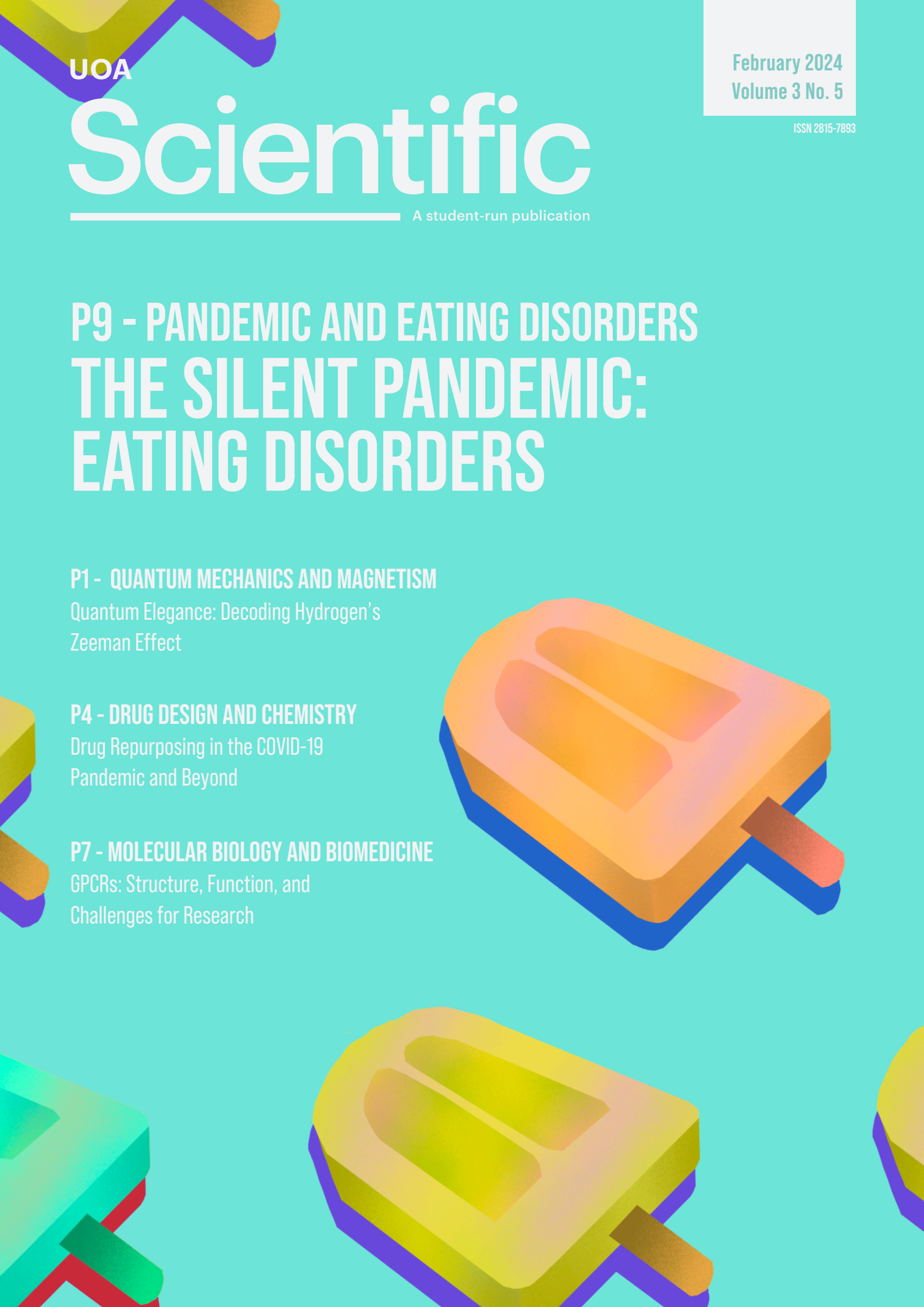
UOA
Scientific
A student-run publication

February 2024
Volume 3 No. 5

ISSN 2815-7893

P9 - PANDEMIC AND EATING DISORDERS
THE SILENT PANDEMIC: EATING DISORDERS



Editors' Note

Kia ora koutou katoa! Welcome to the final edition of Volume 3 and the very first edition of 2024!

As we emerge from the university break and into a new year of learning, it is the perfect time to embrace the insights offered by this edition.

Ayush Varma explores the Zeeman effect, digging into its theory and real-life applications. Beatrix Goggin looks at drug repurposing and its role during and after the COVID-19 pandemic. David Lu delves into G-protein coupled receptors, explaining their structure, function, and relevance to human diseases. Sarah-Anne Meares unravels the link between the COVID-19 pandemic and eating disorders. Jarod McTaggart reviews the current state of insect conservation in New Zealand, while Sanchani Brabhaharan looks at the impact of artificial intelligence in healthcare.

Thank you to our writers and executive team for putting together this Summer School edition! We also extend our gratitude to you, our dear readers, for your valuable support. As you dive into the coming pages, we hope you find inspiration, knowledge, and enjoyment. Here's to another year of science communication!

Ngā mihi maioha,

Riya Balia, Head Editor for UoA Scientific, 2024

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Explained

Quantum Elegance: Decoding Hydrogen's Zeeman Effect

Ayush Varma

Quantum Mechanics and Magnetism

In the captivating realm of hydrogen stationary states, foundational quantum concepts such as expectation values, position operators, and angular momentum operators are indispensable as they serve as guiding lights for physicists navigating the intricacies of electrons within atoms. These quantum tools provide a nuanced understanding of quantum mechanics, particularly when applied to hydrogen, a fundamental building block. This article will attempt to interpret the hydrogen emission spectrum and the selection rules associated with quantum numbers, linking the concepts of magnetic moment and Larmor precession. The mechanics of these, in turn, describe the Zeeman effect. Lastly, we look at the various industrial and research applications of spectral shifting, both past and forthcoming.

Expectation values in quantum mechanics offer a statistical perspective to gauge average outcomes in quantum regimes. When looking at hydrogen stationary states, these values become useful tools for predicting the most probable results of measurements relating to observables like position and angular momentum [1]. They act as guiding beacons, steering physicists toward a comprehensive understanding of the behaviour of electrons within their orbitals, and portraying the inherently probabilistic nature of quantum systems [1-2].

The position operator, a fundamental quantum mechanical tool, represents the observable tied to a particle's position (x). For hydrogen's stationary states, this operator allows scientists to compute the average position of an electron within its orbital [2-3]. By acting on the wavefunction, the position operator unveils essential details about the probable location of the electron, offering insights into the spatial distribution of the electron cloud. The wavefunction, denoted by Ψ, encapsulates the quantum state of a system. Its square, |Ψ|2, provides the probability density of finding a particle in a specific position. Understanding the wavefunction is crucial as it forms the foundation for fundamentalising quantum states [3].

Simultaneously, the angular momentum operator plays a vital role, addressing the observable linked to a particle's angular momentum (L). In the hydrogen atom, this operator is instrumental in quantifying the anticipated angular momentum of an electron in a specific orbital [4-6]. Quantum numbers associated with the angular momentum operator impart crucial information about the shape and orientation of the orbital, providing a comprehensive understanding of the electron's rotational motion [5-6].

Distinguishing between sharp and fuzzy quantities is integral to quantum mechanics. Sharp quantities, like energy levels in stationary states, have precisely defined values. In contrast, fuzzy quantities, exemplified by position and momentum, exist in a state of uncertainty as per Heisenberg's uncertainty principle [7]. This principle asserts that the more precisely one quantity is known, the more uncertain the other becomes, challenging classical notions of determinism [8-9].

With the basics covered, let's dive into how this quantum toolkit aids in analysing the hydrogen emission spectrum. The emission spectrum, consisting of distinct lines, results from electrons transitioning between stationary states [9]. As an electron moves from a higher energy level to a lower one, it emits a photon with energy equal to the energy difference between the two levels [10]. This emitted energy corresponds to a specific wavelength or frequency, creating spectral lines [10].

The information derived from the wavefunction is crucial to understanding these transitions. The hydrogen wavefunction, shown in Figure 1, is the current orbital model internationally equipped by science as a whole. Analysing the wavefunction helps physicists predict and interpret the spectral lines in the hydrogen emission spectrum. The quantum numbers associated with the stationary states obtained from wavefunction solutions provide a roadmap for understanding the allowed energy levels and transitions [11-13].

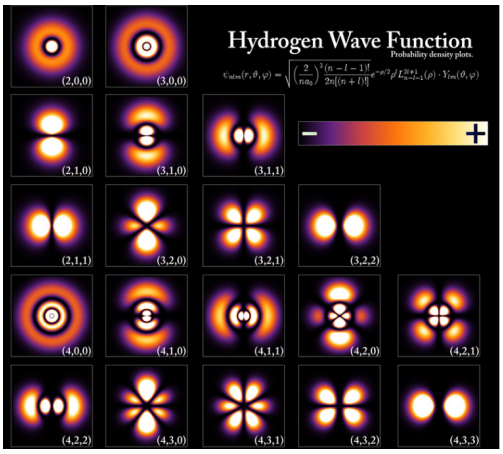

Figure 1: A visualisation of the hydrogen wavefunction. The current electron probability distribution model reveals quantum behaviour. It showcases a H atom's orbital structure and the distinct energy levels with spatial arrangement [13].

