UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI
FOUNDATION

science & innovation
Department: Science and Innovation
REPUBLIC OF SOUTH AFRICA

SPARK KZN
Where Academia Meets Business.

UKZN RESEARCH AND INNOVATION

INVESTING IN KNOWLEDGE

INSPIRING GREATNESS

ABOUT SPARK KZN

The University of KwaZulu-Natal Foundation, in partnership with the Department of Science, Technology and Innovation (DSTI), is connecting business, academia and government in KwaZulu-Natal. South Africa offers a generous Research and Development (R&D) Tax Incentive to encourage innovation and collaboration between universities and industry. Spark KZN provides a clear, practical overview of how the incentive works and how both academics and industry partners can benefit.

SPARK KZN IS IDEAL FOR:

- Academics involved in research and industry collaboration
- Industry partners investing in research, development and innovation
- Finance, research support and innovation managers

Spark KZN is designed to unlock research-led innovation and partnership opportunities across priority sectors, including:

- Food security and agricultural innovation
- Computing, data science and quantum technologies
- Banking and financial services innovation
- Green energy and sustainable solutions
- Pharmaceutical and health-related research
- Public policy, governance and social innovation
- Education, skills development and human capital innovation

The University of KwaZulu-Natal (UKZN) is a leading research-intensive university committed to advancing knowledge that drives innovation, development and social impact. Through its four Colleges — Agriculture, Engineering and Science; Health Sciences; Law and Management Studies; and Humanities — UKZN delivers research that addresses real-world challenges at local, national and global levels. UKZN's research spans food security, climate resilience, digital technologies, public health, pharmaceutical innovation, governance, economic development, education, social transformation and sustainable growth. By combining scientific excellence with social insight, the University fosters collaborative partnerships that translate research into practical solutions for industry, government and communities.

WHAT IS THE DSTI R&D TAX INCENTIVE?

The Department of Science, Technology and Innovation (DSTI) offers a Section 11D R&D Tax Incentive, which allows companies to claim a 150% tax deduction on qualifying research and development (R&D) expenditure. This incentive encourages industry to invest in research partnerships with universities and research institutions.

The R&D Tax Incentive is a government tax benefit that encourages collaboration between universities and industry by supporting research and development activities.

INDUSTRY PARTNERS CAN BENEFIT BY:

- Claiming a 150% tax deduction on qualifying R&D costs
- Writing off R&D equipment faster over three years (50% in year 1, 30% in year 2, 20% in year 3)

Academic researchers contribute through scientific and technological research, while industry applies this knowledge to develop new or improved products, processes or systems.

UNIVERSITY–INDUSTRY R&D IN PRACTICE

- A company partners with a university research team to solve a technical problem or develop a new or improved product or process.
- Academic researchers conduct scientific or technological R&D (e.g. laboratory work, testing, prototyping, data analysis).
- The company funds the project and applies the research outcomes in its operations.
- The company may claim the R&D Tax Incentive on qualifying R&D costs, while academics gain industry-linked research, publications and student training opportunities.

WHO SHOULD INVEST?

- University researchers and research offices
- Industry R&D, innovation and finance teams
- Companies partnering with universities
- Anyone involved in applied research and innovation

For more information, visit https://foundation.ukzn.ac.za/dsti-spark-kzn-workshop/

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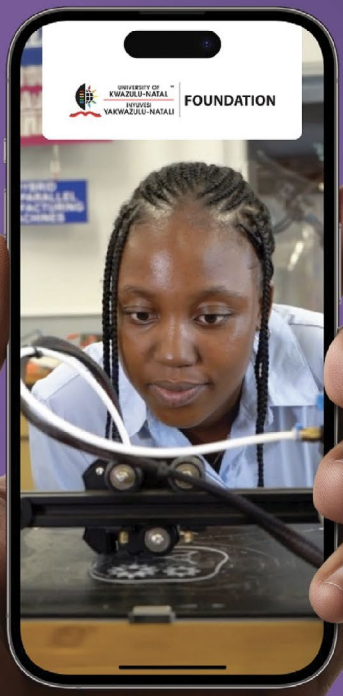
THE UKZN FOUNDATION AND WHAT WE DO!



Discover how the UKZN Foundation raises strategic funding to advance UKZN's Mission. This dynamic video showcases our efforts to support and empower students, driving community projects and addressing critical local and global challenges.

MAKE AN IMPACT:
See how your donation creates meaningful change. Your contribution matters.

BE INSPIRED:
Witness the transformative power of philanthropy at UKZN.

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INSPIRING GREATNESS

ABSTRACTS

Circular Economy and Resource Recovery Hub (CERR-Hub)

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The current linear economic model ("take, make, dispose") drives unsustainable waste and ecological degradation. To achieve sustainable development and environmental safety, South Africa must transition to a circular economy (CE) that prioritise resource efficiency. The Circular Economy and Resource Recovery Hub (CERR-Hub) strategically addresses these challenges. It functions as an innovation system that integrates academia, industry, government, and local communities to transform waste into valuable resources through practical research, decentralized systems, and community-driven innovation. In addition to the existing DEWATS, urine-diverting toilets, constructed wetlands, agricultural trial fields, and hydroponic systems, the proposed Hub will include sludge and urine-based fertilizer production technologies, various sludge-drying technologies, and other innovations (building materials, high-energy-value biomass, etc.). Our Centre has expertise and experience gained through decades of practical research and development in the sector. The CERR-Hub is also proposed to work hand in hand with existing initiatives in KZN through strong, strategic collaborations and to serve as a platform for innovators to showcase their inventions. This helps to fill critical gaps in waste, water, and other resources management in South Africa. The proposed CERR-Hub could be a pioneering initiative in South Africa, maximizing resource efficiency, thereby contributing to sustainable development.

Bioreactor-Driven Exploration of the Cannabis sativa Cannabinome for Targeted Antibacterial Activity

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Cannabis sativa has gained significant attention for its phytocompounds, especially the major cannabinoids. However, >150 trace (minor) cannabinoids (the "dark cannabinome") are routinely discarded during purification, despite their reported pharmacological and therapeutic potential, leaving their bioactivities largely uncharacterised. Obtaining sufficient biomass enriched in these minor compounds remains a core obstacle. The proposed study intersects plant biotechnology, chemistry, and microbiology. Récipient à Immersion Temporaire Automatique (RITA®) and Balloon-Type Bubble (BTB) bioreactors will systematically upregulate the minor compounds in shoot tissues via chemical elicitation. Solvent partitioning and column chromatography will yield three fractionated pools: crude extract, major-cannabinoid fraction, and dark-cannabinome fraction. Following characterisation (high-performance liquid chromatography-mass spectrometry [HPLC-MS], gas chromatography-mass spectrometry [GC-MS], and nuclear magnetic resonance [NMR] profiling), computational chemistry will predict and elucidate antibacterial mechanisms of action using molecular docking, density functional theory (DFT), molecular dynamics simulations, and chemoinformatic/QSAR modelling. Thereafter, pools will undergo rapid antibacterial screening via the resazurin microtiter assay (REMA). Active pools will undergo Clinical and Laboratory Standards Institute (CLSI)-compliant microdilution assays to determine minimum inhibitory concentrations (MICs) against susceptible reference strains for Mycobacterium tuberculosis and selected Gram-positive and -negative bacteria. This multidisciplinary approach converts industrial byproducts into a chemical library, establishing a reproducible platform for analysing underexplored phytocompounds.

Continuous Thermal Dehydration and Fry-Drying of Sludge for High-Energy Value Biomass Production

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This project evaluates an innovative "fry-drying" process that uses waste cooking oil to transform sludge into a safe, high-density biofuel. By treating sanitation waste as a resource rather than a burden, the study aims to support circular-economy goals by producing energy-rich briquettes. Laboratory experiments conducted at different operating temperatures demonstrated that less than 10 minutes of fry-drying reduces moisture content from 83.8% to nearly 1%, creating a microbiologically stable material. Crucially, the sludge absorbs oil during the process, which boosts its energy value, by more than 40%, from 17.3 MJ/kg (equivalent to low-grade coal) up to 25 MJ/kg (equivalent to Bituminous coal), making it as powerful as high-grade industrial coal. Beyond laboratory testing, a continuous processing prototype system (2.2 m x 1.8 m x 1.1 m) was designed and constructed. This was done through a multidisciplinary effort that has fostered significant academic growth, supporting an MSc candidate and several engineering students. Ongoing research is now focused on optimising this continuous system on the prototype and refining the final product through briquetting and piloting, ultimately providing a scalable solution for safe sanitation and sustainable energy recovery.

