human health. (Parker, 2023)

How Can we Prevent a Future Problem With Microplastics Without Harming the Environment?

To prevent a future problem with microplastics, we cannot allow plastics to enter the ocean, where they eventually break down into potentially harmful microplastics. However, current recycling methods entail significant energy consumption and reliance on high temperatures. Processes such as melting plastics to reshape them require substantial amounts of energy, typically derived from fossil fuels. These energy-intensive methods not only contribute to greenhouse gas emissions but also increase the overall carbon footprint of recycling processes. Additionally, heating plastics to high temperatures can release harmful pollutants into the atmosphere, posing health risks.

Furthermore, the linear nature of current recycling methods contributes to the unsustainable depletion of resources, highlighting the need for a shift towards a circular economy model where plastics are broken down into their monomers to be reused and recycled indefinitely.

The Discovery of a Bacterium

PET accounts for 12% of all global waste, and it is estimated that 50 million metric tonnes are produced globally every year which is forecasted to rise to 100 million tonnes by 2025. PET has good mechanical, optical, and barrier qualities. Water and soft drink bottles are only two of the countless applications for PET as it is a polyester molecule that is chemically inert due to its high aromatic content. Because of this, it is usually thought to be resistant to microbial deterioration, even though some fungi can grow on mineral media that contain PET. A significant portion of the 50 million metric tonnes of PET produced annually finds its way into the environment (Saxena, 2016). As PET-based products are notoriously difficult to recycle, the demand for PET grows alongside the mountains of plastic waste in landfills.

Key Words:

Buffer: a chemical that keeps a liquid from becoming more or less acidic

Metabolise: to use chemical processes to turn food into energy, new growth, and waste products

Gram-Negative: bacteria that appear red after a chemical process called gram staining is used on them

Hydrolysis: a chemical reaction where water is used to break down the chemical bonds in a particular substance.

Phylogenetic Tree: a diagram which shows the evolutionary history among a group of organisms.

Denature: when an enzyme that loses its normal three-dimensional (tertiary) structure.

Active Site: the region of an enzyme where only specific molecules can bind and undergo a chemical reaction.

Enzyme-Substrate Complex: a temporary molecule formed when an enzyme comes into perfect contact with its substrate at its active site.

In 2016, Japanese scientists were sifting through plastic bottles in search of a bacterium that would degrade polyethylene terephthalate (PET) and use it as a carbon source. Looking through the recycling plant, they collected 250 PET-contaminated samples of sediment, soil, and waste water in total. They cultivated 1 gramme of each in test tubes using yeast extract, ammonium sulfate, a phosphate buffer, and a modified lettuce and egg medium.

By placing a thin, 0.2-mm-thick PET film into each medium, the team was able to observe any culture that thrived on PET. After 15 days, one sediment sample stood out; the culture had eaten through the PET film, degrading the film at a rate of 0.13mg per square centimetre each day and converting 75% of the PET carbon into carbon dioxide.

The researchers then isolated the bacteria that metabolised the plastic film, finding Ideonella sakaiensis (a gram-negative bacteria).

Few enzymes are now known to be able to hydrolyze PET, so the team sequenced the genome of I. sakaiensis to find out what enzymes it employs. They found one gene, ISF6_4831, which codes for a protein that shares half of its amino acid composition with another enzyme that breaks down PET. Using the DNA sequence of the enzyme ISF6_4831, the team created a phylogenetic tree to help find enzymes that are known to degrade PET. Here they found two other enzymes that catalyse the hydrolysis of PET into its monomers, but ISF6_4831 was the best. (Shosuke Yoshida et al., 2016)

Seemingly now PET monomers can be recycled into another polymer without any extra energy input, promoting a circular economy. However, the enzyme found in the study was very unstable, denaturing very easily and requiring a very specific pH and temperature. (Shosuke Yoshida et al., 2016) . A specific pH is needed since changes in pH affect the interactions between the 'R' groups of the amino acids, leading to altering or breaking the hydrogen and ionic bonds that hold the 3D structure of the protein together and changing the shape of the active site (denaturing it and rendering it useless).

A specific temperature is needed as if the enzyme is too hot, hydrogen and covalent bonds are broken, so the 3D tertiary structure of the enzyme changes, changing the complementary active site (again denaturing it and rendering it useless). This is due to an enzyme substrate complex not being able to form. However, if the temperature is too low, the rate of reaction is very slow as the enzyme and substrate molecules have little kinetic energy and thus have a low chance of colliding successfully and reacting.

