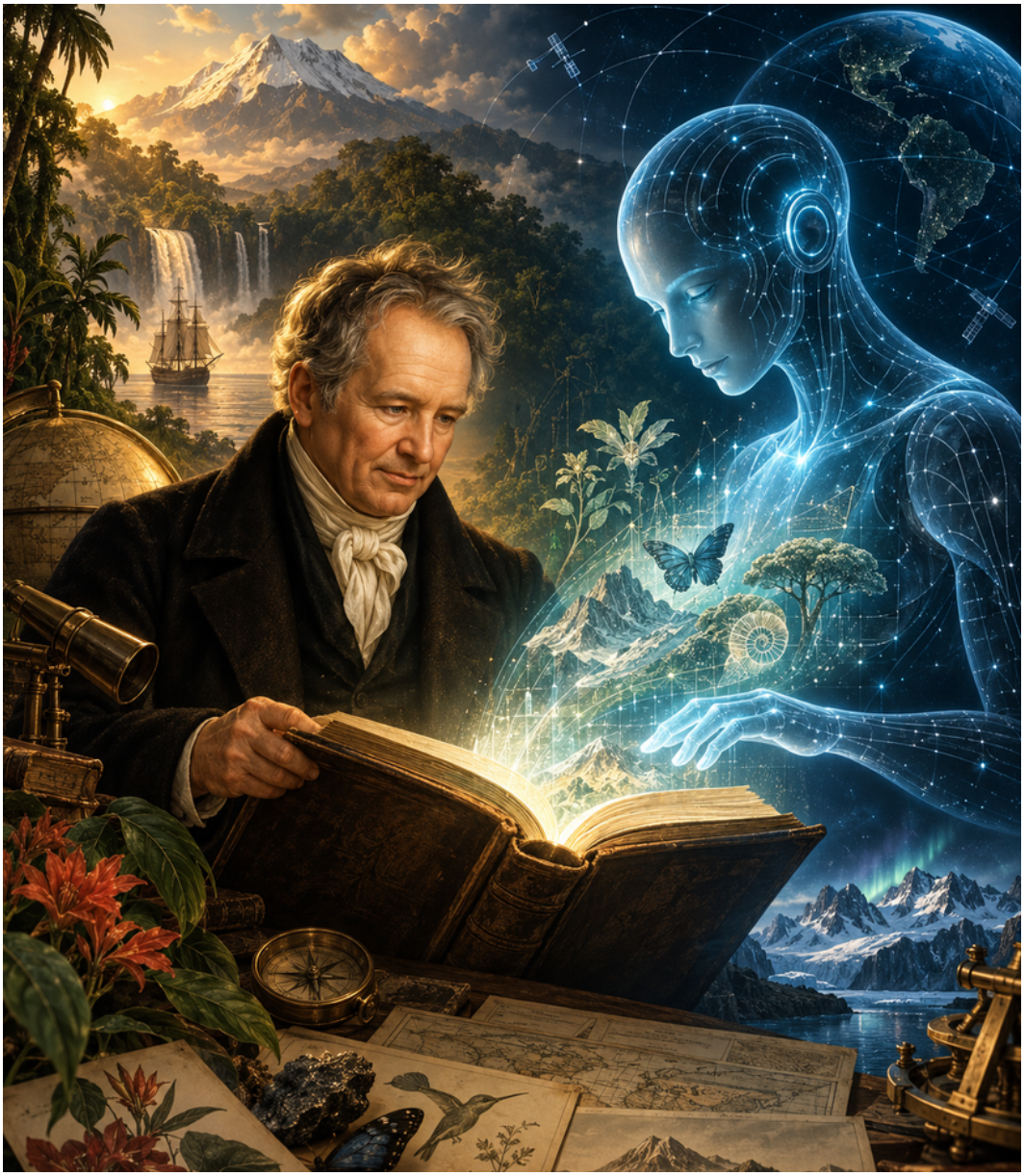
Humboldt Kolleg 2026
21st Biennial Conference of the Australian Association of von Humboldt Fellows



"Humboldtian Scholarship in the Age of Artificial Intelligence"

The Ship Inn South Bank, Brisbane
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Abstracts Booklet



Die Wahrheit an sich ist kostbar,
kostbarer aber noch die Fertigkeit, sie zu finden

‘Truth in itself is precious, but even more precious is the skill to find it.’