Identification and Surveillance of Substandard and Falsified Medicines in South Africa Using the GPHF-Minilab™: A Field-Based Rapid Detection Approach

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South Africa's medicines supply chain — spanning public clinics, private pharmacies, and dispensing doctors — serves millions of patients daily. Yet the scale of substandard and falsified (SF) medicines circulating within it remains poorly quantified. Globally, the World Health Organization estimates that 1 in 10 medicines in low- and middle-income countries fails to meet quality standards, contributing to treatment failure, antimicrobial resistance, and preventable death. This project proposes the procurement and deployment of a GPHF-Minilab™ — a portable, field-ready quality testing system developed by the Global Pharma Health Fund — to conduct rapid identification and content verification of essential medicines across KwaZulu-Natal. The Minilab uses physical testing and thin-layer chromatography (TLC) to assess 107 active pharmaceutical ingredients, delivering semi-quantitative results without the infrastructure requirements of a fully equipped laboratory. Building on locally conducted research that found concerning disconnects between stakeholder perceptions of medicine quality and actual in vitro performance (Patel et al., 2012), this project will generate the first systematic, field-based SF medicine dataset for South Africa — informing regulatory action, procurement policy, and pharmacovigilance systems. For pharmaceutical industry partners, the project offers direct reputational protection, supply-chain intelligence, and a scientifically robust platform for demonstrating product quality to the market. South Africa's post-COVID-19 pharmaceutical landscape has seen an influx of new suppliers, accelerated procurement processes, and heightened public sensitivity about medicine quality. Simultaneously, the country's essential medicines list covers high-burden conditions — HIV/AIDS, TB, malaria, hypertension, diabetes — where treatment failure has catastrophic downstream consequences. A robust, field-deployable quality surveillance tool is not merely useful; it is overdue.

IMPACT PHC: Building Africa's First District-Level Learning Health System for PHC

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Primary health care (PHC) in South Africa faces a critical bottleneck, where routine health data remains fragmented, delayed, and rarely utilised for real-time clinical action. IMPACT-PHC is a five-year initiative designed to establish a district-level learning health system that transforms this idle data into actionable intelligence (Barron & Sankar, 2000; Friedman et al., 2017; Witter et al., 2022). The project develops a first-of-its-kind interoperable digital platform that integrates existing systems, such as DHIS2, with facility-level clinical data to generate real-time indicators for high-burden chronic diseases, including HIV, TB, hypertension, and diabetes (Farnham et al., 2023). By embedding structured governance and capacity building into routine workflows, the initiative enables a shift from retrospective reporting to proactive, data-driven patient care. For industry partners, this offers a validated product for digital health integration and health system strengthening, directly improving service efficiency and patient outcomes. The project promises a scalable framework for universal health coverage, offering high social return and technological leadership in the digital health space.

Fusion Protein Platform for the Construction of Novel TB Antigen Candidates for Diagnostic and Vaccine Development

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Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains a leading cause of mortality in South Africa, particularly among HIV co-infected populations. Current diagnostic tools such as GeneXpert, while effective, face cost, infrastructure, and sensitivity limitations in decentralized and immunocompromised settings. Additionally, the Bacillus Calmette–Guérin (BCG) vaccine offers poor protection against adult pulmonary TB, necessitating innovative solutions. This project aims to develop and evaluate a novel, dual purpose fusion protein platform incorporating immunodominant adhesin antigens of Mycobacterium tuberculosis for diagnostic and vaccine applications. Two recombinant trifusion proteins (tnLPH and tnMPH) previously designed by our research team, will be evaluated as diagnostic biomarkers and vaccine candidates using an ELISA-based proof-of-concept platform. In parallel, their immunogenic potential will be explored in a mouse model to support future vaccine development. In addition, an innovative mucosal delivery platform (PilVax), using Lactococcus lactis to deliver adhesin-derived peptide vaccine candidates intranasally, will be evaluated for enhanced localized immune responses. The primary outcome of this study is the validation of these fusion proteins:

i) as sensitive and specific diagnostic antigens, particularly in HIV co-infected populations;

ii) as potential candidates in the vaccine pipeline.

Expected outputs include robust diagnostic datasets, candidate biomarkers for further diagnostic translation, vaccine development and potential intellectual property. This work lays the foundation for future development of point-of-care diagnostic platforms and vaccine candidates within the South African biotechnology sector.

Moving the Needle: An Online Mathematics Teaching-Enhancement Pilot for the Greater Durban Area

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Mathematics is the gateway to science, engineering, commerce and health-sciences study, yet South Africa's results reveal a quality crisis behind a record headline pass rate. In 2025 the national overall pass rate reached a record 88%, but the Mathematics pass rate fell from 69% to 64% (at the 30% threshold) and only about 34% of candidates wrote Mathematics. The binding constraint is teacher capability across the Grade 8 to 12 pipeline: a strong Grade 12 teacher cannot undo gaps accumulated in earlier grades. Moving the Needle is a three-year pilot in approximately 50 greater-Durban high schools that develops and validates a novel, fully online teacher-development and assessment model. A single lecturer delivers nine grade-specific modules — 270 recorded lectures reused across cohorts through a Moodle content bank — combining content mastery, didactics, "how-I-teach-it" methods and assessment literacy, with quizzes, self-tests and invigilated certification at an 80% standard.

The pilot measures teacher competence and learner outcomes — participation, Grade 11-to-12 progression and the full mark distribution — against matched comparison schools, producing an evidence-based, scalable model for wider rollout. As applied research and development, the pilot does more than deliver training: it develops and validates a new, technology-enabled teacher-development system.

The innovation is an online, grade-pipeline model with a reusable Moodle content-and-assessment bank; its effect is uncertain at the outset; and a matched-comparison evaluation provides the systematic investigation that tests it. Its deliverables — a validated and transferable model, a structured content and assessment bank, an evidence dataset and a costed scale-up blueprint — are reusable assets that a funding or industry partner can co-own and extend, and that underpin any subsequent provincial or national rollout.

Diamond-Like Carbon (DLC) Hard Coatings on Acoustic Drive Unit Diaphragms for Suppression of High-Frequency Breakup Modes

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High-performance loudspeaker drivers, particularly tweeters, suffer from diaphragm breakup at elevated frequencies. When a tweeter diaphragm transitions from pistonic (rigid-body) motion into flexural resonance modes, the frequency response exhibits sharp peaks and dips that degrade sound reproduction quality. This breakup introduces audible coloration, harshness, and loss of detail in the critical upper-frequency range (typically above 10–20 kHz). Solving this problem would allow South African loudspeaker manufacturers such as Vivid Audio to achieve world-leading acoustic performance in their driver units, strengthening export competitiveness.

Nanomaterials for the clean-up of water

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UN SDG 6 identifies clean water and sanitation as a global requirement and the South African constitution also guarantees the right to clean water for all people of South Africa. However, many of our water resources are contaminated by pollutants resulting in poor quality water sources and an increase in pollution in our environment. In order to remediate our polluted water systems, the development of new technology is needed to enhance wastewater treatment processes and so return a cleaner treated water back to the environment. New technology such as nanomaterials has shown effectiveness in removing organic and inorganic pollutants with further photodegradation leading to a complete destruction of the pollutant. We propose the development of nanomaterials doped with suitable metals for the adsorption and subsequent photodegradation of organic pollutants that lead to complete breakdown and destruction of the organic pollutant to carbon dioxide and water. This will result in a cleaner end treated water and also reduces the need for disposal of any removed pollutant which will now be converted to low molar mass molecules that are less harmful. These advanced nanomaterials offer an advanced method of cleaning polluted water and allows for a more effective water treatment process.

Low-Light Image Enhancement

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Low-light image enhancement is a longstanding challenge in computer vision, vital for applications ranging from surveillance to autonomous driving. While existing illumination-based methods eliminate artifact-inducing post-processing (such as gamma correction), they rely on a rigid and empirical exposure parameter. This reliance restricts their adaptability, leading to under-enhancement in extremely dark scenes or over-exposure in moderately dim environments. To address this, we propose an Adaptive Enhanced Self-Reinforced Retinex Projection (AESRRP) model. This innovation introduces three core mechanisms: a novel adaptive mean-aware exposure mechanism that dynamically predicts a control parameter to replace the fixed empirical exposure parameter using a non-linear sigmoid function with two saturation points, to ensures maximum brightening and prevent over-enhancement, a contrast-aware piecewise function incorporating illumination standard deviation and a spatially variant sub-image processing scheme with weighted aggregation to handle complex multi-exposure scenarios. Extensive experiments on standard benchmarks (LOL-v2 and SICE datasets) demonstrate that AESRRP achieves state-of-the-art performance, outperforming sophisticated deep learning neural networks. This provides an efficient, mathematically rigorous framework optimized for real-world adaptability, offering industry partners a lightweight solution to unlock high-fidelity visual data recovery.

MycoShield: Development and Validation of a Broad-Spectrum Antifungal Hospital Disinfectant

Lead Researcher: Professor Ché Pillay
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Hospital-acquired fungal infections pose a growing threat to patient safety worldwide, with Candida species accounting for a significant proportion of healthcare-associated infections (HAIs). Our laboratory has developed a novel antifungal disinfectant formulation, MycoShield, which has demonstrated inhibition of Candida albicans growth in preliminary assays. However, critical knowledge gaps remain: its efficacy against the multidrug-resistant pathogen Candida auris, its minimum inhibitory concentration (MIC), and its ability to disrupt biofilm formation on hospital surfaces have not yet been characterised. Additionally, its activity against clinically relevant bacterial and viral co-pathogens is unknown. This project proposes a systematic programme of in vitro and ex vivo testing to determine the spectrum of activity, MIC values, and biofilm-disrupting capacity of MycoShield, and to optimise the formulation for broad-spectrum performance. Successful outcomes will provide the scientific and regulatory evidence base necessary for commercialisation as a hospital-grade disinfectant, directly addressing an unmet need in infection prevention and control (IPC), particularly in low- and middle-income healthcare settings.