Therefore with this enzyme, the researchers found that it was very difficult to create the optimum conditions for this enzyme to work in.

Key Words:

Neural Network: a machine learning program, or model, that makes decisions in a manner similar to the human brain.

The Help of Artificial Intelligence

Since an enzyme is just a polymer of amino acids folded up to form proteins, perhaps the amino acid sequence could be tweaked so the enzyme could perform better? However, how would we know which amino acids to change?

In May 2022, a team from the University of Texas used a neural network to engineer and improve the performance and stability of a machine learning (AI) algorithm which models amino acids. It was given a data set in which it studied 19,000 proteins, learning the patterns of what makes a protein stable. It came to the conclusion that amino acids that fit well in the protein will lead to stability, increasing the performance of the enzyme. This is due to the molecules being closer together, thus having stronger bonds. The algorithm then focused on the amino acids in the enzyme ISF6_4831; it checked to see if each amino acid fit well by comparing it with its data set. the algorithm suggested different amino acids in the place of amino acids that did not fit well. Out of the 219 amino acids in the enzyme, it suggested replacements for three amino acids. (Lu, H., Diaz, D.J., Czarnecki, N.J. et al., 2022)

These changes of amino acids resulted in the enzyme becoming 'highly, highly active, especially at lower temperatures compared to anything else out there'. (Lu et al., 2022) This enzyme was then tested with real-world items; it managed to break down an entire plastic tray within 24 hours. They concluded that almost all PET plastics could be completely degraded in a week.

The team managed to retrieve 94.5% of the monomers needed to make new plastic. The team would not have to worry about uncontrollable reproduction either since enzymes are used versus entire bacteria.

Many media outlets have criticised the enzyme as it creates a by-product of carbon dioxide, though some argue that a far lesser amount is emitted by this method of degradation versus incineration of the plastic. It should also be noted that the optimal temperature for the enzyme is 50 °C, which is too high to work in ambient conditions. However, this could be reduced in the future using better neural networks to develop a better enzyme.

In conclusion, there is still a large amount of research to be done to fix the microplastic problem, however AI could definitely play a key role.

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TRINITY 2024

Horizontal Gene Transfer Mechanisms in Tardigrades

By Angel Fagboyo

Key Words:

Horizontal Gene Transfer: the movement of genetic material between organisms other than by the transmission of DNA from parent to offspring.

Cryptobiosis: a state of extreme inactivity in response to adverse environmental conditions.

Metabolic Activity : the chemical processes within the body required for life.

Metamorphosis: the process by which the young form of some animals develops into the adult form.

Anhydrobiosis: the ability of certain organisms to survive almost total dehydration.

What Exactly Are Tardigrades?

Discovered in 1773 by German Zoologist Johann August Ephraim Goeze. Tardigrades, commonly known as water bears or moss piglets, are tiny aquatic creatures with chubby, segmented bodies and flat heads. They possess eight legs, each ending in four to eight claws or digits.

What Makes Tardigrades So Unique?

They are near-microscopic animals, and they can survive many extreme conditions on Earth, including freezing temperatures and crushing pressures (Bradford and Weisberger, 2024) and have even survived exposure to outer space (Courtland, 2008).

So Why Are They So Indestructible?

Tardigrades can enter into a death-like state called cryptobiosis, where they can expel more than 95% of the water inside their bodies, retracting their heads and legs and curling into a dehydrated tun. (Bradford and Weisberger, 2024). In cryptobiosis, the metabolic activity of a tardigrade decreases to as low as 0.01% of its usual levels. The cells are shielded from harm by specific water-soluble proteins found only in tardigrades, referred to as tardigrade-disordered proteins (TDPs). TDP molecules create a resilient, glassy enclosure around the cells as tardigrades expel their bodily water. This safeguards cellular components while the tardigrade enters a dormant state, allowing it to revive in water when conditions become favourable. (Boothby et al., 2017).

How Do Tardigrades Enter a "Tun" State?

Tardigrades enter their tun state through a metamorphosis known as anhydrobiosis, but how they do this has been a longstanding mystery. However, recently, researchers discovered the molecular underpinnings that allow them to enter their near-invincible state. (Smythers et al., 2024). The team exposed the Hypsibius exemplaris to a series of life-threatening conditions, such as dangerous levels of hydrogen peroxide and temperatures of minus 80 degrees C. It measured the chemical environment inside the tardigrades' cells. They discovered that tardigrades produce free radicals - oxygen

atoms with an additional unpaired electron that emerge in animal cells during a phase known as oxidative stress. This would be very harmful in most animals, but in tardigrades, free radicals react with the amino acid cysteine to transform them into their tun state. They then inhibited the cysteine oxidation process and saw that the tardigrades could not enter the tun state.