Optical transitions play a pivotal role in the hydrogen emission spectrum. When an electron transitions between two stationary states with different energy levels, it absorbs or emits a photon with energy corresponding to the energy difference between these states [14]. This process involves changes in the electron's orbital configuration and is fundamental to the creation of spectral lines. Optical transitions are at the heart of spectroscopy, allowing scientists

to probe the energy levels and quantum states of atoms. [14-15]

The selection rule is a critical concept in understanding these transitions. It stipulates which transitions are allowed and which are forbidden based on the conservation of angular momentum. The selection rule for hydrogen spectral lines involves a change in the principal quantum number (n). Specifically, the change in n must be ±1 for a transition to be allowed. This rule arises from the law of conservation of energy and angular momentum in quantum systems [16].

In the intricate dynamics of hydrogen stationary states and optical transitions, the conservation of momentum emerges as a pivotal factor. The selection rule for hydrogen spectral lines, governed by the conservation of angular momentum, dictates the allowed transitions based on changes in the principal quantum number [16].

Spectral shifting, a phenomenon where spectral lines change position, can be justified through these quantum concepts as energy levels and their transitions affect the wavelength or frequency, respectively, of emitted or absorbed photons. As we see in Figure 2, this provides a profound correlation between quantum principles and the observed shifts in the spectral lines of hydrogen [17].
We now explore the concept of magnetic moment, a property associated with the movement of particles, which is especially relevant when considering hydrogen. The magnetic moment (μ) of an electron is a measure of its intrinsic magnetic properties, arising from its spin and orbital motion [17]. The quantisation of the magnetic moment in quantum mechanics means that only discrete values can be taken along a particular direction [18].

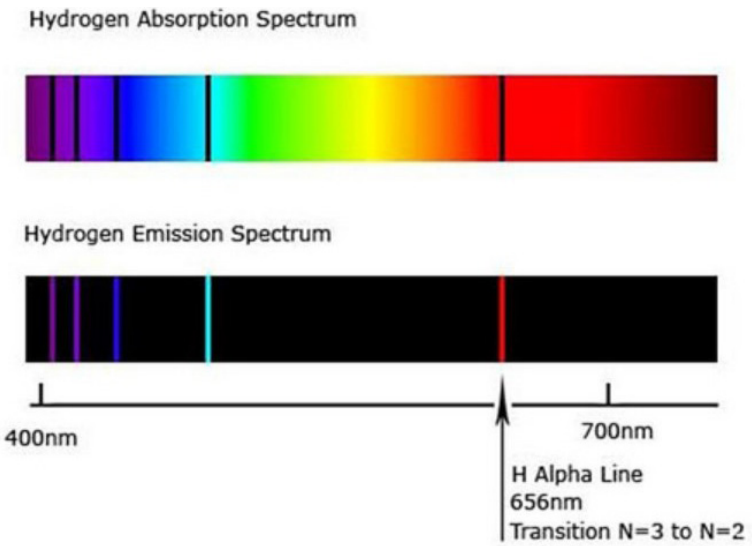

Figure 2: The hydrogen spectrum reveals the fingerprints of hydrogen's energy transitions in the form of an array of spectral lines.

This quantisation of the magnetic moment has significant implications in the realm of spectroscopy, particularly in the phenomenon known as Larmor precession [18]. Larmor precession refers to the motion of the magnetic moment of a charged particle, such as an electron, in response to an external magnetic field. The quantisation of the magnetic moment introduces discrete precession frequencies associated with specific transitions between energy levels.

The torque experienced by the magnetic moment in an external magnetic field is a crucial element in Larmor precession. The torque induces the rotational motion which enables precession [18]. The quantisation of the magnetic moment leads to discrete torque values, corresponding to specific transitions between energy levels. In the context of hydrogen, with an external magnetic field, the quantised magnetic moments of electrons lead to discrete changes in precession frequencies, contributing to the fine structure observed in the hydrogen spectrum. This phenomenon provides valuable information about the magnetic properties of electrons and the effects of external magnetic fields on atomic behaviour [18].

Integrating the influence of these physical quantities on the Zeeman effect within the hydrogen atom tells us a lot. The Zeeman effect is observed when atoms are subjected to an external magnetic field, causing a so-called spectral line splitting. The gyromagnetic ratio and Bohr magneton collectively govern the behaviour of electrons in response to the external magnetic field, influencing the extent and pattern of line splitting [18].

The gyromagnetic ratio determines the strength of the interaction between the magnetic moment of the electron and the external magnetic field. Larger gyromagnetic ratios result in more pronounced Zeeman splitting [18]. The Bohr magneton (μB), representing the magnetic moment associated with the orbital motion of an electron, plays a pivotal role in determining the magnitude of the Zeeman splitting. These are both usually derived from theoretical constants.

In summary, the interplay of physical quantities, such as the gyromagnetic ratio, Bohr magneton, quantum numbers, and Larmor frequencies, profoundly influences the behaviour of electrons within the hydrogen atom in the Zeeman effect. The quantisation of the magnetic moment and the discrete nature of transitions between energy levels give rise to the characteristic splitting patterns observed in the spectral lines. Understanding these quantum principles provides a deeper insight into the magnetic properties of atoms and the intricate dynamics of electrons in the presence of external magnetic fields. The Zeeman effect, with its spectral signatures, stands as a testament to the profound connections between quantum mechanics and experimental observations in the realm of atomic physics.
The extent of industrial applications and impacts of spectral shifting are limited but handy. In material science and nanotechnology, the analysis of shifted spectral lines aids

in characterising electronic and magnetic properties and steering advancements in material design. Shifted spectral lines help with detecting and quantifying pollutants, contributing to efforts to understand and mitigate environmental impacts.

In medical diagnostics, particularly in MRI scanning, the Zeeman effect's principles play a crucial role. When a patient is placed in a strong external magnetic field (such as that of an MRI scanner), the Zeeman effect induces the splitting of nuclear magnetic resonance signals emitted by hydrogen nuclei in water molecules within the body. By precisely detecting these shifted signals, MRI scanners create detailed images of internal structures, offering unparalleled insights into tissues and organs. The role of the Zeeman effect in NMR spectroscopy and MRI scanning exemplifies its practical applications, showcasing how fundamental quantum principles contribute significantly to scientific research and healthcare diagnostics [19]. The precision of spectral analysis contributes to the accuracy of medical diagnoses and the development of advanced imaging techniques with detailed views of internal structures.

Beyond scientific research, spectral shifting studies on the electronic and magnetic properties of materials influences the development of advanced materials with tailored properties. The industry of nanomaterials hugely appreciates spectral splitting as precise control over electronics manufacture is needed. Spectral analysis is used to characterise and manipulate the electronic structure of nanomaterials, influencing their conductive properties. This has implications for the development of novel electronic devices with enhanced performance [19-20].

The use of spectral shifting in astronomics branches out into more specific domains. In solar physics, the analysis of shifted spectral lines allows scientists to unravel the delicate details of solar sunspots, providing insights into localised magnetic activity on the sun's surface. In molecular and atomic rotational dynamics, spectral shifting assists in understanding orbital rotations accurately. Beyond this, celestial objects at any reachable point in our cosmos can be rigorously assessed based on the magnetic field knowledge gathered from the Zeeman effect. In turn, this information contributes to a broader understanding of the evolution of our universe [20].

Satellite technologies also benefit from precise navigation and communication offered by the leveraging of magnetic sensors, thanks to the Zeeman effect. Satellites are therefore able to accurately orientate and align with respect to earth's magnetic field, creating stabilisation.

As quantum technologies continue to advance, the applications of spectral analysis in quantum computing and communication hold promise for transformative breakthroughs. Spectral shifting, with its roots in quantum principles, becomes a key tool in manipulating and analysing quantum states, contributing to the development of more powerful and efficient devices [21-22].

Conclusion

Hydrogen stationary states, optical transitions, and the Zeeman effect unveils not only the fundamental principles of quantum mechanics but also their profound applications across scientific disciplines and industries. From unravelling the mysteries of celestial bodies to steering advancements in material science, environmental monitoring, and medical diagnostics, the impact of spectral shifting resonates across the spectrum of human knowledge and technological innovation. The Zeeman effect's role in NMR spectroscopy and MRI scanning further emphasises its versatile applications, bridging the gap between fundamental quantum concepts and practical advancements in healthcare diagnostics.

Ayush Varma - BAdvSci (Hons), Astrophysics

Ayush is an astrophysics student who has particular interests in cosmic inflation and the Higgs field, with a dream of visiting CERN to witness the LHC in action. He plays competitive badminton and cricket, and enjoys watching astronomy documentaries. You can almost always find his talkative self outdoors. He claims to be a buff for Indian movies, and reads fictional thrillers.