Enabling Self-Employment for Persons with Disabilities: Validation of the OTeSP Framework

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Persons with disabilities in South Africa face disproportionately high unemployment, limiting economic participation and increasing poverty. While self-employment presents a viable solution, there is currently no validated, contextually relevant framework to guide practitioners, organisations, and policymakers in supporting sustainable entrepreneurship among this group. This project implements and validates the Occupational Therapy Evidence-Based Framework on Self-Employment (OTeSP), a novel tool designed to support inclusive enterprise development. The framework will be tested across multiple real-world settings, including individuals, organisations, and government stakeholders, to refine its effectiveness, scalability, and sustainability. For industry and public sector partners, the project offers a structured, evidence-based approach to supporting disability-inclusive economic development, improving programme outcomes, and strengthening compliance with national and international policy frameworks. Expected outputs include a validated framework, training resources, policy recommendations, and scalable implementation models. The project contributes to inclusive growth, workforce participation, and innovation in social and economic development.

Research, Development and Innovation in waste and biomass valorisation

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The SMRI/DSTI/NRF SARChI Chair in Sugarcane Biorefining in South Africa is providing research, development and innovation in chemical engineering and chemistry, producing chemicals and materials from biomasses and wastes. We seek to provide solutions for local industries and our society. We have established state-of-the-art laboratory instrumentation and pilot plant infrastructure that enables us to provide reliable analytical and characterisation data, e.g. purity, composition and properties of industrial samples; conduct systematic optimisation studies for reactions and processes (both in experimental studies and through Aspen Plus modelling); develop new methods and processes, focussing on efficiency and sustainability; train individuals; provide consultations, including in-depth open and patent literature reviews and technoeconomic analyses.

We have over 25 years of experience in working at the crossroads between industry and academia, both in bilateral contract or research projects, and large research networks. We have a track record of successful project applications from various funders, both nationally and internationally, responding to the respective funding requirements. Examples of current projects include the extraction of value-added compounds from locally grown plants, fermentation broths or industry wastes; production of bioplastics material from sugar mill streams; development of sustainably sourced binders, e.g. for particle boards or coal dust; recycling of household plastics (outreach to rural areas and schools) and determination of industrial process conditions on product purities.

Development and Forensic Validation of a Multiplex Biosensor Platform for Rapid Body Fluid Identification on Forensically Relevant Substrates

Lead Researcher: Dr Meenu Ghai
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Body fluid identification is a critical step in forensic biology because it provides contextual information about the biological origin of DNA evidence. DNA profiling can identify a person, but does not always explain which body fluid or tissue the DNA originated from. This distinction is important in reconstructing events and interpreting biological evidence. Current serological tests are presumptive, single-target, substrate-sensitive, or limited in sensitivity and specificity. Emerging epigenomic, transcriptomic and proteomic methods require extensive laboratory steps. Biosensors offer a promising alternative because they can provide rapid, sensitive and potentially non-destructive screening with limited sample preparation. Portable biosensors have been highlighted as useful in forensic investigations.

A 2025 National institute of justice / Office of Justice Programs project focused on a multiplexed, paper-based chemi resistive biosensor system for rapid, selective and on-site identification of multiple forensically relevant body fluids. Portable biosensor platforms could improve crime scene decision-making by allowing investigators to screen biological stains in real time, prioritise samples for DNA analysis, and reduce unnecessary laboratory submissions. This could decrease case backlogs and lower operational costs in forensic laboratories. In addition, multiplexed biosensors could enhance the interpretation of complex biological evidence, particularly in cases involving mixed stains or low-template samples. However, there remains a need to evaluate biosensor performance under realistic forensic conditions, including aged stains, mixed body fluids, porous and non-porous substrates, environmental exposure, low-template samples, and compatibility with downstream DNA profiling. Addressing these gaps will be essential for determining whether biosensor-based body fluid identification can provide a reliable, validated, and operationally practical alternative or complement to existing forensic serological methods.

Development of a Multipurpose Modular Hydrometallurgical Pilot Plant for Critical Metal Recovery from Electronic Waste

Lead Researcher: Professor Kuven Moodley
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The increasing global demand for rare earth elements (REEs) and critical metals required for renewable energy systems, electric vehicles, batteries, and advanced electronics has intensified pressure on conventional mining operations and global supply chains. Simultaneously, growing volumes of electronic waste (e-waste) present environmental challenges and an opportunity for resource recovery through urban mining. This project proposes the development and validation of a multipurpose modular pilot-scale hydrometallurgical process for recovering REEs and critical metals from multiple e-waste streams, including NdFeB permanent magnets, nickel-metal hydride batteries, lithium-ion batteries, fluorescent lamps, and printed circuit boards. The process integrates feedstock-specific pre-treatment with low-energy hydrometallurgical separation techniques involving leaching, solvent extraction, stripping, and precipitation. The project addresses scientific and technological uncertainties associated with selective extraction from heterogeneous waste matrices, modular process integration, pilot-scale continuous operation, and process flexibility across multiple waste streams. The expected outcome is a validated modular pilot plant capable of high-purity recovery of strategic metals while supporting circular economy initiatives, local beneficiation, environmental sustainability, and advanced recycling technologies within South Africa.

Development of a Pilot-Scale Continuous Mineral Carbonation Process for CO_2 Sequestration Using Mine Tailings

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The mining sector faces increasing pressure to reduce greenhouse gas emissions while simultaneously addressing the environmental burden associated with mine tailings storage. This project proposes the development of a pilot-scale continuous mineral carbonation process for the sequestration of carbon dioxide (CO_2) using reactive mine tailings sourced from South African mining operations. The technology is based on enhanced weathering and mineral carbonation, where CO_2 reacts with calcium- and magnesium-rich tailings to form stable carbonate minerals suitable for long-term storage. Previous laboratory and bench-scale investigations demonstrated significant carbon uptake under controlled temperature, pressure, and pH conditions. The proposed work aims to address key scientific and technological uncertainties associated with scaling the process from batch laboratory systems to a continuous pilot-scale operation capable of processing variable tailings compositions and fluctuating CO_2 feed streams. The project will generate a validated pilot-scale process, operational datasets, process models, and engineering design recommendations. Industry partners may benefit through reduced carbon liabilities, improved ESG compliance, mine tailings valorisation, and the development of sustainable low-carbon mining operations.

Performance Evaluation of Pavement's Seal Course Using Nanomaterial and Sasobit® REDUX

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Pavement surface seals such as chip seal and Cape seal are cost-effective treatments that preserve roadways and extend their service life (TG1, 2020; Sabita, 2021). In South Africa, however, current practice does not favour their construction during the winter period because cold temperatures impair binder–aggregate adhesion, accelerate cracking, bleeding and lead to costly material wastage. The resulting winter embargo significantly shortens the maintenance window available to road authorities and inflates whole-life pavement costs. This research evaluates two innovative modifiers, namely Sasobit® REDUX (a refined Fischer–Tropsch synthetic wax) as a tack-coat modifier in chip seal, and anionic nano-modified bitumen emulsion (NME) as the slurry component in Cape seal, with the aim of enabling durable winter sealing. The study systematically determines optimum dosages, the safe construction temperature, and field performance against rutting, stripping, cracking and skid loss. Key outputs are a 200-metre Cape seal trial section in KwaZulu-Natal and a purpose-built portable cyclic shear and aggregate retention tester for affordable in-field bond assessment. The work is expected to deliver a validated winter-weather sealing protocol that lowers material wastage, extends the construction window and supports sustainable, year-round road maintenance.

Engineering Molecular Hybrid Therapeutics from Existing Drugs to Address the Global Challenge of Drug-Resistant Tuberculosis

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Tuberculosis (TB) remains one of the leading infectious diseases affecting South Africa and continues to place a major burden on the national healthcare system. The increasing prevalence of multi-drug-resistant (MDR) and extensively drug-resistant (XDR) tuberculosis poses a significant threat to public health, treatment success, and socioeconomic development. Despite the availability of existing anti-TB therapies, the rapid emergence of drug resistance, prolonged treatment regimens, toxicity, and poor patient compliance highlight the urgent need for innovative and locally driven therapeutic interventions. This project aims to engineer novel molecular hybrid therapeutics from existing anti-tuberculosis drugs to address the growing challenge of drug-resistant TB. Using a ra tional molecular hybridization strategy, established anti-TB pharmacophores will be integrated with complementary bioactive scaffolds to generate next-generation hybrid molecules with enhanced antimycobacterial potency, improved pharmacokinetic properties, reduced toxicity, and the ability to overcome resistance mechanisms in resistant Mycobacterium tuberculosis strains. The project will adopt an integrated multidisciplinary approach combining computational drug design, molecular modelling, synthetic medicinal chemistry, in vitro antimycobacterial evaluation, cytotoxicity profiling, and structure–activity relationship (SAR) studies to identify and optimize promising lead compounds. The proposed study aligns strongly with the priorities of the Department of Science, Technology and Innovation by promoting health innovation, pharmaceutical development, local research capacity, and the advancement of indigenous scientific solutions to diseases of national importance.