What Is Horizontal Gene Transfer?

Horizontal gene transfer (HGT), or lateral gene transfer, is the non-sexual transfer of genetic information between genomes. It occurs in both eukaryotes and prokaryotes (Rogers, 2011). DNA or RNA can replace existing genes or introduce new ones into a genome. (Keeling and Palmer, 2008). This can include passing on genes that make bacteria resistant to antibiotics. Instead of passing from parent to offspring like usual, these genes can spread among bacteria, helping them evolve into more dangerous pathogens. HGT happens through three precise genetic mechanisms: Transformation, conjugation and transduction. Transformation is when the bacteria are taken up from the environment, conjugation is when the bacteria directly transfer genes to another cell, and transduction occurs when bacteriophages move genes from one cell to another. (Burmeister, 2015).

In horizontal gene transfer, newly acquired DNA is incorporated into the recipient's genome through either insertion or recombination. Recombination is the regrouping of genes, such that the foreign and the native homologous DNA segments are edited and combined. Insertion happens when the foreign DNA introduced into a cell shares no homology with the existing DNA. This means the new genetic material is incorporated between existing genes in the recipient's genome. However, in eukaryotes, the process of horizontal gene transfer is a lot more complicated. This is because the DNA has to pass through both the outer cell membrane and the nuclear membrane in order to reach the eukaryote's genome.

Key Words:

Oxidative Stress: an imbalance of free radicals and antioxidants in your body that leads to cell damage.

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

Eukaryote: a type of organism that has one or more cells each with a separate nucleus containing chromosomes, which includes all animals and plants.

Prokaryote: a type of organism that has only one cell and does not have a nucleus, for example a bacterium.

Bacteriophage: a virus that grows and divides inside a bacterium, destroying it.

Homologous: having a similar position, structure, value, or purpose.

Vesicle: a small structure like a bag in a human, animal, or plant.

Prokaryotes can share DNA with eukaryotes, although the exact mechanisms still needs to be adequately understood. Proposed mechanisms include conjugation and endocytosis, where a eukaryotic cell engulfs a prokaryotic cell and encloses it within a specialised membrane-bound vesicle for breakdown. It is believed that in certain rare cases of endocytosis, genes may elude prokaryote degradation and become integrated into the eukaryotic cell genome. (Rogers, 2011b).

How Does Horizontal Gene Transfer Link to Tardigrades?

As mentioned, extremophiles possess the suitable proteins and enzymes to survive extreme conditions. (Kumar et al., 2018). By researching the genetic material transferred through horizontal gene transfer, scientists can identify

the genes responsible for producing these unique biomolecules. These enzymes and proteins could have industrial applications. Thermophilic microorganisms (organisms that thrive in high-temperature environments) are significant reservoirs of thermozymes. The resilience of thermozymes to high temperatures is frequently exploited in demanding industrial procedures, rendering them highly advantageous for biotechnological endeavours. Thermostable hydrolases, such as amylases, lipases, and proteinases acquired from thermophilic bacteria and archaea, find application in diverse biotechnological sectors like agriculture, pharmaceuticals, and food processing. Additionally, thermostable polymerases originating from thermophilic microorganisms have transformed the realm of molecular biology. (Tadevosyan et al., 2022).

Studying how tardigrades avoid this damage during desiccation (drying) could help uncover how HGT functions. By investigating how tardigrades transfer their genes conferring resistance to extreme dryness, scientists might discover novel genetic mechanisms of HGT. These techniques could eventually lead to methods to transfer favourable genetic attributes, such as desiccation resistance, between organisms and create organ-preservation solutions for transplants. Think of doubling, tripling or quadrupling the period a heart or kidney or another organ can last in storage for transplantation. The possibilities for the development of organ transplants would be endless. (Criswell et al., 2022).

Tardigrade stress genes have successfully been transferred into humans because tardigrades possess a repertoire of genes that enable them to withstand desiccation, radiation, and other stressors. Being able to incorporate these genes into human cells, researchers aim to enhance cellular resilience, offering new avenues for therapeutic interventions and insights into ageing processes. (Team and Team, 2023)

Key Words:

Thermozymes: enzymes that have unique characteristics such as temperature, chemical, and pH stability.