Academic

Drug Repurposing in the COVID-19 Pandemic and Beyond

Beatrix Goggin

Drug discovery is a longstanding and increasingly fast-paced field at the intersection of chemistry, biology, and medicine. While modern techniques and technologies have accelerated the process significantly in recent decades, the drug discovery pipeline still struggles to win the race when new (and potentially lethal) diseases enter the world, such as SARS-CoV-2. Drug repurposing is not a new concept, but during the COVID-19 pandemic, the urgent need for treatments and prophylactics inspired many scientists to further investigate existing tools intended for other purposes.

Throughout history, humans have endeavoured to create interventions to improve health and prevent disease. Over time, the strategies used have progressed from herbal tinctures inspired by vague theories into a dynamic, fast paced, multibillion-dollar global industry.

Pharmaceutical products were responsible for US$806 billion in global revenue in 2021, with Germany, Switzerland, and the United States each exporting approximately $100 billion worth [1]. The United States was the top importer of pharmaceutical products globally in 2021, bringing in a staggering $145 billion worth of products. As in any industry with such high consumer demand, there is an equally high incentive to maintain, increase, and improve supply. Unfortunately, both the monetary cost and the length of time it takes to introduce a new drug into the market are high. The average timeline from the initial idea to the commercial availability of a drug is 10-15 years. The "drug discovery pipeline", as it is commonly called, is a long-winded and interdisciplinary process requiring chemists, biologists, doctors, and workers in many related fields. At any stage of the process, a potential drug candidate may fail during testing, resulting in the waste of both time and money. While this is an inconvenience at the best of times, during events such as the COVID-19 pandemic, it can be life threatening. When a health emergency sweeps the world, the typical timeframe of the drug discovery pipeline may be too lengthy to make a timely impact—herein lies the potential of drug repurposing.

What is drug repurposing?

Drug repurposing is the practice of discovering a previously unknown and unintended use for an existing drug [2]. By starting with an existing drug, investigations into a new therapeutic can be expedited significantly. When the chemical compound of interest is a current commercially available drug, it will have already passed clinical testing. This is one of the most common stages for a potential new drug to fail. Additionally, there is likely an existing understanding of the drug's mechanism of action. In cases where the exact cause or mechanism of a disease is not known, this can offer valuable information about the possible pathophysiology of the condition. In fact, the lack of understanding of potential targets is a common reason why a drug repurposing approach may be selected to find treatments for a disease. Repurposing an existing drug also allows the practical aspect of drug design (such as how the compound can be synthesised or how it should be delivered to its target site) to proceed in less time. Finally, the process of testing existing drugs for new uses can reveal valuable insights about a drug that may have gone unnoticed during its initial testing. Unknown effects may be harmless or affect something irrelevant to the desired action, but occasionally, a new discovery may warrant extensive further research.

Oleg's COVID-19 Drugs

A retrospective study carried out by researchers at King's College London (KCL) revealed that during the first wave of the COVID-19 pandemic in the UK (April to December 2020), patients who received antidepressant drugs (ADs) one to three months before admission had a 40% lower incidence of COVID-19 [3]. Previous cell biology evidence had shown that ADs affect membrane trafficking, and it was hypothesised that this mechanism may underlie the prophylactic (disease-preventing) effect of ADs on COVID-19 [3]. In a 2020 publication, KCL researcher Oleg Glebov investigated how this membrane trafficking effect may specifically prevent (or decrease the severity of) SARS-CoV-2 infections.

SARS-CoV-2 enters the lung epithelium via endocytosis, a process where extracellular materials are taken into the cell by vesicles – small, fluid-filled sacs that facilitate transport through membranes [4]. Specific endocytosis pathways vary depending on cell type and what is being brought into the cell. Early in the pandemic, little was known about the particular mechanism (or mechanisms) employed by SARS-CoV-2 (some of which are shown in Figure 1), which made it difficult to target antivirals to disrupt a specific biological process [5]. With his research into repurposing ADs, Glebov hoped to shed light on the exact mechanisms of SARS-CoV-2 cell entry and uncover potential treatment options for SARS-CoV-2 itself or other similar viral infections.

In addition to its impact on the pandemic, this research is also compelling because of the ubiquitous nature of the antidepressants themselves. From 2021to 2022, 8.32 million people in the UK were prescribed antidepressants [6]. Despite their widespread prescription, ADs are not well understood. The discovery of significant off-target activity is a sobering reminder of the potential extensive and damaging consequences of these unknowns.

In his 2020 article, Glebov detailed 11 candidate ADs for future investigation into their effect

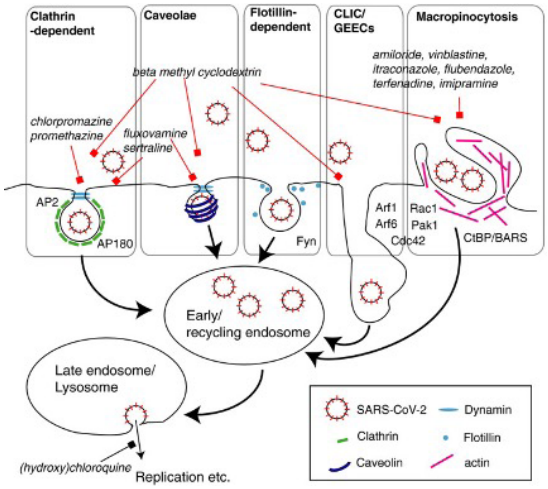

Figure 1: A representation of potential endocytic pathways facilitating the entrance of SARS-CoV-2 into the cell, and the potential action of drugs against the processes [5].

on SARS-CoV-2. A subsequent publication in 2021 focused on one AD in particular, fluvoxamine, and its proven effect on SARS-CoV-2 spike protein trafficking. Using HEK293T cells expressing ACE2 receptors, sub-therapeutic concentrations of fluvoxamine (Figure 2) as low as 80 nM was found to significantly upregulate fluid-phase endocytosis [7]. This resulted in the increased accumulation of the spike-ACE2 complex in enlarged early endosomes, where they may be recycled back to the outside of the cell rather than progressing to late endosomes/lysosomes and onto the replication stage of viral infection. While this research was not conducted rapidly enough to be used as a treatment during the pandemic, it provided valuable insight into the mechanism of COVID-19 infection and viral uptake into cells in general, as well as opening up a new area of research into the effects of ADs outside the central nervous system.

Continued Research

In collaboration with Beatrix Goggin and Jane Allison from the University of Auckland, further studies are being undertaken to better understand the effects of ADs on membranes of various compositions. This research will be aided by the use of computational molecular dynamics simulations which allow the prediction and observation of atom-level motion and interactions. It will investigate the interactions of fluvoxamine, as well as other drugs, with cell membranes of different compositions in an effort to understand the effect these drugs have on various tissue types. At the moment, initial research involves a comprehensive overview of diverse membrane types and compositions to determine the model systems that would be ideal to simulate drug interactions.

This international collaboration highlights another trend in the modern drug design landscape: increased use of computational tools. Researchers from Vanderbilt University and Emory University conducted a ten-year literature review on drug repurposing for Alzheimer's disease, which revealed that 71 of the 124 studies reviewed employed computational strategies for drug repurposing. In the first year covered by the study, 2012, zero computational studies were identified. By 2021, the penultimate year, 26 of the 44 studies reviewed contained significant computational components [9]. This increase over just a ten-year period (and only for one disease) showcases the drug design field's participation in the exciting and rapidly evolving world of technology. Drug repurposing is an area of drug design where computational methods are particularly useful. In order to meaningfully model a system, you must have enough assumptions to build the model on. Existing drugs and some knowledge of their action on other systems are excellent starting places to investigate their effects in new, lesser known systems.

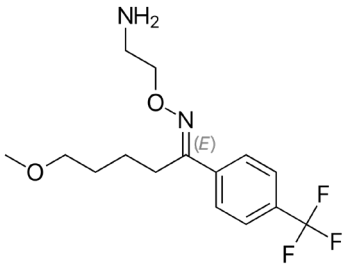

Figure 2: The chemical structure of selective serotonin reuptake inhibitor (SSRI), fluvoxamine [8].

Conclusion

This research is just one of many examples that showcase the power and potential of drug repurposing. Early in the COVID-19 pandemic, very little was known about the method of disease spread and infection, yet solutions were desperately needed. Many drugs were appraised as a potential cure for COVID-19, including the highly publicised attempts and ultimate failures of hydroxychloroquine and ivermectin. While no single drug proved successful, each trial and study provided insight into the virus itself, in addition to new knowledge that may be helpful in the future. As well as the savings in money and time, it is also important to acknowledge the potential environmental impacts of a drug repurposing approach (especially when combined with computational methods) [10]. By starting with an existing compound, the chemical waste produced during the design and synthesis process can be avoided. Using existing drugs (and computational methods) also allows targets to be refined before screening and testing, hopefully reducing the number of trials required before a lead is identified. Overall, the surge in drug repurposing during the pandemic was a valuable reminder and needed renewal of interest in a sustainable and under-utilised approach to drug design.

Beatrix Goggin - BSc, Chemistry

Beatrix is a computational biochemist with a passion for drug design. She hopes to make an academic career of using interdisciplinary skills to increase understanding of existing treatments and their mechanisms of action. Beatrix is looking forward to finishing undergrad and starting her Honours year in Semester Two 2024.