A Responsive Caregiving and Maternal Mental Health Support Toolkit for Vulnerable Mother - Infant Dyads

Lead Researcher: Dr Gina Rencken
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Many vulnerable mother-infant dyads in South Africa experience the combined pressures of maternal mental health concerns, poverty, infant medical risk, disrupted caregiving confidence, and limited access to specialist early intervention. These factors can affect responsive caregiving, infant regulation, early bonding, and developmental participation, yet frontline services often lack a structured, practical toolkit that bridges mental health, occupational therapy, and early infant development. This project will develop and pilot a responsive caregiving and maternal mental health support toolkit for use by occupational therapists, allied health professionals, community-based organisations, and early childhood service providers. The toolkit will include dyad vulnerability indicators, brief caregiver reflection prompts, parent education resources, developmentally supportive activities, referral guidance, and a facilitator guide for individual or small-group use. The R&D objective is to determine which toolkit components are feasible, acceptable, culturally responsive, and clinically useful in low-resource South African contexts. Industry partners would benefit from an evidence-informed, scalable support package that can enhance maternal-infant services, strengthen prevention-focused care, support staff training, and create opportunities for digital, print or hybrid implementation models.

Tape-Assisted Closure (TAC): A Novel Mechanical Wound Therapy for Accelerated Skin Healing

Lead Researcher: Professor Mahendra Daya
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Skin wounds resulting from trauma, disease, and surgery represent a growing global healthcare burden. Many wounds fail to close promptly using conventional dressings, leading to prolonged healing, increased infection risk, and the need for surgical intervention. Existing advanced wound therapies are often expensive, complex, or inaccessible in resource-limited healthcare settings. Tape-Assisted Closure (TAC) is a novel handheld mechanical applicator designed to deliver and apply adhesive surgical paper tape to skin and wounds in a controlled manner. The device enables clinicians to apply tape segments of user-defined length across a wound while generating controlled mechanical tension across the surrounding skin. This tension stretches the skin and immediately reduces wound width while securing the wound under a semi-occlusive tape dressing. Skin possesses a natural biomechanical property of *stress relaxation and mechanical creep.* Over time, taped skin relaxes and generates additional laxity. By periodically removing and reapplying tape using the TAC device over hours to days, this physiological property can be harnessed to progressively approximate wound edges. Serial application allows wounds to close *spontaneously or with minimal surgical assistance*, providing a simple mechanical method for wound closure and tissue expansion. Non-invasive and painless, simple and rapid to apply, cost-effective alternative to complex wound therapies, utilises widely available surgical tape, harnesses natural skin biomechanics, Reduces surgical demand for wound closure, applicable across diverse healthcare settings.

Optimisation of animal manure extracts for hydroponic tomato (Solanum lycopersicum L.) and spinach (Spinacia oleracea L.) production

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South Africa's agricultural sector is divided between a well-developed commercial farming industry and resource-poor smallholder farmers. To improve productivity, especially for smallholder farmers, the Department of Agriculture, Forestry and Fishes (DAFF) proposed adopting advanced soilless technologies to enhance yields without requiring additional resources. However, these systems heavily rely on chemical fertilisers for production, which, for the most part, are not environmentally friendly. Organic and inorganic fertilisers have been suggested as a more effective solution, as they can synchronise nutrient release with crop demand, reducing losses and ensuring sustainable productivity. Research indicates that combining organic manure with inorganic fertilisers can increase crop yields and nutrient uptake. Inorganic fertilisers or organic sources alone cannot achieve sustainable productivity, but their combination significantly improves crop performance. This is because synthetic fertilisers stimulate the availability of nutrients in organic fertilisers. Thus, investigating the integration of organic and inorganic fertilisers as a cost-effective, eco-friendly solution for nutrient management in crops such as tomato and spinach is critical to achieving sustainable agricultural production.

Direct conversion of carbon dioxide (CO2) through transition metal catalysis to dimethyl ether (DME) for hydrogen storage

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Greenhouse gas emissions and associated global warming are considered one of the most serious environmental problems of our time.[1] The chemical industry significantly contributes to the emission of such greenhouse gases. In particular, the combustion of fossil fuels is increasingly generating CO_2. CO_2-induced climate change leads to physical, health, and ecological challenges. These disruptions have an impact on ecosystems and socio-economic stability. Removing CO_2 from the atmosphere and moving away from fossil fuels as a source of energy can help mitigate this problem. Wind and solar power are key to supplying future energy needs in a climate-friendly way. Producing electricity is especially cost-effective in places such as South Africa with strong sunlight, steady winds. Coupled with abundance of platinum group metals, large-scale electrolyzers that can convert the renewable energy to green hydrogen could be built in South Africa. Storage and transport of this cheap sustainable energy can be realized by generating green hydrogen.[2] This hydrogen can be stored as dimethyl ether (DME), through a chemical reaction with CO_2. The hydrogen can be extracted and re-electrified. This presents an opportunity for industries in South Africa to export clean energy to countries like, Lesotho and Germany that depend on energy imports.

The application of epinecrotic bacterial communities as toxicological indicators of lethal drugs and their metabolites in decomposing pig carcasses and surrounding soil.

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The decomposition of a cadaver involves the processes of autolysis, putrefaction, and breakdown of the biomass of the carcass and is divided into five stages. These stages are reported to be associated with different bacterial communities and their succession serve as a promising forensic tool for post-mortem interval (PMI) estimation and cause of death. Certain drugs have been reported to influence microbial succession indirectly by interacting with the host's physiology before and after death. Stimulants have been shown to speed up microbial emergence and decomposition rate while depressants such opiates and sedatives may decelerate breakdown, which could impact the anticipated microbial presence. Drug-related changes can produce inaccurate microbial time signatures since epinecrotic bacterial communities are being increasingly utilised in PMI estimate techniques. Results may become less accurate if community dominance shifts away from predicted taxa (Firmicutes to Proteobacteria) and alter chronological microbial indicators. Therefore, to prevent inaccuracies, forensic microbial clocks must account for drug-induced changes in microbial succession.

Certain epinecrotic bacteria may serve as indicators of drug exposure because certain taxa preferentially digest drug residues or dominate in settings that have been altered by drugs. When chemical studies are inconclusive due to post-mortem degradation, the persistence of specific bacteria on the skin or the oral cavity may indirectly indicate the presence of substances like cocaine, heroin, or paracetamol, providing an alternative toxicological determination tool. Furthermore, secondary toxicological evidence can also be obtained from microbial metabolites, where distinct microbial biotransformation products reveal pre-mortem drug consumption. The results of this study will be beneficial in forensic microbiology investigations in cause of death cases as drugs such as heroin and cocaine in South Africa are the cause of most suicides or overdoses.

Investigating the Molecular and Immunomodulatory Roles of Vaginal Gardnerella Extracellular Vesicles in Bacterial Vaginosis and Associated Mucosal Inflammation

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Bacterial vaginosis (BV) is the most prevalent vaginal dysbiosis among women of reproductive age and is strongly associated with genital inflammation, adverse reproductive outcomes, antimicrobial resistance, and increased susceptibility to HIV infection. Despite its high burden, the molecular mechanisms driving BV pathogenesis remain poorly understood. This project investigates extracellular vesicles (EVs) produced by vaginal Gardnerella species, key bacterial contributors to BV, to determine how their molecular cargo influences host inflammatory responses. The study combines advanced EV isolation, characterization, cargo profiling, and host-cell interaction analyses to identify strain-specific differences among Gardnerella species and their contributions to mucosal inflammation. By elucidating the role of microbial EVs in host-microbe communication, the project aims to identify novel biomarkers and therapeutic targets for BV. The outcomes have significant translational potential for the development of precision diagnostics, microbiome-compatible therapeutics, and innovative interventions that reduce BV recurrence, limit antimicrobial resistance, and improve reproductive health outcomes. The project also strengthens South African capacity in extracellular vesicle research, multi-omics technologies, and women's health innovation.

Synthesis, Characterization and Biological Evaluation of Novel Chromene and Chromeno[2,3-d]pyrimidine Derivatives as Antiproliferative Agents Against MCF-7 Breast Cancer Cells and Antibacterial Agents

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Cancer and antimicrobial resistance remain among the leading causes of morbidity and mortality worldwide, necessitating the continuous search for novel therapeutic agents with improved efficacy and reduced resistance potential. Chromene and chromeno[2,3-d]pyrimidine derivatives have emerged as promising heterocyclic scaffolds owing to their diverse biological activities, including anticancer and antimicrobial properties. The present study aims to synthesize, characterize, and evaluate a series of novel chromene and chromeno[2,3-d] pyrimidine derivatives as potential antiproliferative agents against MCF-7 breast cancer cells and as antibacterial agents against selected Gram-positive and Gram-negative bacterial pathogens. The synthesized compounds will be characterized by Fourier-transform infrared spectroscopy (FTIR), nuclear magnetic resonance spectroscopy (NMR), high-resolution mass spectrometry (HRMS), and single-crystal X-ray diffraction. Antiproliferative activity will be assessed against MCF-7 breast cancer cells using the MTT assay, while antibacterial activity will be evaluated against *Klebsiella pneumoniae, Pseudomonas aeruginosa, Enterococcus faecium, and Staphylococcus aureus* using growth inhibition and mini mum inhibitory concentration (MIC) assays.