Thermostable: capable of withstanding moderate heat without loss of characteristic properties.

Hydrolase: a class of enzymes that commonly function as biochemical catalysts that use water to break a chemical bond.

Thermophilic: of, relating to, or being an organism living at a high temperature.

Archaea: a type of microorganism similar to bacteria but with a different structure, thought to have existed for billions of years.

Irrigation: the practice of supplying land with water so that crops and plants will grow.

The insights into tardigrade genes might also improve crops, making them more resistant to various challenges, from heat and drought to attacks by pathogens. Researchers can search for tardigrade genes and mechanisms that allow crops to tolerate extremes. Inspired by HGT mechanisms that make tardigrades so good at horizontally acquiring beneficial genes, researchers could create new ways to modify crops genetically. It should be possible to move the tardigrade genes involved in desiccation resistance, thermal tolerance and resistance to pathogens into crop plants, potentially turning crops into much more resistant and resilient organisms in poor growing conditions. This approach to agricultural biotechnology can transform farming here and everywhere by improving crops' resilience to environmental stressors, leading to higher yields, fewer losses after environmental stress and less use of chemical pesticides and irrigation.

The development of genetically modified crops using HGT will also help with the sustainability of agriculture by increasing the diversity of crops in use and stress-resilience in an era of climate change and ever-evolving pathogen threats to crops and agriculture themselves. (MacDonald, 2015).

Investigating the complexities of horizontal gene transfer processes in tardigrades is extremely promising since it could lead to discovering a wealth of new enzymes and biomolecules with enormous potential in various fields. Through understanding the genetic codes that allow tardigrades to survive in harsh settings, scientists may imagine a time in the future when these amazing creatures will be the source of novel ideas for advancements in industry, medicine, and environmental preservation. A new era of scientific and technological discovery and application may be brought in by using the insights gained from tardigrade research to guide unrelenting exploration and interdisciplinary collaboration toward innovative answers to urgent global concerns.

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TRINITY 2024

Mind Over Medicine, the True Power of Perception - The Placebo Effect

By Samarth Vemala

Key Words:

Placebo: an inactive substance given to someone who is told that it is a particular medicine, either to make that person feel as if they are getting better or to compare the effect of the particular medicine when given to others.

Physiological: relating to the way in which the bodies of living things work.

Arthroscope: an instrument through which the interior of a joint may be inspected or operated on.

Opioids: a broad group of medicines used to relieve pain

The mind is a weird and wonderful thing we still have much to learn about. Its intricacies still puzzle many researchers to this day and there is still much to be discovered about how our brain works. One such effect that astounds many is the placebo effect. The placebo effect is a fascinating phenomenon where a person is given a pharmaceutically ineffective treatment but still feels better. This concept seems counter intuitive, as it seems impossible that something that has no physiological effect on a person could have any way of making them feel better, but the power of this effect rests in the mind and the unassuming but great power that a person's beliefs and willpower can have. The placebo effect challenges the traditional notions of healthcare and underlines the powerful effect of the mind.

An example of the placebo effect was seen in a study conducted in which one group of patients underwent knee surgery for symptomatic relief (to reduce pain), while the other group underwent a placebo surgery.

An arthroscope wasn't actually inserted but the patients still received skin incisions, went to theatre, and were reassured by doctors as if they were actually having the surgery.

The outcomes after arthroscopic lavage (washing out the knee cavity) or arthroscopic debridement (removing dead or infected tissue) were no better than those after a placebo procedure.' (Moseley JB *et al.*, n/a). This encapsulates the essence of the placebo effect, as the familiarity and reassurance given within the medical procedure actually reduced the pain of the patient without surgery being needed. This pain relief can be explained as the act of going into surgery which stimulates the release of endorphins (chemicals the body releases in response to pain or stress); chemicals similar to opioids like morphine. 'Like morphine, these endorphins bind to opioid receptors and cause pain relief. Therefore, in response to positive expectations of treatment, your brain becomes flooded with its own supply of natural painkillers.' (SITNFlash, 2016). This gives us the chemical reason for why the placebo effect occurs as drugs such as morphine are chemically engineered to simulate endorphins that activate our natural reward pathway.

Key Words:

Evolutionary: a relating to the way in which living things develop over millions of years.

Peptide: a molecule that contains two or more amino acids. Multiple peptides join together to form proteins.

This then raises the question of whether surgery is needed for symptomatic relief (reducing pain) if a placebo alternative has the same effectiveness.