Academic

GPCRs: Structure, Function, and Challenges for Research

David Lu

One of the most ubiquitous proteins in human cells are GPCRs. They are involved in the signalling cascade and are the interface between the extracellular and intracellular contents of a cell. Research has allowed us to determine some of their structures and functions, but there is still a large gap in the visualisation of some GPCR classes. This article will give an introduction to GPCRs and why it can be hard to research them.

G protein-coupled receptors (GPCRs) are the largest family of membrane proteins and are involved in many signalling pathways related to neurotransmission, development, and the senses [1-3]. Their relevance to human physiology and medicine is demonstrated by the fact that GPCR genes make up 4% of the human genome and that 34% of FDA-approved drugs target GPCRs [1-3]. Despite the significance of GPCRs to human physiology and the effort spent researching them, many GPCR structures and binding sites are still unknown. This is due to a combination of factors related to the dynamism of GPCRs [2-3]. This article will explain the function of GPCRs, their general structure, and why it is difficult to visualise and determine the molecular structure of specific GPCRs.

GPCRs are membrane proteins, meaning they exist at the cell's surface and typically interact with G proteins [1-5]. GPCRs have seven transmembrane domains which pass through the membrane in a serpentine fashion [1-5]. At one end, there is an extracellular N-terminus, and at the other, there is an intracellular C-terminus [1-5]. This means that the N-terminus interacts with the ligand while the C-terminus interacts with the G protein to which the GPCR is coupled [1-5].

There are six families of GPCRs, classified from A to F, with each family having unique structures and functions [1-5]. All the classes have the same general structure as mentioned above, with minute differences. For example, class A GPCRs have a short extracellular N-terminal chain, while class B GPCRs have a longer one [2]. Class C GPCRs also have large extracellular domains, with their chains resembling a "C" or venus fly trap [2]. Despite research efforts, the class D-F GPCR structures are still largely unknown and have little to no clinical significance [2]. The functions of proteins are usually dependent on their structure – and GPCRs are no different. Although all GPCRs have the same broad function of binding to a ligand and promoting a downstream signalling process, the specifics of this process varies for each individual GPCR [2]. For example, research on the visualisation and binding of class A GPCRs has shown that in their transmembrane domain are a conserved proline, a NPxxY motif, and a DRY motif [2]. When a ligand binds to the transmembrane seven domain, it causes a conformational change. The transmembrane domain seven then positions itself closer to transmembrane domain three, locking the ligand in the active site [2]. For class B GPCRs, the ligand first binds to the extracellular N-terminus. Then, the N-terminal domain swings towards the transmembrane domains, causing the peptide to bind to the transmembrane domain, activating the complex [2]. Lastly, for class C GPCRs, the ligand binds to their large extracellular domain which causes the GPCR to dimerise so it can be fully activated [2].

Once a GPCR is activated, it associates with a specific G protein [2-5]. G proteins are heterotrimeric, meaning they have three different subunits: the alpha, beta, and gamma subunits, and it is the alpha subunit that binds to the GPCR [2-5]. This initiates the G protein cycle, where the alpha subunit dissociates from the beta and gamma subunits of the G protein to associate with a downstream effector protein, initiating a change within or outside the cell [2-5].

Furthermore, other features of GPCRs promote their function and specificity. For example, GPCRs have specific ligands and specificities for each ligand, called biased agonism. This bias can affect the GPCR protein itself, as in receptor bias, or it can affect the peptide that the GPCR binds, as in ligand bias [3-5]. Receptor bias occurs when the receptor itself is biased towards a specific signalling pathway as it only activates a specific downstream effector [3-5]. Ligand bias is when the ligand itself causes the GPCR to adopt a specific conformation, which only allows a specific G protein to bind, causing that signalling pathway to become activated [3-5].

Being such an important aspect of the signalling pathway, GPCRs must have processes in place to keep them in check so they do not produce excessive signalling within the cell. Thus, there are some key processes that can reduce or halt the function of GPCRs: phosphorylation and desensitisation, internalisation, recycling, and degradation [5]. Phosphorylation reduces the GPCR's affinity for its G protein, resulting in decreased signal transduction [5]. This phosphorylation is typically done by kinases, which can be facilitated by arrestin proteins, while the reverse process, dephosphorylation, is carried out by phosphatases [5]. This process inevitably leads to the GPCR becoming desensitised [5]. Internalisation is when the GPCR is internalised into an endosome due to ubiquitination, causing it to be absent from the cell's membrane [5]. This can then lead to recycling and degradation, where the GPCR is either recycled to the surface again at a later time or is sent to a lysosome to be degraded [5].

The relevance of GPCRs to the normal functioning of the human body is exemplified by the sheer number of medications on the market that target GPCRs. This is due to the fact that they exist on the plasma membrane at

the cell's target and are responsible for many downstream effects, making them ideal candidates for drug targets [6]. The malfunction of GPCRs are implicated in many disease states, ranging from mild, such as migraines, to lethal cases, such as myocardial infarctions [6].

There have been mounting research efforts to determine the molecular structure of different GPCRs so that their mechanism of action can be elucidated and better drug targets can be developed [2-3]. The advancement of technologies like cryo-electron microscopy has accelerated the visualisation of many GPCRs, but despite this, around a third of all GPCRs still have their structures to be revealed [2-3]. The reason why it is difficult to visualise GPCRs is because many visualisation techniques require the GPCR to be static or crystallised, and thus require specific conditions to induce that state [3]. However, these conditions are typically contradictory to the conditions needed for the GPCR to be functional, and thus the active sites, conformational changes, and mechanisms are difficult to determine [3]. For example, to make the GPCR soluble and crystallised for X-ray crystallography, short-chain detergents need to be applied to the protein, while for normal function, the GPCR requires long-chain detergents [3]. However, the future is bright; there have been major advances in microscopy and visualisation techniques, as seen in the case of cryo-electron microscopy. This method does not require protein crystallisation to resolve the minute molecular structures of GPCRs [3]. With the aid of such tools, we look forward to new information on GPCR structures to contribute to more effective drug development in the near future.

David Lu - MBChB

David is a Stage II MBChB student at the University of Auckland. He has completed a BSc specialising in Biomedical Science and has keen interests in cancer research, mental health and wellbeing, and neurosurgery.

Explained

The Silent Pandemic: Eating Disorders

Sarah-Anne Meares

Pandemic and Eating Disorders

Trigger Warning: The content of this article discusses topics of a sensitive nature, including mental illness (eating disorders) and the COVID-19 pandemic, that may be challenging for some readers.

Support Organisations are available to help support you:
0800 2 EDANZ / 0800 2 33269 or (09) 5222 679 (Eating Disorders Association of New Zealand)
Lifeline – 0800 543 354 (0800 LIFELINE) or free text 4357 (HELP)
Youthline — Free call 0800 376 633 or Free text 234

Psychiatrists warned of a "tsunami" of eating disorders post-lockdown. The world responded by more than just warranting the ominous premonitions.

As COVID-19 itself transpired fully-fledged, major cities retreated into nationwide lockdowns, social distancing was implemented nearly everywhere, and the world itself shut down. Shutting these global doors in an effort to save us from one pandemic unwittingly opened the doors to another, often kept hushed up, suppressed, censored and otherwise severely misunderstood. What "pandemic" could possibly render such an effect, we might ask ourselves?

That would be the pandemic of mental illness, and specifically, in this case — the pandemic of eating disorders (EDs). With a 128% increase in the number of patients waiting for routine treatment compared to the year before the pandemic, the "tsunami" of eating disorders that psychiatrists warned of during the COVID-19 pandemic has hit health services in full force [1]. When the world retreated into realms of masks, lockdowns, and daily-case-number news updates, serious mental disorders like **anorexia nervosa** and **bulimia nervosa** rubbed their hands together gleefully, eyes shining in anticipation — what better place for an eating disorder to thrive than the isolation accompanying a global pandemic?

With unhelpful worldwide conversations rapidly circulating around "COVID-19 kgs", "lockdown diets", and rigorous COVID-19 exercise regimes, those already vulnerable to these messages became inadvertently triggered by conversations intended to target another population altogether. By inherently linking "health" to "weight", our global lens has focused on something as insignificant as a number on a scale, even in the midst of a life-threatening pandemic.

With social isolation already stifling the state of affairs, well-intended messages concerning weight gain during the lockdowns put more pressure on a society already focusing heavily on weight control en masse. This created a space for eating disorders to be fed, watered, and nurtured. 86.7% of participants in one NCBI study reported that their eating disorder symptoms worsened during the pandemic lockdown, whilst 41.9% of participants reported a reactivation or relapse of ED symptoms [2].

Glossary

Anorexia nervosa (AN): A mental illness and a type of eating disorder caused by a wide range of environmental, emotional, psychological, biological, occupational, and social factors. This disorder is often characterised by an intense fear of eating and gaining weight. It can lead to many disturbances in all aspects of health, including (but not limited to) obsessive thinking and actions (e.g. intense exercise, fasting), depression, heightened anxiety, social difficulties, and malnutrition.