Alexander von Humboldt
letter to Georg Christoph Lichtenberg, 3 October 1790

Application of AI tools to advance malaria drug discovery

Katherine Andrews [1], Wisam Dawood [1], Hannah Smith [1], Eva Hesping [2]
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Malaria is a global health priority, with almost half the world population at risk. There were an estimated 282 million cases and 610,000 deaths due to this disease in 2024. Despite a global agenda focused on eradication, malaria cases are rising, and if the current trajectory is not altered, 2030 morbidity and mortality goals will fail. As there is currently a lack of highly effective malaria vaccines for all at risk populations, drugs remain critical for prevention and treatment. However, the effectiveness of all current drugs is compromised by parasite drug resistance. This means that there is a critical need to replenish the malaria drug candidate pipeline with diverse new options and to identify novel drug targets to stay ahead of resistance and deliver the new types of drugs required for malaria eradication.

Next generation artificial intelligence and machine learning tools are providing exciting new opportunities to speed up the malaria drug discovery process. In this presentation, challenges and opportunities for AI in malaria drug discovery will be discussed. Data will be presented on the application of quantitative structure activity relationship (QSAR) models to triage compounds with predicted activity against malaria parasites and to identify compounds that may represent new chemical space for malaria drug discovery.

University education in science, now with A-Intelligence or A-Dumbness?

Hans Bachor

ANU

Information technology is moving fast and is omnipresent - creating discussions across our society and all age groups. Hot debates are raging. Meanwhile machine learning, fast data-processing, autonomous machines and programming are introduced at a rapid rate. Educating university students now in science, to prepare them for careers in science based occupations, requires a quick response, too fast for long term studies. That means guessing and relying on basic ideas of what makes good science trained professionals. Central to science are 3 pillars. Facts, means data combined with authenticity and known uncertainty. Concepts, the need to query, evaluate and test them. Or expand or revise them in new regimes of data. Trusted communication and availability of information.

Such ideas grew strongly at the time when the brothers von Humboldt were active. With AvHumboldt acquiring large sets of new reliable data testing them rigorously and WvHumboldt influencing education at Universities, and both communicating widely exchanging data and ideas.

Our present tasks can benefit from such high level observation, asking the students to focus use their evolving new tools to create an understanding of science, a personal way how to see, probe and explain the world around us.

Asking teachers to develop tests of such knowledge. This includes personal interaction, discussion of hypotheticals, the old oral exams we enjoyed or hated?
Asking all to make trust a key in communication, which includes reproducibility, reliability and possibly a new quantitative measure. I will try to illustrate this with examples from physics courses.

Turning Silicate Minerals into Climate & Environmental Solutions

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The University of Newcastle

Primary industries face severe challenges from converging environmental stressors, including high greenhouse gas emissions, climate-driven algal blooms, and contamination in aquatic food webs. Conventional pollution management is often reactive and energy-intensive, frequently shifting contaminants across ecosystems rather than eliminating them. Transforming abundant, naturally occurring silicate minerals, such as clay minerals and zeolites, into active eco-remediators offers a proactive, scalable, source-level solution for soil, water, livestock, and climate applications. Laboratory and field testing demonstrate the potential of these engineered minerals across multiple systems.

For livestock emissions, specialized edible clay formulations significantly reduce enteric methane, while natural and modified clays capture greenhouse gases from manure, compost, farms, and landfills. Soil treatments with activated clays simultaneously curb emissions and improve crop yields. In agriculture, clay minerals enhance nutrient efficiency by supporting beneficial microbial activity in the root zone and enabling the slow, controlled release of essential nutrients like nitrogen and phosphorus. In aquatic systems, buoyant modified clays effectively absorb pharmaceutical residues, while lanthanum-treated minerals rapidly remove excess bioavailable nutrients from water bodies to suppress harmful algal blooms. Aligning the versatile chemical properties of silicate minerals with circular economy principles provides a low-cost, effective pathway to tackle climate-driven environmental challenges across primary industries.