The incredible power of the placebo effect is even effective when the patient knows about its use. This was seen in a study led by Kaptchuk and published in Science Translational Medicine conducted on people's reaction to migraine pain medication. In the study 'one group took a migraine drug labelled with the drug's name, another took a placebo labelled "placebo," and a third group took nothing. The researchers discovered that the placebo was 50% as effective as the real drug to reduce pain after a migraine attack.' (Havard health, 2021).

This study therefore presents the evidence that just the act of taking a pill, while knowing that it was a placebo pill, still had a positive effect. This could be a result of the associative learning we have picked up through our lives. An analogy for this is the experiment regarding Pavlov's dogs. Pavlov paired the sound of a bell with the presentation of food. Over time, the dogs began to associate the bell with food and would start to salivate at the sound of the bell, even when no food was presented.' (Structural learning, n/a). This demonstrates the idea of associative learning, and this same phenomenon is present in humans. This could have led to the positive effect of the placebo pills, given that the act of ingesting pills is associated with reducing pain.

The origins of the placebo effect have been theorised by the pain researcher Patrick Wall to be an evolutionary benefit after pain. He explains that pain not only has the function of alerting the sufferer of tissue damage but also acts as a motivator for the sufferer to withdraw from the harmful situation they are in (e.g. moving their hands out of fire). Therefore, once suitable action is taken, the pain is allowed to subside. This is seen with the placebo effect as Wall says, 'the placebo is not a stimulus but an appropriate action' (Wall, 2000, p. 155). This can extend to actions that seem to have no obvious effect, an example of this is a parent kissing an injury on their child to make it better. The child's pain due to injury is an evolutionary mechanic to prevent the child moving and further damaging the area.

It also acts as a deterrent for the child to do the dangerous activity that caused the injury in the first place. Once the parent comes over to care for the child and gives them the kiss, there is no physiological effect as the saliva has little effect on the wound, but instead the brain believes appropriate action was taken as the carer can now properly look after the child, so the need state has been fulfilled and the pain subsides.

The placebo effect is not just within the mind however and can actually illicit a physiological response. This is seen in a study done on the effect of what people were told, and the amount of the gut peptide ghrelin that they produced. Ghrelin is a hormone secreted in the gut that manages hunger levels and signals to the brain when it is time to seek out food. When ghrelin levels in the stomach rise, hunger is signalled to the brain so it can find food, while if ghrelin levels drop the opposite reaction occurs and the brain realises that the body is full and it must focus on metabolism to burn the calories that were just ingested. In the experiment, one group of people were told that they were given an 'indulgent' shake with 620 calories in it, while another group of people were told they were given a 'sensible' shake with 140 calories in it.

Key Words:

Neurology: the branch of medicine concerned with the study and treatment of disorders of the nervous system.

Nocebo: an effect that occurs when negative expectations of the patient regarding a treatment cause the treatment to have a more negative effect than it otherwise would have.

Both parties were actually given a 380 calorie shake and their ghrelin levels were measured intravenously, 'The mindset of indulgence produced a dramatically steeper decline in ghrelin after consuming the shake, unlike the mindset of sensibility, which produced a relatively flat ghrelin response. Participants' satiety was consistent with what they believed they were consuming rather than the actual nutritional value of what they consumed.' (PubMed, n/a) This highlighted the fact that the placebo effect doesn't just influence neurology but also influences the rest of the body. This proves that people undergoing the placebo effect aren't just 'crazy' and the symptoms they are having are real and they aren't 'faking it'; it's just that the source of these symptoms is their mind as opposed to their external surroundings.

Conversely, the nocebo effect is the placebo effect's vicious counterpart. This is because there is a very real inverse to pain killing effects and if the patient believes so; they can experience pain and discomfort. This can mean that 'germs are not the only way that illnesses can spread. Psychological outbreaks are very real' (MCpress, 2024). This conveys the fact that the media especially holds a lot of power and should therefore take responsibility and caution in what it displays. An example of a hoax that spread was the Covid-19 vaccine having many side effects (such as blood clotting and headaches); the nocebo effect then often caused people who believed this to get these side effects more often than people who didn't.

In conclusion, the placebo effect is proof of the wonderous strength and ingenuity of the human mind that we have barely scratched the surface of. The placebo effect has many benefits to healthcare and can reduce our use of drugs such as morphine. The serious ethical question we must ask ourselves however is whether it is morally acceptable to lie to a patient about the drug they are taking to maximise the outcome of the placebo effect; in our current medical system we oppose this. Despite this, the placebo effect can still play a role in helping patients as we know that it has a positive effect even if the patient knows about it (even if this effect isn't as big versus when patients don't know about it). So, it can be disclosed, and doctors don't have to lie to patients.