To gain insight into the mechanisms underlying biological activity, DNA and bovine serum albumin (BSA) binding will be studied using UV–Vis spectroscopy. In addition, molecular docking and ADME analyses will be conducted to investigate target interactions, binding affinities, and drug-likeness properties. The integration of experimental and computational approaches will facilitate the establishment of detailed structure–activity relationships that link molecular structure, physicochemical properties, and biological performance. The study is expected to identify biologically active chromene-based derivatives with enhanced antiproliferative and antibacterial activities while providing a comprehensive understanding of the structural factors governing their activity. The findings will contribute to the rational design of novel multifunctional therapeutic agents and advance current knowledge in medicinal chemistry, cancer research, and antimicrobial drug discovery.

AI- Driven O-RAN Slice Orchestration for 5G-Advanced and 6G Networks

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Future 5G-Advanced and 6G networks must simultaneously support heterogeneous services with conflicting requirements, including enhanced Mobile Broadband (eMBB) applications requiring high throughput and Ultra-Reliable Low-Latency Communications (URLLC) services requiring stringent latency and reliability guarantees. Traditional static resource allocation methods struggle to adapt to rapidly changing traffic conditions, leading to inefficient network utilization and reduced service quality. This project proposes an Artificial Intelligence (AI)-driven O-RAN slice orchestration framework based on Hierarchical Reward Weighting (HRW), a novel multi-objective reinforcement learning approach that dynamically allocates radio resources according to real-time network conditions and service requirements. The framework employs a two-timescale control architecture aligned with O-RAN principles, enabling adaptive resource optimization while maintaining service-level agreements across multiple network slices.The expected outcome is a scalable and intelligent resource orchestration solution capable of improving network efficiency, reducing operational costs, enhancing user experience, and supporting future digital transformation initiatives across telecommunications, smart industry, mining, and public-sector connectivity environments.

Environmental stress tolerance breeding for dual-purpose pearl millet *(Pennisetum glaucum)* using marker-assisted selection and CRISPR-Cas9 technology

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Co-Supervisors: Professor Alfred Oduor Odindo and Professor Augustine Gubba South Africa's agriculture is threatened by climate change, drought, and rising demand for both food and livestock feed (Jagermyer et al, 2021; van Dijk et al., 2021). This creates a need to explore the potential of "under-utilised crops" in addressing the systemic vulnerability of staple crops posed by climate change (Ngounou et al., 2025). Pearl millet is a climate-resilient crop with significant potential to address these challenges due to its ability to adapt to marginal environments and its value as both a grain and a fodder crop (Satyavathi et al., 2021). However, existing varieties often exhibit trade-offs among drought tolerance, grain yield, and stover quality. Furthermore, despite its genetic potential to produce up to 3,000 kg/ha of grain, average yields remain only 800-900 kg/ha, highlighting a substantial productivity gap. This project aims to develop high-yielding, drought-tolerant, dual-purpose pearl millet that provides grain for human consumption and high-quality stover for livestock feed. This will be achieved through a combination of marker-assisted selection, induced mutagenesis, and gene-editing (CRISPR-Cas9) technology. The project will contribute to improved food and fodder security, increased agricultural productivity, and enhanced resilience of mixed farming systems. By unlocking the untapped yield potential of pearl millet while maintaining performance under water-limited conditions, the research will support climate-smart agriculture, strengthen smallholder livelihoods, and promote sustainable agricultural development in South Africa and beyond.

Intersecting crisis: Investigating the Compounded Impact of Climate Change on Food Security, Mental Health, and Foodborne Diseases Among Farming communities in the uMkhanyakude District, KwaZulu-Natal.

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This study investigates the compounded effects of climate change on mental health, foodborne diseases, and food security in the uMkhanyakude district of KwaZulu-Natal. Recognising that climate change creates interconnected social, health, and economic challenges, the research seeks to understand how rural communities experience and respond to these overlapping vulnerabilities. A mixed-methods research design will be employed to collect both quantitative and qualitative data. Participants will be selected through purposive and snowball sampling techniques to ensure the inclusion of individuals with relevant experiences and knowledge. Data collection methods will include structured questionnaires, surveys, focus group discussions, and interviews, allowing for a comprehensive assessment of community experiences and perceptions. The collected data will be captured, coded, and analysed using STATA and SPSS software. Analytical approaches will include descriptive statistics, logistic regression, Tobit regression, and multivariate analysis. The study will also draw on livelihood and resilience frameworks to better understand household adaptation strategies and vulnerabilities. The research is expected to identify critical gaps in understanding the links between climate change, health outcomes, and food security. Findings will contribute to the development of climate-resilient food systems, improved mental health and disease interventions, and evidence-based adaptation strategies. The study will also provide valuable insights to policymakers, development practitioners, and NGOs to strengthen resilience in rural KwaZulu-Natal communities.

Quantifying the Impact of Land Use/Land Cover and Climate Change on Forest Ecosystem Service Value in the Nkandla Forest Complex, South Africa

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The Nkandla Forest Complex in KwaZulu-Natal is a biodiversity hotspot and critical water source area providing essential ecosystem services including carbon sequestration, water regulation, and non-timber forest products to rural communities. However, this socio-ecological system faces unprecedented dual pressures from land use/land cover change (agricultural expansion, settlement encroachment, invasive species, illegal harvesting) and climate change (altered rainfall patterns, temperature increases, drought, fire risk). While foundational remote sensing work has mapped contemporary forest cover, the compounded impact of LULC change and climate change on the total economic value of ecosystem services has not been quantified. This project addresses this gap by integrating multi-temporal remote sensing (Landsat, Sentinel-2, PlanetScope), downscaled CMIP6 climate projections, and spatial ecosystem service valuation using the CICES framework. The expected outcomes include high-resolution LULC and ESV change maps, future ESV projections under different climate scenarios, and evidence-based recommendations for Ezemvelo KZN Wildlife. The methodology will be transferable to other vulnerable forest ecosystems across sub-Saharan Africa.

Iterative Algorithms for Solving Fixed Point and Optimization Problems in Hilbert and Banach Spaces

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Optimization and fixed point theory form the mathematical foundation of many modern technologies, including engineering design, telecommunications, machine learning, network optimization, resource allocation, image processing, financial modelling, and operational research. Despite significant advances in this field, many existing iterative methods suffer from slow convergence, restrictive assumptions, and limited applicability to complex nonlinear problems arising in real-world systems.

This research aims to develop novel iterative algorithms for solving fixed point problems and optimization-related problems in Hilbert and Banach spaces. The project focuses on designing computationally efficient algorithms with stronger convergence properties and wider applicability than existing methods. Particular attention will be given to variational inequality problems, monotone inclusion problems, equilibrium problems, and others related optimization models.

The proposed research seeks to address scientific uncertainties concerning convergence behaviour, Algorithmic stability, computational efficiency, and applicability under weaker mathematical Assumptions. The outcomes will contribute new mathematical theories, Algorithms, and computational frameworks capable of supporting advanced optimization processes across multiple industries. The project aligns with South Africa's strategic objectives of promoting scientific advancement, innovation, and knowledge generation through high-level research and development.

Comparative seasonal analysis of heat shock protein (HSP) expression and thermotolerance in indigenous vs. Broiler chicken breeds.

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As climate change brings more frequent and intense heat stress events, poultry production around the world is facing serious challenges. Commercial broiler chickens are especially at risk when temperatures rise. They have high metabolic rates and can't regulate their body temperature very well, even moderate heat can lower their growth, hurt their welfare, and lead to more deaths. On the other hand, indigenous chicken breeds from South Africa have adapted over time to local conditions, which may give them an edge in coping with heat. So far, we don't know much about exactly how they handle thermal stress at the physiological and molecular levels. This study will compare how indigenous chickens and commercial broilers deal with heat and cold stress under normal seasonal conditions in KwaZulu-Natal, South Africa.

We will measure physiological responses, look at oxidative stress markers, and check the expression of heat shock proteins (HSP70 and HSP90). By bringing together molecular, biochemical, and physiological data, the study aims to pinpoint key breed-specific traits linked to thermal adaptation. The results could help the poultry industry by identifying useful biomarkers and genetic traits tied to heat and cold resilience. That information can then be used to create breeding programs that produce hardier birds, support more sustainable poultry farming, and boost food security and rural incomes in areas most affected by climate change.