Please note: everybody's experience with AN is unique. Please reach out for help if you think you or someone you know might be struggling. Eating Disorders Association of New Zealand Helpline - 0800 2 EDANZ / 0800 2 33269

Bulimia nervosa (BN): A mental illness and a type of eating disorder caused by a wide range of environmental, emotional, psychological, biological, occupational, and social factors. This disorder is often characterised by taking steps (e.g. purging or fasting) to avoid weight gain following eating what the person may consider a "large" amount of food. This disorder can also lead to difficulties in all areas of health, including (but not limited to) social difficulties, depression, heightened anxiety, and malnutrition.

Please note: everybody's experience with BN is unique. Please reach out for help if you think you or someone you know might be struggling. Eating Disorders Association of New Zealand Helpline - 0800 2 EDANZ / 0800 2 33269

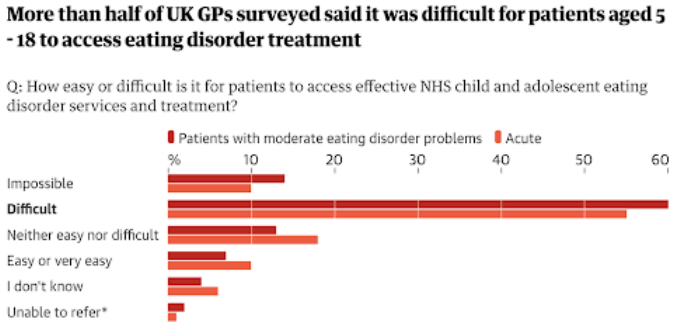

Figure 1: Due to monumental pressure on the mental health sector, many UK GP practices are no longer making referrals to mental health services but instead advising patients to directly contact relevant services [3].

Dr Lorna Richards, a psychiatrist specialising in adult eating disorders at The Priory Group, described to The Guardian how the rise in eating disorder behaviour could be attributed to many factors affiliated with the pandemic, some of which included "fear and uncertainty, fuelling anxiety symptoms" and changes to people's routine and home lives [1]. She also noted that the "focus on eating and weight control can become a way of coping", with many using weight-control measures such as food restriction, purging, or over-exercising to provide "a sense of control or mastery" during particularly challenging times [1].

With reported cases of eating disorders skyrocketing, we now turn the lens to this "tabooed" illness and its long-denied inadequate care and support — a "chronic" underfunding of services and attention, as Dr Agnes Ayton, the chair of the Eating Disorder Faculty at the Royal College of Psychiatrists put it [1]. Over half (60%) of General Practioners (GP) affiliated with the NHS indicated in early 2023 that it is now extremely difficult for even dangerously ill young patients to access the specialist treatment and care they need to get well, with one GP despairing that we are "fighting a losing battle" and in a silent "crisis" [4]. 60% of GPs also fear that their young patients will come to serious harm due to lack of treatment access from adolescent eating disorder services. One GP said that "the provision is awful and I worry my young patients may die". Another GP described specialist NHS services available in their area as "virtually nonexistent and not fit for purpose" [4].

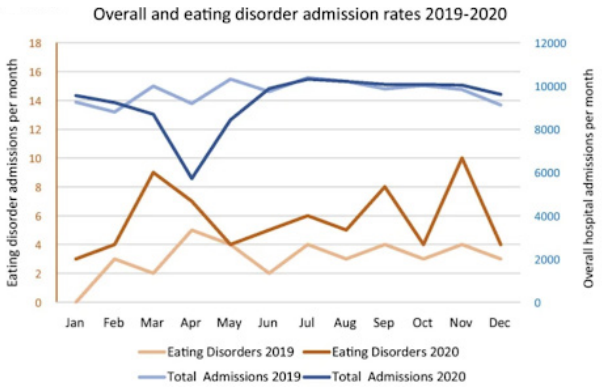

Figure 2: The overall eating disorder admission rates in Waikato, New Zealand, from 2019 to 2020. There is a drop in the count of total admissions in April 2020, in parallel with an increase in the count of eating disorder admissions [5].

Eating disorders, far from the stereotypical "teenage girls wanting to look like a model on the cover of a Vogue magazine", are in fact, complex illnesses resulting from a wide range of biological, environmental, psychological, occupational, social, and emotional factors that can affect anyone, regardless of age, background, sexual or gender orientation, ethnicity, or demographic [6].

Biological factors deeply affect the brain circuitry of affected individuals. Links have been found to the levels of particular hormones (such as dopamine) in our brains, and other factors may include variants in the **serotonin transporter gene** in those with bulimia nervosa. Walter Kaye, a prominent eating disorder researcher, investigated the level of the hormone serotonin in patients. He found that patients with the eating disorder anorexia nervosa tend to have a higher level of serotonin in their brains and that they "feel better" by performing actions that effectively decrease their serotonin level. However, as sufferers continue to carry out disordered actions like dangerously restricting their food intake, the brain's response is to increase the number of serotonin receptors, resulting in the more efficient utilisation of the remaining serotonin. This ultimately means that in order to maintain the feeling of "feeling better", the person needs to starve themselves even more — which leads, in essence, to the illness's vicious and potentially deadly cycle. When a person suffering from anorexia begins to eat again, serotonin levels soar, which causes extreme anxiety and total emotional upheaval — a"fight or flight" response.

Recovery from all types of eating disorders can be extremely difficult without adequate support, because often the individual believes they are not suffering and do not need help. At the same time, they may be severely malnourished, or suffering from severe maladaptive cognitions with the potential to seriously diminish quality of life. Like serotonin, dopamine also controls a complex neural network and overlap of processes within the brain. Scientific evidence suggests that individuals performing disordered actions feel a boost of dopamine after performing a disordered task, further reinforcing the very actions that make the individual unwell [7].

Because our brain is highly **neuroplastic**, the more actions an individual performs to relieve their anxiety about food or eating, the more neurally wired our brains become to execute that action, and the more neurally entrenched the illness itself becomes. As one GP said, "The threshold for seeing patients is too high, so illness is entrenched by the time any meaningful support is given. The treatment received is too little and too late." [3]. Due to the "flood" effect post-pandemic, individuals who reach ED-recovery providers are already in dire need of help, whilst others, also in dire need, are "backlogged" and forced to wait while their illness only worsens. Consequently, those with early ED symptoms are forced to wait even longer, meaning that by the time these patients receive help, the illness has likely had enough

time to become "established". As a result, both in New Zealand and globally, healthcare systems have experienced somewhat of an "onslaught" with emergency departments being relied upon more and more for patients with eating disorders [5]. To prevent such neural-entrenchment from developing, preventative treatment should ideally be commonplace. This would help to assist patients to effectively "disrupt" networks of neural connections that lead to the thought patterns and subsequent harmful behaviours seen in those living with EDs [3]. To address this treatment gap, knowledge, research, enhanced awareness and education, as well as substantially-improved medical and psychological ED treatment and care/support funding needs to be implemented into Aotearoa New Zealand's healthcare system [5].

Overall, it is essential for us, as budding scientists, to become aware of the science behind these mental health disorders so that we may work towards combining our unique neurobiological, chemical, pharmacological, physical, statistical, and psychological knowledge to champion treatments and research in this long-denied space. We must advocate for fair, equitable treatment for all illnesses and disorders, no matter their prior unfounded stigma, while recognising the implications and challenges of what accompanies the science we work for. As Anastasia Amour, a celebrated member of the Eating Disorder Recovery Community, once said, "Eating disorders are deadly…and the silence around them even more so." [6].

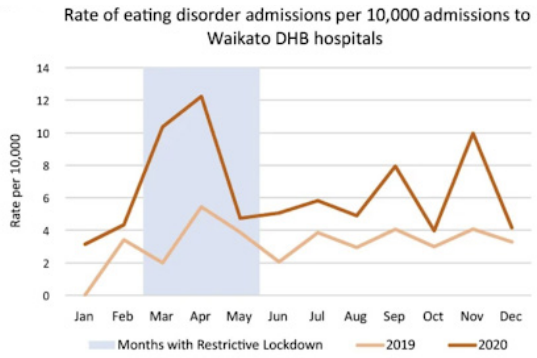

Figure 3: The rate of eating disorder admissions per 10,000 admissions to Waikato DHB hospitals. Compared to 2019, 2020 was consistently increased, with a significant spike coinciding with the commencement of lockdown around March to April [5].

Please reach out for help if you think you or someone you know may be struggling. There is always hope. Support Organisations are available to help support you:

0800 2 EDANZ / 0800 2 33269 or (09) 5222 679 (Eating Disorders Association of New Zealand)
Lifeline – 0800 543 354 (0800 LIFELINE) or free text 4357 (HELP)
Youthline — Free call 0800 376 633 or Free text 234

Glossary

Neuroplastic:
Neuroplasticity is the nervous system's capability to alter its framework and activity through growth or reorganisation/rearrangement of functionality, structure, or connectivity due to exposure to various stimuli over time (e.g. external or internal stimuli); that is, the ability to undergo processes of "rewiring".