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TRINITY 2024

The Use of Artificial Intelligence in the Future of Dentistry

By Yusuf Desai

In recent years, artificial intelligence (AI) has become key in many sectors with its many applications. From its simple daily uses within home devices such as Google Home and Alexa to its medical applications; AI is much more, as it can mimic human cognitive abilities, offer innovative solutions, and more. As AI technology continues to advance, the use of AI in dentistry is imminent. The use of this technology will help to revolutionise patient care and improve oral healthcare, increasing efficiency and accuracy.

Current Dentistry

Dentistry heavily relies on manual processes and assessments, which are used for diagnoses and treatment plans based on clinical judgment. Oral health and disease are diagnosed by a dentist based on visual and multiple tactile exams. A dentist's work is also closely supported by imaging techniques such as X-rays. A treatment plan is then derived from the examinations, and investigations are undertaken by the dentist following the latest research and guidelines. However, this may be subjective as it is based on factors such as the knowledge of the individual dentist, the studies and research used, and the local guidelines. This creates discrepancies in treatment planning and in patient care. This poses the question, "How can AI be used to improve patient care in the oral health sector?"

Key Words:

Artificial intelligence - a set of technologies that allow computers to perform a variety if advanced functions, like the ability to see, understand and translate spoken and written language, analyse data, make recommendations and more.

Intraoral tissue - soft tissues within the mouth such as the tongue, mouth, throat and gums.

Radiolucency – an area almost entirely transparent to radiation; almost entirely invisible in x-ray photographs.

Pathology – the study of disease and injury.

Current Uses of AI in Dentistry

Currently, in oral health, AI is often used along with an intraoral scanner. This scanner involves a camera that takes multiple pictures simultaneously of the intraoral tissues to create a 3D image that can be viewed, manipulated, and printed. This helps to minimise the use of impression materials, which can be costly, environmentally unfriendly, and uncomfortable for the patient. From the dentist's perspective, this is a quick and straightforward way to visualise the intraoral tissues on a screen and discuss them with patients. AI is used in the formulation of these images by filling in any areas that have been captured inaccurately by the scanner.
This processing alone has improved the efficacy of intraoral scanners. Furthermore, patients can be visually guided when considering treatments such as orthodontic alignment.

Invisalign is one of the brands that offer a simulation at the initial consultation appointment to help the patient envision their desired results. This can often help to manage a patient's expectations and give a realistic indication of the treatment outcome.

Future Applications of Artificial Intelligence in Dentistry

AI has no limitations on its software development or the roles it could take up in the dental sector. AI can analyse large data sets quickly, aiding in the analysis of dental images, patient records, and medical histories, highlighting them to the dentist.

One major use of AI in the future of dentistry is for diagnosis and treatment planning. The AI algorithms can be used to aid dentists in creating personalised treatment plans, catering to each patient's critical medical concerns, such as allergies, drug interactions, and complications, all of which should be carefully considered. It can then recommend to the dentist a plan of procedures to ensure the patient is treated safely and efficiently. (Chen et al., 2021)

X-rays are used regularly in the dental clinic. An X-ray helps give the dentist a deeper insight into what is causing a problem. When a dentist believes an X-ray is justified for an assessment of a problem such as tooth decay, they are looking for areas of radiolucency in the image. Radiolucency is a change in contrast on a radiograph, which can be used to identify various tissues as well as pathology. Radiolucency can be easy to miss and misinterpret. A dentist must be thorough with their diagnosis before undergoing any treatment. However, any dentist can make a mistake. So where can artificial intelligence help? When an x-ray or radiograph is taken, AI can be used to help identify any abnormalities in the images.

Key Words:

Plaque - a biofilm of microorganisms that grows on surfaces in the mouth.

Tartar - plaque that is initially sticky and colourless but eventually turns brown or pale yellow.

Gingivitis - inflammation of the gums.

Periodontitis - a serious gum infection that damages the soft tissue around teeth (gum disease).

Radiograph - an image produced on a sensitive plate or film by x-rays or other radiation and typically used in medical examination

Film faults - errors or defects that occur during the process of capturing and developing dental radiographs (X-rays).