RFI detection in Interferometric data using Machine Learning tools

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Radio Frequency Interference (RFI) is a major problem faced by engineers/scientists across telecommunications, astronomy, GPS systems and Industrial communities, as it interferes with and degrades the signal of interest, reducing data quality. In the past, traditional RFI detection methods, such as thresholding, signal estimation and statistical filtering often failed to generalise to noisy environments. In this project, we aim to address the problem of accurate detection and RFI classification in time-frequency spectrograms, especially in our case, where the data is from a real-world source (MeerKAT), and some RFI signals are very weak and Uncontrolled. The project focuses on developing and evaluating deep learning models, including Convolutional Autoencoders (CAEs) and Vision Transformers (ViTs), to identify anomalous signals associated with RFI. Simulated and observational datasets will be used to train and validate the models, and their performance will be compared with that of conventional flagging tools such as AOFlagger. There is a need for a scalable and robust solution that can generalise and identify RFI signals with higher accuracy. The research will contribute to the advancement of intelligent data processing systems for next-generation radio telescopes and support the growing data-analysis needs of the radio astronomy industry

Biological responses to land-use and climate changes in KwaZulu-Natal major catchments.

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Freshwater ecosystems have played a vital role in supporting human livelihoods since ancient times and, as a result, have been subjected to substantial human influence. To better understand the ecological integrity of KwaZulu-Natal rivers, which serve as important sources of water, and to assess the impacts of land-use change and climate variability on these systems, this study evaluated fish and macroinvertebrate communities at sites surveyed under the River Eco-status Monitoring Programme (REMP) during the 2014–2015 drought period.

It is important to note that fish and macroinvertebrate communities in these rivers were severely affected by the prolonged drought. Consequently, this study seeks to address existing knowledge gaps regarding the recovery of river ecosystems following extended drought events. The findings will contribute to the development of effective water resource management policies and strategies aimed at mitigating the impacts of climate change. Given the importance of freshwater resources for both domestic and industrial use, the study provides valuable information to support conservation efforts and promote the long-term sustainability of KwaZulu-Natal rivers and the essential ecosystem services they provide.

BiFeO3-Based Multifunctional Thin Films for Energy and Non-Volatile Memory Storage Devices

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This project focuses on the development and optimisation of bismuth ferrite based multifunctional materials for energy related and non-volatile memory device applications. The work responds to the growing demand for compact, efficient, and low-power materials that can combine several functions within a single platform, thereby reducing reliance on multiple separate device components. is a strong candidate because it exhibits ferroelectric behaviour, magnetic response, optical activity, and semiconductor-like properties, which are relevant to memory switching, sensing, photovoltaic response, and energy-conversion technologies. The research will involve the synthesis, deposition, and characterisation of based bulk and thin-film systems, with particular focus on phase purity, microstructure, electrical performance, optical response, and device-relevant stability. The intended outcome is a reliable materials-processing route supported by experimental performance data for guiding prototype energy and memory-device structures. For industry, the project may contribute to improved functional materials, reduced power consumption in electronic components, and new opportunities in advanced manufacturing, sensors, electronics, and energy-storage technologies.

Late Quaternary Climate Change and Human Impact, St. Lucia, KwaZulu-Natal

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This project focusses on understanding long term human-environment interactions in the Indian Ocean Coastal Belt biome of northeastern South Africa. The project will use multiproxy analysis of sediments from the Mfabeni Peatland in the iSimangaliso Wetland Park to reconstruct a high-resolution record of vegetation (pollen), fire (charcoal) and herbivory (SCFs) over the last 6000 years, and compare with the archaeological framework. The Mfabeni record is uniquely placed to achieve an integrated comparison of past landscape change and human interactions, due to the presence of undisturbed peat sediments with a relatively high rate of accumulation, and positioning adjacent to the known Early Iron Age Site Enkwazini. Research will test the hypothesis that human activities since the start of the Iron Age increasingly obscure climatic impacts in driving vegetation composition; and secondly, that contemporary vegetation composition is broadly the product of Iron Age farming activities, therefore representing a cultural landscape c. 1500 years old.

Solution processable thin film organic solar cell as alternative source of renewable energy

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The growing demand for clean, affordable, and sustainable energy has increased interest in thin-film organic solar cells (TFOSCs) as alternatives to conventional silicon-based photovoltaic technologies. TFOSCs offer several advantages, including low-cost fabrication, lightweight construction, mechanical flexibility, and compatibility with large-area solution processing. Despite these benefits, their commercial adoption remains limited by challenges such as low power conversion efficiency, inadequate light absorption, inefficient charge transport, and poor long-term stability. To address these limitations, this research proposes the incorporation of quantum dots and plasmonic noble metal nanoparticles into TFOSC architectures. Quantum dots possess tunable optical properties and broad light absorption capabilities, while plasmonic nanoparticles enhance light harvesting through localized surface plasmon resonance effects. By combining these nanomaterials within the solar cell structure, the study seeks to improve photon absorption, exciton generation, charge separation, and charge transport, ultimately leading to enhanced photovoltaic performance. The expected outcome is the development of more efficient, stable, and commercially viable organic solar cells. Such advancements could accelerate the deployment of flexible and lightweight photovoltaic technologies in applications such as wearable electronics, portable power systems, and building-integrated photovoltaics, thereby contributing to the global transition toward sustainable and renewable energy solutions.

Use of carrion insects as indicators of paracetamol poisoning and overdose in decomposing carcasses and the implications for postmortem interval estimation

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Entomotoxicology plays an important role in evaluating the effects of drugs on insect development, which can assist in estimating the postmortem interval (PMI). This field provides an alternative approach for investigating drug-related deaths when the tissues normally used for toxicological analysis are no longer suitable due to advanced decomposition. However, the effects of paracetamol on carrion-feeding insects in KwaZulu-Natal have not been investigated, despite their potential value in PMI estimation and forensic investigations involving paracetamol-related deaths. This study aims to determine the efficacy of using carrion-feeding insects as toxicological indicators of paracetamol poisoning and overdose in decomposing pig carcasses. Four pig carcasses, each weighing approximately 35 kg, will be used as human analogues. Three carcasses will be administered different concentrations of paracetamol (100, 300, and 500 mg/kg), while one carcass will serve as a control. The study will identify insect species that may serve as indicators of paracetamol exposure, determine the persistence of paracetamol in insect tissues across decomposition stages, assess the effects of paracetamol on decomposition rates and postmortem changes, and evaluate its influence on insect succession patterns. The findings will contribute to the advancement of forensic entomotoxicology and support the South African Police Service in the investigation of paracetamol-related and other drug-related deaths.

Phenotypic characterization and breeding objectives of non-descript cattle in KwaZulu-Natal province, South Africa: Implication for the design of community-based breeding programme

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The productivity of non-descript cattle remains low. These animals are, therefore, susceptible to genetic dilution, inbreeding depression , and mismanagement through indiscriminate crossbreeding. Challenges mentioned may result in the loss of specialized adaptation traits of non-descript cattle and eventual population extinction. Phenotypic characterization of non-descript cattle is the first essential step in formulating community-based breeding program strategies to improve their productivity and better utilize them. Quantifying information on the phenotypic characterization of non-descript cattle will help to gain a better understanding of the breed, its present and potential uses in food and agriculture in defined environments, enabling the improvement of its productivity. Researchers have turned their eyes to the genotypic characterization of non-descript cattle. It intends to contribute both empirically and methodologically by documenting farmer driven breeding objectives, quantifying phenotypic diversity, establishing structural indices, and developing practical body weight prediction models. The findings will support sustainable utilization, conservation, and improvement of non-descript cattle under small holder production systems.

Developing an operational framework on the nutritional management of secondary severe acute malnutrition in children under 5 years of age in KZN

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This novel research will explore the nutritional management of secondary severe acute malnutrition in children under 5 in KZN. Secondary SAM, often associated with HIV, TB, and other chronic illness, increases healthcare costs due to prolonged hospitalisation as they are of a complicated nature. At tertiary and central levels of care, disease specific nutrition management protocols and feeds may be available, although very costly when malnutrition is detected late, worsening the clinical presentation and increasing hospital stay. There are limited clinical or operational guidelines for this population of patients and thus morbidity and mortality rates are high. There is also limited research on this patient population internationally. Improving the nutritional management of chronic diseases will prevent complicated cases of SAM and thus reduce the frequency of admissions and hospital stays in this subset of patients, reducing the total expenditure on health services while improving childhood morbidity and mortality rates. The research will look into the prevalence of secondary SAM in KZN and explore health worker knowledge, attitudes and practices to better understand the management, and consult with a South African expert panel outside of KZN to develop a framework on nutritional management of secondary SAM that would support health workers.

Development of Sustainable Biological and Plant-Based Strategies for the Management of Trichoderma Species in Oyster Mushroom (Pleurotus ostreatus) Production

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Oyster mushroom (Pleurotus ostreatus) production is increasingly important for food security, nutrition and income generation. However, fungal diseases caused by Trichoderma species remain one of the major constraints limiting mushroom productivity and profitability. Current disease management practices rely heavily on chemical fungicides, which have led to fungicide resistance, environmental concerns, and increased production costs. This research aims to develop sustainable and environmentally friendly alternatives for managing Trichoderma infections using biological control agents and plant-derived extracts. The study will isolate and characterize Trichoderma species affecting oyster mushrooms, evaluate the efficacy of selected biocontrol agents and plant extracts under laboratory and production conditions, and assess their effects on mushroom quality, nutritional composition, metabolic profiles, and antioxidant properties. The expected outcome is the development of effective, eco-friendly disease management strategies that can reduce reliance on synthetic fungicides while maintaining or improving mushroom yield and quality. The findings will provide valuable information for commercial mushroom producers, smallholder farmers, agricultural input suppliers, and the broader horticultural sector, supporting sustainable agricultural production and innovation.