Serotonin transporter gene (SLC6A4 gene):
This gene is also commonly known as the "sodium-dependent serotonin transporter". The serotonin transporter (5-HTT) protein encoded by the SLC6A4 gene (in humans), plays a key role in the regulation of neurotransmission involving the hormone serotonin (as well as being the principal target of many antidepressant medications, including Selective Serotonin Reuptake Inhibitors or SSRIs).

Please note that though this article uses terms like "neural-entrenchment" to help explain the effect of neuroplasticity in the development of eating disorders and the consequent effect of delayed treatment, there is always hope for recovery, rehabilitation, and a return to full mental and physical health. Please reach out for help as soon as possible — and remember that even if you or someone you know has been struggling for a long period of time, humans can use our neuroplastic ability for an ultimate benefit in recovery, too.

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Sarah-Anne is a 2nd-year Psychology student specialising in Cognitive Neuroscience. Passionate about all things mental health, she hopes to amalgamate her interests in neuropsychology, mental wellbeing, and medical science by pursuing a career in Medicine and Research that investigates and advocates for less-explored areas of psychiatry and mental illness.

Opinion

A Review on the Conservation of Kiwi Critters

Jarod McTaggart

Entomology and Conservation

Introduction

Aotearoa New Zealand is highly praised for its conservation efforts, and renowned for its clean green image. This image is a byproduct of a national identity centered around a connectedness with and duty to protect the environment. Within te ao Māori, the worldview of the indigenous people of Aotearoa, all things, both living and non-living, are interconnected [1]. Kaitiakitanga describes the guardianship of Māori over taonga such as land, species, people, and culture [2]. In New Zealand, recognition of the importance of our native species and conservation is a point of pride. As a post-colonial nation, this pride was driven by a national identity formed as a response to English superiority over early settlers [3]. In the New Zealand context, settlers' anxiety after colonisation drove the formation of a new cultural identity based on the environment and native species, rather than the colonial source [4].

Many stories of successful New Zealand conservation are centered on vertebrates, especially native bird species. However, this prioritisation of vertebrates has unfortunately limited the conservation efforts aimed at threatened native plants and invertebrate species. The Department of Conservation (DOC) has been limited in capacity and funding since its inception and thus must prioritise species and systems to protect. It often targets terrestrial vertebrates, particularly native birds and reptiles [5]. The 1953 Wildlife Act also highlights this historical blindness to insects. When released, it did not protect invertebrates, specifying animals as birds, mammals, reptiles, and amphibians, though this was later amended, adding invertebrate species in 1980, 1986, and 2010 [6].

This being said, why should we even care about insects? Normally when you hear 'insects' you think of creepy crawlies that you want out of sight and out of mind. What value do they actually bring?

The concept of 'ecosystem services' serves as a framework for understanding how different species and ecosystems provide for humans. It underscores the importance of insects to human life. Insects provide various services, including [7-8]:
(1) Provisioning services, such as food/fiber production, biocontrol, and habitat indicators,
(2) Regulating services, such as nutrient cycling, pollination/seed dispersal, and water flow/treatment,
(3) supporting services, such as habitat creation, oxygen production, and soil formation,
(4) cultural services, such as heritage, knowledge systems, and spirituality.

Global Insect Biodiversity Loss

Coined as the "Sixth Mass Extinction" in reference to the increasing number of species extinctions during the Anthropocene, we find ourselves amidst a global biodiversity crisis. [9-10]. Populations of insects and other invertebrate groups are significantly decreasing, leading to an "insect armageddon" [11]. These declines are due to a number of anthropogenic factors, including climate change, which impacts life cycles, changes in geographical range, and the facilitation of invasive species through environmental changes or human-mediated dispersal [12-15]. Anthropogenic land use further impacts native insects by reducing biodiversity and homogenising insect communities [16-18]. Furthermore, pollutants such as agrochemicals disperse out of agricultural areas and have been found to reduce biodiversity and community composition in insect communities [19-21].

Current Status of NZ Insect Conservation

Establishing the current status of and threats to the biodiversity of native insects is an essential step in understanding contemporary management as well as providing direction for future conservation projects. In the DOC annual report for the year ended June 30, 2023, the threat status of resident native invertebrates was evaluated using the New Zealand Threat Classification System (NZTCS) [22-23]. In this report, ~30% of invertebrates were considered data deficient,~ 7% were considered threatened, ~31% were considered at risk, and ~32% were considered not threatened [22]. While this report evaluates all invertebrates, not just insects, it indicates some overall trends of insect threat status. There is very limited knowledge of the vast majority of New Zealand insect taxa and their conservation status. While around half (~11,000 out of ~20,000) of the estimated species have been documented, only 13% (~1400) have been assessed under the NZTCS [24]. Therefore, little can be gleaned as to the overall trends in population and abundance due to a majority of the insect population being unrepresented in this report.

The management of insect species by DOC also leaves room for improvement. Over 90% of insect groups do not have enough data to establish management strategies (Figure 1), and even for those under management, 5.2% did not meet management requirements, and 3.15% had management requirements only partially met (the species received some management in at least one site). Only 0.15% of managed species have requirements fully met in at least 90% of the sites identified as crucial for species persistence. This management is not distributed evenly across insect orders, indicating that DOC prioritises a select few insect taxa, and when it does, there is a hierarchy of orders that are managed.

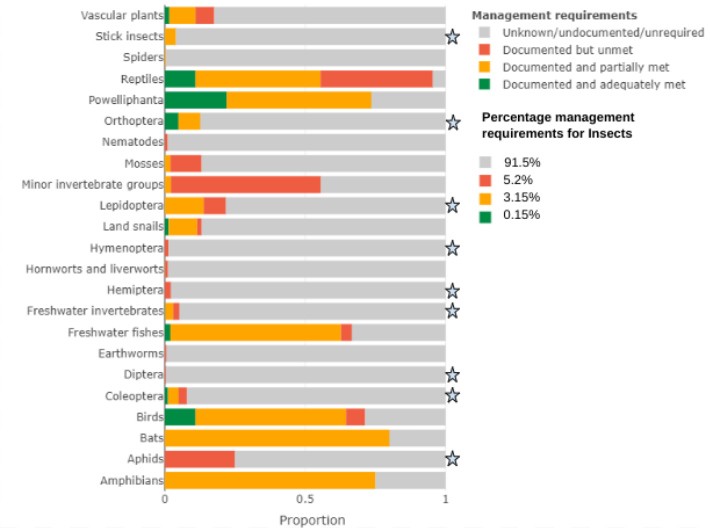

Figure 1: Proportion of species in each animal group that required conservation management. Insect groups indicated by stars, total proportions for each category of insect groups indicated. Each colour represents their current management and conservation status: (a) Green: adequately met, (b) Orange: partially met, (c) Red: unmet, and (d) undocumented. Adapted from "Number of managed indigenous species 2021-2022" by The Department of Conservation. 2022.https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2021-2022/indigenous-species-2021-2022/. Note. Freshwater invertebrates are included despite the fact not all are insect species.

Conservation Gaps

This begs the question of how effective New Zealand's conservation efforts are at a landscape scale. One method for evaluating landscape-level conservation is utilising museum records of insect specimens and mapping their location on the Protected Area Network (a database of legally protected areas). Species classified as 'threatened' or 'at risk' under the NZTCS were less likely to be present in these protected areas than species that were not [25]. This demonstrates how current protected areas are ineffective at protecting insect populations, stemming from a prioritisation of vertebrate taxa when planning protected areas. While some insect taxa may benefit from umbrella vertebrate species conservation, they are not equally protected when vertebrates are prioritised [26].

Mammalian predator removal is a conservation technique often used in New Zealand contexts as one of the most effective measures for protecting native bird species. However, when insect communities were monitored in a predator-free fenced reserve, the level of success between species was variable [27]. The majority of surveyed taxa had similar abundances both inside and outside the reserve, indicating that while fenced reserves and other predator-free areas may provide refuge for some species, they are not a universal conservation tool for insect populations. Even species that benefit from mammalian pest removal like wētā are nationally impacted due to the patchy or poor coverage of these strategies [28]. Declining wētā populations from 2014 to 2022 illustrate this. When the conservation status of 38 wētā taxa was monitored over this period, 5 improved, 19 worsened, and 14 stayed neutral [29].

However, it is not just the active management of insects that is lacking - the literature on New Zealand conservation also under-represents insects. To investigate this, the search terms "New Zealand", "conservation", and "insect" were input to scientific literature databases/search engines, and their relative occurrences were calculated to determine the proportion of New Zealand conservation articles/papers that relate to insects. The results from three databases/search engines (Google Scholar, Scopus, and Web of Science (core collection)) show that, on average, only 3.7% of the New Zealand conservation literature is related to insects (Table 1). While this is not completely representative, it gives an indication of the general trends in the literature. As with management and conservation action, the literature is biased away from insect groups, under-representing the diversity and conservation challenges this group faces.