For example, concerning tooth decay, the depth of the cavity is key to the subsequent filling procedure that follows. If all decay is not removed from the tooth, it can cause reinfection and spread to cause more problems for the patient in the future and potential tooth loss. So, this is a measurement needed at great accuracy. AI can help to not only find any decay in the x-ray of the patient by pointing out radiolucency but also give the information needed for further procedures to guide the clinician to a more accurate result. (Sharma et al., 2020)

Periodontal disease, more commonly known as gum disease, usually begins with poor oral hygiene practices. The build-up of plaque accumulating on the gum line reacts with minerals in your saliva to harden and become tartar. This causes bleeding under small amounts of pressure and swelling of the gums. If left untreated, gingivitis can worsen, causing a chronic inflammatory response that causes the gums to pull away from the teeth, forming pockets where infection occurs underneath.

This causes mass amounts of damage to the bone and surrounding tissues of the tooth, leading to the worst state of gum disease, periodontitis. For dentists, periodontitis is further split up into different grades and stages when diagnosing. The staging is based on the degree of bone loss and grading on how aggressively the disease is progressing; both are based on numerical values from a radiograph. Risk factors, such as smoking and diabetes, can also influence the diagnosis. As periodontitis is the sixth most prevalent disease in the world (Scott, J. et al., 2023), dentists must undergo the prolonged process of staging and grading the disease.

AI can be used in the future to help make this process more efficient and much easier for the dentist to do. With AI's ability to analyse radiography, combined with the patient's data, it will be able to diagnose the stage and grade of periodontitis the patient is currently undergoing. This will inevitably give a more accurate and reliable set of results to create a treatment plan to prevent the periodontitis from becoming worse, which can inadvertently contribute to many other health complications.

Challenges and Problems AI Could Encounter

In many of the methods mentioned above as to where AI can be used in the future, radiography and x-ray images are used. The AI may work completely fine; however, dental x-rays can have their limitations. If the X-ray is not substantial, it can cause film faults, which could easily be mistakenly read by AI. This could cause substantial changes to the treatment plan, causing mass complications for the patient in the long term.

The use of AI may also raise complications due to ethical and legal standards. It may be seen as a massive confidentiality breach for many if AI is allowed to access all the data that dentists have.

Key Words:

Impression material- a substance used to create a detailed negative replica (impression) of a patient's teeth, gums, and other oral structures.

Efficacy- the ability of a drug to produce a desired therapeutic effect or outcome under ideal and controlled conditions, typically measured in clinical trials.

The clinician and patient have a strictly confidential relationship, and some patients may be unhappy with the thought of AI holding their personal information. Dentists must navigate ethical dilemmas daily, considering patient autonomy and a multitude of other factors. The AI cannot factor these in while making a treatment plan as the relationship is different. AI knows no boundaries for humans. So, as good as it may seem, some challenges and problems would need to be resolved for AI to be fully introduced in the oral healthcare system. (Williams, 1990)

In conclusion, AI technology has impacted the healthcare industry massively over the last decade; however, this is only the beginning. AI can only improve, and its integration into dental care marks a new era for dentistry. AI can make the job of dental clinicians much more efficient and accurate, leaving no room for mistakes in the future. The collaborative ability between AI and dental experts can only be used to enhance patient care and contribute to a brighter future in the dental system and the healthcare system.

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Key Words:

Stigma: a strong feeling of disapproval that most people in a society have about something, especially when this is unfair.

Neuronal: relating to neurons (nerve cells).

TRINITY 2024

Overcoming the Stigma Around Childhood ADHD

By Dev Dhesi

Imagine if someone thought you weren't good at something, just because you're you. That wouldn't feel very nice, right? That's what stigma is - when people think something bad because they don't understand things properly. Stigma makes things really tough for children with ADHD and their families. (Lovering, 2022)

Prevalence

ADHD (attention deficit hyperactivity disorder) is a neurodevelopmental disorder - it affects neurons maturating in our brains. Its prevalence is approximately 5% worldwide, affecting millions of children. (American Psychiatric Association, 2013)

Definition of Childhood ADHD

The World Health Organisation (2018) defines ADHD as: "a persistent pattern of at least 6 months of hyperactivity-impulsivity and/or inattention that has a direct negative impact on academic, occupational, or social functioning, with symptoms appearing prior to 12 years, though some individuals may come to attention at a later age".