Security and Sustainable Resource Management

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Inland fisheries spanning rivers, streams, dams, and reservoirs represent a critically undervalued source of food, nutrition, and livelihood for millions of rural South Africans. Despite their significance, subsistence and small-scale inland fisheries remain poorly documented, underregulated, and largely absent from national food security frameworks. This PhD project conducts systematic socio-economic investigation of small-scale fisher communities across multiple freshwater systems in KwaZulu-Natal, South Africa, quantifying their contribution to household food security, income generation, and community resilience. The research addresses a fundamental scientific and socio-ecological uncertainty: to what extent can formalised, data-driven management models grounded in fisher livelihood realities improve both the sustainability of inland fish stocks and the food security outcomes of dependent communities? Expected outputs include validated socio-economic models, policy-applicable management frameworks, and evidence-based recommendations for industry partners in the aquaculture, conservation, and rural development sectors. The project directly aligns with South Africa's National Development Plan (NDP 2030) goals for food security and inclusive economic participation.

Comparison of the Effect of Waste Swine and Cooking Oil Biodiesel on Combustion Efficiency and Regulated Emissions of a Variable Compression Ratio Engine

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The continued dependence on petroleum diesel in compression ignition engines presents persistent challenges related to fuel security, greenhouse gas emissions, regulated exhaust pollutants, and the underutilization of waste lipid resources. At the same time, pork processing, rendering, slaughterhouse, and food service activities generate waste swine oil that is commonly treated as a low-value waste stream, despite its potential as a renewable biodiesel feedstock. This project develops and validates waste swine oil biodiesel as a practical alternative fuel for diesel engine applications through fuel production, physicochemical characterization, engine testing, emission analysis, and compression ratio/load mapping.

The proposed solution is a data-driven biodiesel validation framework that converts waste swine oil into biodiesel and identifies technically defensible engine operating conditions using a variable compression ratio diesel engine. The work compares waste swine oil biodiesel with waste cooking oil biodiesel and conventional diesel-relevant performance benchmarks. Expected industry impact includes cleaner fuel deployment, waste valorization, reduced disposal burden, improved calibration guidance for biodiesel-compatible engines, and evidence-based support for transport, agricultural, generator, waste-management, rendering, and biofuel-sector innovation.

Impacts of Pluralistic Extension Delivery on Farmers' Production in KwaZulu-Natal, South Africa

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Agricultural extension services play a critical role in enhancing agricultural productivity, farmer capacity, food security, and rural development. In South Africa, extension service delivery has evolved from a predominantly public-sector model towards a pluralistic system involving government agencies, research institutions, agribusinesses, farmer organizations, NGOs, and private service providers. Despite this transition, limited empirical evidence exists regarding the effectiveness of pluralistic extension delivery and its contribution to farmers' production outcomes.

This study investigates the impacts of pluralistic extension delivery on farmers' production in KwaZulu-Natal. The research will identify extension service providers, characterize their activities and coverage, examine collaboration among actors, and assess the influence of extension services on farmer productivity and livelihoods. Quantitative and qualitative data will be collected from farmers and extension stakeholders across KwaZulu-Natal. The findings will generate evidence-based recommendations for improving coordination among extension actors, strengthening farmer support systems, and enhancing agricultural productivity. The study will contribute to policy development and provide industry stakeholders with insights into more efficient and effective extension delivery models.

Elucidating The Mechanisms of Action of The Antimalarial Property of a Polyherbal Extract from Azadirachta Indica, Persea Americana, and Mangifera Indica Leaves

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Malaria persists as a major global health crisis, particularly in sub-Saharan Africa, where Plasmodium falciparum has developed significant resistance to artemisinin-based combination therapies. This resistance, combined with the limited accessibility and side effects of conventional drugs in rural and low-resource settings, exacerbates morbidity and mortality, especially among children and vulnerable populations. The proposed solution is a systematic Research and Development investigation into a novel polyherbal extract from the leaves of Azadirachta indica, Persea americana, and Mangifera indica. Leveraging traditional knowledge, the project employs phytochemical profiling using LC-MS and GC-MS, in vitro antiplasmodial and βhematin inhibition assays, in silico molecular docking and dynamics simulations targeting key parasite proteins such as plasmepsin II and falcipain-2, and comprehensive in vivo studies in Plasmodium berghei-infected murine models. This includes toxicity profiling, efficacy tests such as suppressive, prophylactic and curative assays, antioxidant and anti-inflammatory assessments, and histopathological analysis to elucidate synergistic mechanisms of action.

Expected industry impact includes the development of a cost-effective, accessible, and resistance-resilient natural antimalarial formulation. Pharmaceutical and herbal medicine sectors stand to gain new intellectual property-protected leads, scalable production opportunities from local plants, improved treatment outcomes, and enhanced innovation capacity in malaria-endemic regions.

Development of a Microalgae-Bacteria Bioremediation System for the Removal of Antimicrobial Resistance and Priority Pathogens from Municipal Wastewater in KwaZulu-Natal

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Antimicrobial resistance (AMR) is a growing global public health threat, with wastewater treatment plants increasingly recognized as reservoirs and dissemination points for antibiotic-resistant bacteria and antimicrobial resistance genes (ARGs). Current wastewater treatment systems were not specifically designed to eliminate these emerging biological contaminants, releasing resistant pathogens and ARGs into receiving water bodies. This research aims to characterize the occurrence and persistence of WHO priority antimicrobial-resistant pathogens (also known as ESKAPEE pathogens) and ARGs across wastewater treatment plants in KwaZulu-Natal using metagenomics, culture-based methods, and quantitative PCR. Building on these findings, the project will develop and optimize a microalgae-bacteria bioremediation system using locally sourced Chlorella and Scenedesmus species to reduce pathogen loads, ARG abundance, and nutrient concentrations in municipal wastewater. The expected outcome is an environmentally sustainable wastewater polishing technology that can improve effluent quality, reduce environmental dissemination of AMR, and support water utilities in achieving regulatory compliance while strengthening public health protection.

Crystalline nanocellulose for new generation solar cells

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Solar cells that utilise solar energy are an emerging renewable energy resource. They display tremendous potential in replacing fossil fuel-based energy resources. However, the third-generation cells suffer from stability issues and relatively low power conversion efficiencies (PCE). This has prompted further research in this area. Fabrication of solar cells with nanomaterials is one way of enhancing device stability and performance for commercial applications. However, compared with silicon-based solar cells, these new-generation solar cells exhibit poorer optoelectronic properties. More work is needed to optimise their capabilities through low-cost solution processing, heteroatom doping, and the preparation of effective nanocomposite materials that are not only complementary but also synergistic. Transparent, flexible, and conductive films are vital components of future flexible devices and bio-inspired actuation materials, where the electrode layer, material, and structure are critical for achieving higher performance.

Thus, the creation of synergistic properties can be reinforced by functionalisation with a suitable 2D material, such as carbon-based and graphene-based materials, which is cost-effective to prepare in a lab that can replace rare metals like platinum and palladium-based electrodes. One relatively novel material that can improve the physicochemical, electrochemical and thermal stability of solar cells is crystalline nanocellulose (CNC). These CNCs are particularly useful for producing flexible devices. Indium-doped tin oxide (ITO) and fluorine-doped tin oxide (FTO) glasses are widely adopted as transparent electrodes and are very expensive; crystalline nanocellulose (CNC) based electrodes can be a potential in replacing these transparent electrodes. It is also biodegradable and does not create a disposal problem. However, there is a lack of experimental data on the incorporation of this material in solar cell devices. Hence, this project seeks to collect such data.

Design and Performance Evaluation of a Pre- Treatment Sedimentation Basin for Reducing Siltation Inflow at Water Treatment Plants: A Case Study of the Upper Umkhomazi Catchment, KwaZulu-Natal, South Africa

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This proposal presents a PhD research project aimed at developing and empirically validating a hydraulic design framework for gravity pre-treatment sedimentation basins at surface water treatment plants subject to high suspended sediment loading. The research addresses a substantive gap in South African water engineering practice; the absence of field-validated, CFD-verified design guidance for pre-treatment systems operating under the extreme turbidity conditions characteristic of geomorphologically active catchments in KwaZulu-Natal — and is positioned to contribute directly to the revision of DWAF Technical Report TT130/00 (2000), the primary national design standard for pre-sedimentation infrastructure. Excessive siltation at water treatment plant (WTP) intakes is a critical but under-addressed challenge in South Africa and across sub-Saharan Africa. The Upper Umkhomazi Catchment, KwaZulu-Natal, presents an extreme case: total suspended solids (TSS) at the WTP intake regularly exceeds 2 000 mg/L during summer flood events, triggering coagulant demand overload, rapid filter blinding, and emergency plant shutdowns that interrupt safe drinking water supply to the Ixopo municipal area. No engineered pre-treatment solution currently exists at this site. This research investigates the spatial and temporal drivers of siltation using hydrological analysis, RUSLE erosion modelling, and a 312-sample suspended sediment programme. Drawing on this evidence base, a hydraulic design framework is developed for a gravity pre-treatment sedimentation basin (SOR = 90.3 m/day; HRT = 12.7 h; L:W = 4:1) and verified through computational fluid dynamics (CFD) modelling incorporating density current analysis. A pilot basin at 1:4 scale is constructed, instrumented, and monitored across a full seasonal cycle. A benefit-cost analysis using 2026 South African market rates and National Treasury methodology establishes the economic case for full-scale investment. Generalised design guidelines applicable to comparable high-turbidity WTPs across KwaZulu-Natal and southern Africa are synthesised as the primary industry-facing deliverable.