	"New Zealand" "conservation"	"New Zealand" "conservation" "insect"	% of New Zealand conservation papers containing the term "insect"
Google Scholar	2,050,000	111,000	5.4%
Scopus	4,702	136	2.9%
Web of Science (Core Collection)	11,342	324	2.9%

Table 1. The number of results on academic search engines & databases for papers including keywords "New Zealand"&"conservation" compared to "New Zealand", "conservation" & "insect", including the percentage of articles containing the term "insect".

Points of Success

While the current state and trends of insect conservation in New Zealand appear mostly negative, there are also several examples of successful conservation, such as that of the nationally endangered robust grasshopper (Brachaspis robustus) [30-31]. In addition, the restoration of native forests is an effective and common technique often used as a conservation tool. Initially developed for the conservation of plant and bird communities, forest restoration also positively influences insect communities. Native insect diversity increases in replanted native forests, as illustrated by research showing that restored native ecosystems have higher proportions of native beetle species than non-restored reference sites [32].

A comforting prospect is that New Zealand has a track record of monitoring and eradicating invasive species with robust biosecurity protocols both pre- and post-border [33]. Due to this, the risk of invasive species is minimised as long as New Zealand maintains strict border security, reducing potential pressure on native insects [34]. Another major factor impacting insect populations is climate change, though, unlike specific predatory or competitive pressures, climate change is a far broader issue with wide-ranging impacts. Globally, these noticeable and measurable impacts have led to increased environmental awareness and climate action [35]. Thus, while climate change poses a threat to insect populations and biodiversity, it is actively being addressed. Current climate-based policy decisions provide a source of hope in the face of the insect biodiversity crisis.

Future Strategies

In order to successfully protect vulnerable native insect populations, we must develop and refine strategies that will effectively act to conserve native insect biodiversity. Understanding life history/life cycles, environmental/habitat requirements, and biotic relationships at a species-specific level is crucial for translocation and wider conservation efforts [31]. Thus, an overhaul of taxonomic and ecological research must be done to understand native insect biodiversity and facilitate more successful conservation efforts [36-37]. It is also important to actively engage with Māori stakeholders in translocation and conservation efforts, taking care to respect rangatiratanga and tikanga (Māori customary practices) [38].

Due to the number of taxa present in New Zealand, there must be prioritisation of specific taxa that are ecologically, culturally, or conservationally significant. Legislative protection for flagship, taonga, and ecologically significant species (eg. indicator species) provides a basis for safeguarding some of the most valuable and vulnerable taxa [39-41].

A vital part of conservation biology going forward is collaborating with Māori and integrating mātauranga Māori approaches into environmental understanding and conservation. A mātauranga Māori approach provides a knowledge base formed from a multi-generational history of observing the ecology of New Zealand. An example of this in entomology is the use of te reo Māori to understand complex relationships between multiple species, with the language naming conventions capturing spatial scales, distribution, and relationships between two insect species and plant interactions [42]. This understanding of complex relationships and systems is needed for successful insect conservation. Furthermore, working with Māori and respecting rangatiratanga (Māori self-determination/agency) provides opportunities for Kaitiakitanga and benefit sharing in the conservation and environmental management space [6].

Conclusion

Aotearoa has a long history and culture of conservation, rooted in a national identity of connection to nature. However, these conservation efforts often leave invertebrates, particularly insects, behind. Due to global changes and anthropogenic impacts on the environment, native insect populations are at risk of global and local extinction. Currently, the biodiversity of New Zealand's native insect communities is under threat, with historical and contemporary conservation attempts generally not successful enough to maintain robust populations or improve the conservation status of insects. This largely is due to the imbalanced prioritisation of conservation efforts, skewing funding and resources towards vertebrate species, particularly birds. Insect conservation in New Zealand is not all doom and gloom, however, as there is a growing awareness and agency to protect insect species. While some traditional, vertebrate-centric conservation strategies may work, others do not, and innovation and further understanding of species, ecosystems, and relationships are needed. The most important thing is developing a better understanding of insect species, from taxonomy, distribution, and ecological relationships. Establishing effective partnerships with Māori, where mātauranga Māori and kaitiakitanga can be practised, is fundamental to improved conservation in New Zealand. Finally, modifying existing tools and developing new effective strategies for insect management is crucial. It is time for insects in Aotearoa to get the conservation attention they desperately need and begin prioritising the little guys before it is too late to save this invaluable group.

Jarod McTaggart - PGDipSci - Biosecurity and Conservation (Biology)
Jarod is studying for a Postgraduate Diploma in Science as well as holding a BA/BSc conjoint degree from the University of Auckland. He has a passion for filmmaking as well as the environment, and his goal is to make a substantial contribution to conservation in New Zealand.

Academic

AI's Potential in Medicine: A Glimpse into the Future of Healthcare

Sanchani Brabhaharan

This report explores the transformative impact of artificial intelligence (AI) on healthcare, focusing on its integration with big data for advanced diagnostics and treatment. AI-driven decision-support systems reshape medical methodologies, enabling early cancer detection and personalised care. While recognising the complementary nature of AI and human expertise in achieving comprehensive and effective healthcare outcomes, this report delves into groundbreaking studies leveraging machine learning and deep learning in cancer diagnosis. Ethical considerations highlight the importance of unbiased algorithms and addressing healthcare disparities. This report concludes by emphasising AI's potential for equitable, accessible, and advanced medical solutions, marking a paradigm shift in healthcare.

The rapid evolution of generative artificial intelligence (AI) and the growing use of big data is transforming healthcare and scientific exploration. Notably, healthcare facilities are progressively integrating AI-driven decision-support systems, fundamentally reshaping the landscape of diagnostic and treatment methodologies. Advancements now enable us to rapidly detect cancer, foresee diseases before they manifest, and identify potential genetic disorders that could affect us in the future. As this powerful tool becomes integrated into the health sector, it is crucial to understand its benefits to foster positive advancements.

In some cases, AI may take over scientific thinking, medical diagnoses, and surgeries. However, every individual and every case is different; therefore, the knowledge, care, and understanding that doctors have will continue to save many lives. Medical professionals can use AI to research, conduct tests, and efficiently predict and diagnose diseases, utilising the algorithm models created with massive datasets. For example, it is tough to run tests, and with a lack of hospital staff and time, it is challenging to carry out intraoperative histopathology to deliver rapid, accurate diagnostic images that inform decisions during surgery. On this front, AI can increase efficiency with a trained dataset for accuracy [1]. Can AI effectively drive other healthcare advancements into the future?

AI in Medicine: Earlier Cancer Detection?

Cancer continues to pose significant challenges to healthcare systems. Although interventions targeting the uncontrollable growth of these cancer cells have shown improvement in recent years, diagnosis at advanced stages, rather than early detection, compromises treatment outcomes and renders intervention strategies less effective. In this instance, AI emerges as an innovative approach to overcome the limitations inherent in the current diagnostic methodologies and interventions.

Machine learning (ML) is a form of AI where computers are designed to learn from data structures and algorithms to analyse and identify patterns. This can allow the technology to forecast and make informed predictions and decisions based on unseen data. ML can assist in a broad scope of medical research and clinical areas, particularly in predicting various types of cancer. Numerous studies and practices have indicated that integrating AI and ML has exhibited a higher accuracy in predicting cancer compared to traditional clinical assessments [2]. The significance of AI in healthcare lies in its ability to assimilate multifaceted data from diverse patient assessments, allowing for a personalised and precise approach to care, patient survival, prognosis, and disease progression predictions [2]. This advancement facilitates individualised care strategies unique to the conditions of each patient.

Study 1:

Research was undertaken to determine if ML could provide accurate diagnostic predictions for brain tumour specimens [1]. It explores the ability of ML to accurately classify stimulated Raman histology (SRH) images of fresh human brain tumour specimens. SRH is an imaging technique paired with ML and deep learning that helps to detect brain tumours automatically during surgery. The research involved developing a clinical SRH microscope, comparing SRH with traditional hematoxylin and eosin (H&E) images, and employing a multilayer perceptron (MLP) machine learning model. The results demonstrated that ML algorithms, particularly MLP, can effectively diagnose and detect brain tumours, showcasing the potential of combining ML with imaging techniques like SRH in medical applications.

The accuracy of the MLP was rigorously tested using a leave-one-out approach, optimising the training set's size while mitigating potential correlations between samples in both the training and test sets. This approach was applied to 30 cases, each falling into one of four diagnostic categories: non-lesional, low-grade glial, high-grade glial, or non-glial tumours, encompassing meningioma, lymphoma, metastases, and medulloblastoma. These categories were selected due to their critical significance in providing essential information to guide decision-making in brain tumour surgery. Figure 1 shows the level of prediction accuracy by utilising MLP, i.e., the machine learning model. Figure 2 summarises the results shown in Figure 1(c).

Deep learning (DL) is another form of AI that utilises models based on neural networks to imitate the analytical capabilities of the human brain, particularly in the processing of extensive large data. This approach finds applications in diverse fields, including language processing, image recognition, and drug discovery.