Research shows that childhood ADHD involves genetic, neuronal and environmental factors, none of which are within the control of a child. (Barkley, 2002)

The Symptoms of Childhood ADHD and Misconceptions

So why is there a stigma around childhood ADHD? This stigma is the by-product of several factors. Let us explore the 3 hallmark symptoms of ADHD and consider in parallel the misconceptions they engender:

1. Hyperactivity: This is noticeable as lots of physical energy, which makes sitting still, remaining quiet or taking turns difficult, especially in situations requiring calm. This can be tiring for teachers as well as parents, and friends as they struggle to keep up with this highly energetic child. Yet sometimes these kids can focus better, like in short, engaging activities. These bursts of energy followed by calm moments can be confusing to others, and cause the misperception of deliberate naughtiness, even though they aren't.

Moreover, their fidgetiness can be distracting, making them unpopular in class. They sometimes get moved to sit in a corner. This isolates them and knocks their self-esteem. As it is this child that is moved, it wrongly leads others to believe that this child is a troublemaker.

Also, some people mistakenly think these children could be better behaved if they were strictly disciplined by their parents. This unfortunately overlooks the neurodevelopmental basis of ADHD, leading to unfair criticism and blame.

Key Words:

Neurotypical: not having, or not associated with, a brain condition, (especially autism), that is often considered as different from what is usual.

2. Impulsivity: Impulsivity makes these children act without considering consequences- like saying something before they realise it might not be a good idea.

Society's expectation of these kids is the same as neurotypically developing children. This leads to the unfair judgement of these kids being intentionally rude and defiant.

3. Inattention: Despite high levels of physical energy, paying attention can be tricky for kids with ADHD. They are easily distracted by external stimuli or even their own thoughts - like their mind wants to think of everything else except what they're meant to focus on. This makes learning and doing school tasks difficult, leading to underachievement compared to their peers. This is frustrating for the child, the teachers as well as parents.

Unlike hyperactivity, inattention is not visible to others, and so their difficulty in finishing tasks is misinterpreted as laziness or 'not trying hard enough'.

Besides these 3 key symptoms, there can be other challenges:

ADHD can make it tough for kids to remember stuff, to prioritise and to manage their time. Breaking tasks down into manageable steps and meeting deadlines is a struggle. What seems unmanageable to the poorly organised child, can be seen by others as being work-shy. But that's not true! They just need a bit more help sometimes.

ADHD may make them feel emotional and low in confidence. Negative attention from those around them makes them feel guilt and shame. Mood disorders like depression and anxiety are frequently seen in children with ADHD, exposing them to further stigmatisation. (Biederman, Newcorn and Sprich, 2006)

Finally, in recent years, the media has sometimes portrayed childhood ADHD overdramatically and inaccurately, contributing to the negative stereotypes in society.

So, having gained an understanding of how childhood ADHD presents, as well as how it can be perceived with prejudice, let us see what can help in shifting the stigma. (Lebowitz, 2013)

Strategies to Shift the Stigma of Childhood ADHD

1. Awareness campaigns: Launching campaigns to provide accurate information about ADHD to the public. These can include talks and podcasts by specialists like child and adolescent Psychiatrists and Paediatricians who diagnose ADHD, explaining that ADHD is a condition involving the development of the neurones in the brain, not a result of poor parenting or bad behaviour.

2. Training Professionals: Evidence-based training for professionals working with children, looking at strategies for managing ADHD in a variety of settings.

3. Helping Kids with ADHD Shine: Advocating for themselves, by talking about their strengths and challenges. They can join groups where they meet other kids like them as well as be supported by mentors to explore their creativity, build resilience, and become agents of change in their communities. (CHADD, n.d.)

Key Words:

Neurodiversity: the range of differences in individual brain function and behavioural traits, regarded as part of normal variation in the human population (used especially in the context of autistic spectrum disorders).

4. Community Support Groups: They can help in improving access to mental health services and provide a sense of community to the young person and family.

5. School Help: To include adjustments like a suitable seating plan, extra time on assignments and a quieter working space. When schools, parents and healthcare professionals work together, kids with ADHD engage better in education.

6. Media representation: TV shows, movies and printed media should show ADHD in a true and sensitive way, of how well kids with ADHD accomplish when adequately supported and have the potential to. This will promote inclusion.

In conclusion, while progress has been made in understanding childhood ADHD, it needs to now translate into tackling the stigma around it. This will require a holistic approach involving campaigns to have an open dialogue about childhood ADHD, helping kids with ADHD feel valued, making schools better for them and showing their uniqueness in media. These strategies will create a more inclusive society - a society that celebrates neurodiversity and where these children are supported in reaching their full potential.

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