Enhancing Human Excreta-Derived Co-Compost Using Water Treatment Residuals and Biochar

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Improper organic waste management and soil nutrient depletion remain as major challenges for the agricultural and waste management sectors, compounded by water scarcity in regions such as South Africa. While co-composting human excreta with garden waste offers a low-cost route to recovering nutrients and closing the organic waste loop, its industrial adoption is constrained by contamination risks, including microplastics, heavy metals, and pharmaceutical residues, that threaten soil health, crop safety, and regulatory compliance. This study proposes integrating biochar and biochar-treated liquid water treatment residuals (WTRs) as functional amendments into the composting process. Biochar's high adsorption capacity targets contaminant immobilisation, while WTRs serve a dual role as a moisture source and nutrient supplement, disposal costs and improper managements of these waste streams. This research is expected to produce a contaminant-reduced compost product suitable for agricultural use, reduced waste disposal costs, and a practical pathway for reusing WTRs. The approach also supports carbon sequestration goals and regulatory alignment with circular bioeconomy frameworks offering composting operators, agricultural input suppliers, and water utilities a scalable, evidence-based model for sustainable waste valorisation.

Optimising Harvest Maturity Indices and Postharvest Quality Preservation of South African-Grown Blueberries

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Blueberries are among the fastest-growing horticultural crops in South Africa due to their high nutritional value and export potential. Berry quality deterioration, postharvest losses, and inconsistent determination of harvest maturity, however, remain the major constraints on profitability and market competitiveness. This project aims to develop science-based harvest maturity indices and optimise postharvest quality preservation strategies for South African-grown blueberries. The research aims to investigate physiological, biochemical, nutritional, and sensory changes during fruit ripening and storage, while evaluating innovative quality-preservation technologies. The project will generate cultivar- and site-specific recommendations for harvest timing and postharvest handling. Expected outcomes include improved fruit quality, extended shelf life, reduced postharvest losses, enhanced export competitiveness, and increased profitability for the blueberry industry. The findings will contribute to sustainable berry production, food security, and innovation within South Africa's horticultural sector.

Nanotechnology and Biostimulants: A Sustainable Approach to Abiotic Stress Management and Shelf-Life Extension in Blueberries

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Blueberry production is increasingly threatened by abiotic stresses such as drought, heat, salinity, and fluctuating environmental conditions, which reduce plant productivity, fruit quality, and postharvest shelf life. At the same time, the berry industry faces growing pressure to adopt sustainable production practices that minimize chemical inputs while maintaining profitability and market competitiveness. This challenge presents an opportunity to develop innovative technologies that enhance crop resilience and extend fruit longevity. This project proposes the integration of silica base nanoparticles and amino acid based biostimulants as a sustainable strategy for abiotic stress management and shelf-life extension in blueberries. Silica based nanoparticles and amino acid based biostimulants can improve the stability and efficacy of blueberries, enhancing nutrient uptake, antioxidant activity, water-use efficiency, and stress tolerance. Furthermore, these technologies can help maintain fruit firmness, reduce postharvest deterioration, and preserve nutritional and sensory quality during storage and transport. The anticipated outcomes include improved blueberry yield and quality under adverse environmental conditions, reduced postharvest losses, and enhanced supply chain efficiency. By promoting sustainable production and extending marketable shelf life, this approach has the potential to increase grower profitability, strengthen the resilience of the berry industry to climate change, and support the delivery of high-quality fruit to consumers while reducing food waste.

The Application of Quadrupedal Mobile Robots in SA Manufacturing Environments: Manufacturing Task Value Fit, Design Adaptation and Secondary Development, Operational Validation, and Industry piloting

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South African manufacturers face growing pressure to improve productivity, safety, equipment uptime and data-driven decision-making as manufacturing competitiveness becomes increasingly linked to Industry 4.0, AI, digital capabilities and advanced skills [1], [2]. However, research on South African manufacturing shows that adoption is constrained by skills shortages, fragmented task environments, inadequate ICT infrastructure, limited digital capabilities and uneven digital maturity. These constraints are particularly important for inspection and maintenance-intensive environments, where conventional inspection remains labour-intensive, can expose workers to hazardous or difficult-to-access areas, and often limits the collection of continuous, high-quality asset data needed for predictive maintenance and operational decision-making. Quadrupedal mobile robots are increasingly viewed as promising platforms for industrial inspection and monitoring because legged locomotion enables mobility in environments that are difficult for conventional wheeled systems, including stairs, uneven terrain, cluttered layouts, and human-centred industrial spaces [3], [4]. Recent studies also show their potential for automated inspection, reality capture, safety monitoring, and human-robot teaming[5], [3]. However, their practical value in South African manufacturing remains uncertain because the available evidence is still dominated by international pilots, laboratory demonstrations, construction-site studies, and non-South African smart-factory case studies. For South African plants, further validation is required under local factory conditions, including safety expectations, integration with existing digital and maintenance systems, operator skills, and workforce acceptance factors.

This PhD project will develop and validate an adapted quadrupedal robotic system and implementation framework for inspection and monitoring tasks in manufacturing environments. The research will combine literature review, industry interviews, task analysis, robot configuration, sensor and data workflow design, controlled demonstrations, and pilot-style validation in representative industrial settings. The expected outcome is a practical, evidence-based R&D pathway that helps firms assess, test, and adopt quadrupedal robotic systems while reducing deployment risk and building local technological capability.

Development of a Novel SDI–SuperDARN Data Fusion System for Quantifying Mesoscale Auroral Energy Deposition and Thermosphere–Ionosphere Coupling

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This project develops a novel computational and observational framework to quantify mesoscale (10–100 km) auroral energy deposition and its coupling to thermospheric neutral winds. A key unresolved scientific and technological uncertainty is how localized auroral electric fields translate into ion-neutral momentum transfer and Joule heating at intermediate spatial scales, where neither global models nor point observations are sufficient. The study integrates Scanning Doppler Imager (SDI) neutral wind observations from Kevo, Finland (69.76° N, 27.01° E) with Super Dual Auroral Radar Network (SuperDARN) electric field measurements to develop a new data fusion methodology for resolving mesoscale ionosphere–thermosphere dynamics. A core innovation is the development of a hybrid inversion framework that combines radar-derived electric fields with optical wind measurements to reconstruct ion-neutral coupling processes and quantify Joule heating:

Where (E) is the electric field magnitude and () is the Pedersen conductance derived from plasma density and auroral intensity proxies. The expected outcome is a validated computational system that improves physical consistency in estimating auroral energy transfer and enables more accurate representation of thermospheric response processes.

Tracking Of Moving Cell in Time Lapse Video Sequence (Development of a Generalist Deep Learning Framework for Robust Cell Segmentation and Tracking Across Diverse Microscopy Modalities)

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Cell tracking in time-lapse microscopy is a critical task in biomedical image analysis, enabling the quantitative study of cellular dynamics, migration, proliferation, lineage development, and response to therapeutic interventions. Accurate tracking remains challenging due to variations in imaging modalities, cell morphology, density, illumination conditions, and the presence of noise and imaging artefacts. Existing deep learning approaches often demonstrate strong performance on specific datasets but struggle to generalize across diverse microscopy environments, limiting their practical deployment in real-world biological applications. This research aims to develop a robust and generalizable deep learning framework for the automated tracking of moving cells in time-lapse microscopy sequences.

The proposed framework will integrate advanced cell segmentation, feature representation learning, and cell association techniques to accurately identify and track cells across multiple imaging modalities, including fluorescence, brightfield, differential interference contrast, and phase-contrast microscopy. Emphasis will be placed on learning domain-invariant representations that maintain performance under varying imaging conditions and domain shifts. The expected outcome is a scalable and transferable cell tracking system capable of reducing dependence on modality-specific models while improving the reliability of long-term cellular trajectory analysis. The research has potential applications in drug discovery, cancer research, developmental biology, regenerative medicine, biotechnology, and automated biomedical imaging systems.

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Disclaimer

Information was collected at different times during the compilation of this publication.

Printed in 2026

REG: IT589/2003
PBO: 930012812/2003
NPO: 030-967-NPO

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