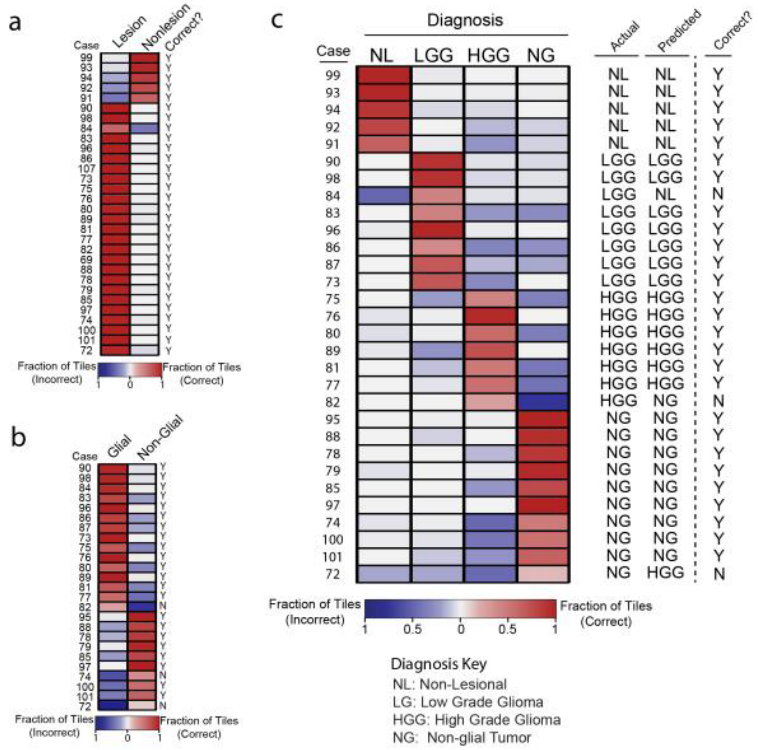

Figure 1: MLP-based diagnostic predictions of 30 neurosurgical cases. The predictions were made using MLP for discerning between lesion or non-lesional (a), glial or non-glial (b), and a summary of the accuracy of predictions made for the four diagnostic categories [1].

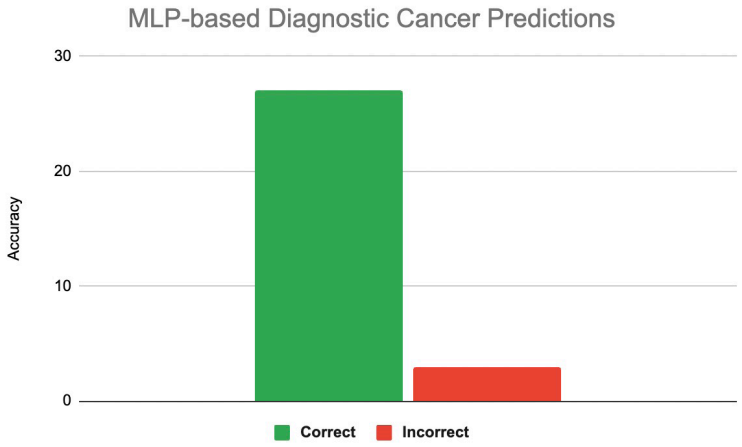

Figure 2: Summary of predictive accuracy across tumour classifications (predicted by the utilisation of MLP artificial intelligence technology). Adapted from D. A. Orringer et al., 2017, Rapid intraoperative histology of unprocessed surgical specimens via fibre-lased based stimulated Raman scattering microscopy.

Study 2:

Peritoneal metastasis (PM) is the most common form of distant metastasis and one of the leading causes of death in gastric cancer. Accurate PM diagnosis is clinically significant for treatment and prognosis [3]. In this research, the authors introduced stimulated Raman molecular cytology (SRMC), an intelligent cytology method based on stimulated Raman scattering (SRS) microscopy, for diagnosing PM from gastric cancer. The study utilised single-cell segmentation algorithms based on deep learning to extract 19 features associated with the morphology and composition of individual cells found in ascites. The team used a hybrid algorithm, K-PCA, combining K-means cell clustering and principal component analysis to simplify and transform distinct cell features. This process identified important marker cell groups, and their feature differences were used to differentiate between cases with positive and negative PM. The study incorporated machine learning classifiers, including support vector machine, linear discriminant analysis, and logistic regression to develop a diagnostic model for PM. The model was trained using the feature matrix and the actual PM results as inputs. Adding composition information significantly improved PM detection sensitivity from 59.25% to 81.5%, emphasising the importance of cellular features. Achieving 84.9% specificity in 20 minutes for 80 patients, the SRMC method shows promise for swiftly and accurately detecting PM in gastric cancer with minimal invasiveness.

AI in Healthcare: An Ethical and Social POV

AI stands out as a transformative tool, not as a replacement for the invaluable skills and knowledge of healthcare professionals, but as a means to elevate their capabilities in accuracy and diagnosis. As we enter this transformative phase, societal concerns prompt reflections on the ethical implications of incorporating AI into healthcare. Striking a balance between potential benefits and ethical considerations is vital to align seamlessly with our shared healthcare values.

Training AI algorithms in healthcare can improve outcomes, but it relies on extensive data input. Concerns arise about bias when training data needs to accurately represent the target population, hindering generalisation and potentially overestimating measures for specific racial or societal groups [5]. This bias can lead to unequal treatment in AI algorithms, emphasising the importance of ensuring fairness and mitigating biases. This is crucial to prevent unfavourable outcomes, safeguard patient privacy, and foster trust among patients and healthcare practitioners.

Initially developed for European-descent demographics, AI technologies face challenges in addressing the health concerns of Māori and Pasifika populations in New Zealand [5]. Diverse backgrounds need inclusion in AI datasets to understand health variations across populations. For example, AI algorithms for drug discovery should consider drug effectiveness across diverse populations. Developers must exercise caution concerning dataset variations,

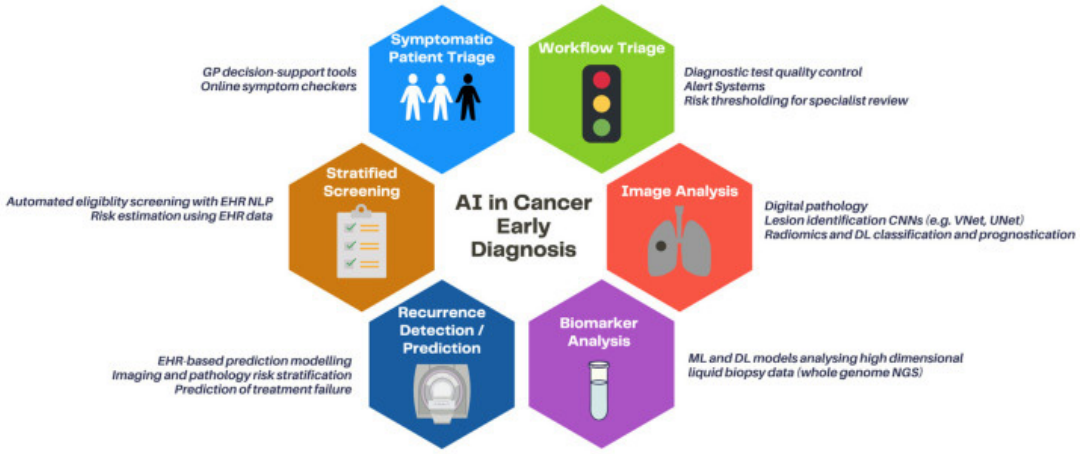

Figure 3: Clinical applications of AI in early cancer diagnosis [4].

unintentional biases, and complexities in generalising to different populations.

Despite the ethical concerns around potential misuse, it is crucial to alleviate existing healthcare disparities with the widespread availability of AI technology. The goal is to harness AI's potential universally, irrespective of socio-economic circumstances. Specific demographics, such as Māori and Pasifika communities in New Zealand, have faced negative impacts in healthcare. It is essential for AI algorithms not only to include these communities in datasets but also to ensure accessibility and affordability. AI-driven resource allocation systems should prioritise patients based on medical needs rather than financial status. However, international guidelines often overlook the importance of addressing persistent disparities endured by Māori. Aligning these efforts with the principles of Te Tiriti and insights from the Waitangi Tribunal Inquiry into Health Services and Outcomes is imperative [6]. The transformative power of AI in healthcare extends beyond diagnostics, offering a comprehensive approach to personalised care, early disease detection, and ethical considerations. As we navigate this technological evolution, the integration of AI stands as a hope for equitable, accessible, and advanced medical and healthcare solutions [7].

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Sanchani is completing her BSc, double majoring in Computer Science and Biological Sciences (Genetics). She aspires to combine both areas of her degree by implementing AI and software development solutions to advance genetics and healthcare in this digital age.

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Fun Fact

Titin, the largest known protein in humans, acts as a molecular spring in sarcomeres. Its full chemical name spans 189,819 letters and can take around three hours to pronounce.

Closing Comments

That concludes the Summer School Edition 2024! We appreciate your support as we continue to showcase outstanding scientific writing emerging from the University.

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A sincere thank you goes to our writers for their efforts during the summer break, and we extend this gratitude to our new executive members for kicking off the year on a solid note.

We hope you have enjoyed this edition, and we look forward to seeing you again soon – perhaps as a guest writer for Volume 4?

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