Enabling next-generation biomedical instrumentation with photonic-chip magnetic sensors

Benjamin J. Carey

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Magnetic fields generated by the human body carry a wealth of information about the physiological processes that sustain life. Measuring these extraordinarily weak signals offers a non-invasive means of studying biological function, with applications spanning neuroscience, medical research, and emerging diagnostic technologies. Yet accessing this information remains technologically challenging, with the most sensitive measurement systems often requiring cryogenic cooling, specialised magnetic shielding, and substantial infrastructure requirements restricting their accessibility.

Silicon photonics offers a promising alternative; harnessing light confined within microscopic structures to make extraordinarily precise measurements. By combining this optical sensitivity with materials that respond to magnetic fields, we are developing miniature sensors that convert weak magnetic signals into tiny mechanical movements detectable using light. Importantly, silicon-chip manufacturing offers a pathway towards scalable, low-cost production. Combined with room-temperature operation and the potential to operate in everyday magnetic environments, this approach could substantially reduce reliance on specialised infrastructure, including cryogenic cooling and magnetic shielding.

Here, we present recent advances in silicon-chip optomechanical magnetometers, including new approaches to detecting extremely weak, low-frequency magnetic signals that are particularly important for biological measurements. Together, these developments lay the foundations for a new generation of biomedical instrumentation, bringing sophisticated capabilities such as magnetic brain imaging closer to widespread use.

Integrating In Vitro and In Silico Tools for Antimalarial Drug Discovery

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Malaria is a global health threat, with an estimated 282 million cases and 610,000 malaria-associated deaths reported in 2024. Malaria eradication is a global priority; however, progress has been hampered by the lack of broadly applicable and highly effective vaccines and by parasite drug resistance. To address drug resistance, the discovery of new medicines with novel modes of action is critical for achieving long-term malaria control and eradication goals. At the same time, important knowledge gaps remain for some clinically used antimalarials whose mechanism of action is not fully understood. Modern antimalarial drug discovery increasingly relies on the integration of experimental, computational and artificial intelligence (AI)-enabled approaches to identify drug targets, understand mechanisms of action and accelerate lead discovery. In our laboratory, a range of target identification and validation tools are used to investigate parasite biology and drug interactions, including CRISPR-Cas9 genome editing, conditional gene knockdown systems, biochemical enzyme assays, and mass spectrometry-based proteomics and metabolomics. Complementing these laboratory-based approaches, computational tools such as homology modelling and AI-enabled quantitative structure-activity relationship (QSAR) modelling support the exploration of protein targets and the prioritisation of compounds for experimental testing. This overview highlights how these complementary approaches are being applied to support the discovery and development of novel antimalarial therapies.

New Research on In-Tl Alloys in the Spirit of Humboldt

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An AI search reveals that In-Tl alloys are significant scientifically on account of the reversible, martensitic transformation exhibited by these alloys which was once suggested to proceed via a double shear such as, $(\mathbf{101})[\bar{\mathbf{1}}\mathbf{01}]$; $(\mathbf{011})[\mathbf{0}\bar{\mathbf{1}}\mathbf{1}]$, and the suggestion that the shear elastic constant, $(c_{11} - c_{12})/2$ (or c') went to zero at the transformation temperature. An early theoretical calculation of the phonon dispersion relations for In-Tl predicted phonon softening along the $[\zeta\zeta\mathbf{0}][\zeta\bar{\zeta}\mathbf{0}]$ (or T_1) branch at low q. But contrary to this, phonon dispersion measurements using an In-Tl single crystal of excellent quality on the cold triple-axis spectrometer, Sika, at the Australian reactor, OPAL, failed to detect this phonon softening and indeed, quite the reverse, i.e., an increase of low-q phonon frequencies with decreasing temperature, along the T_1 branch, was found.

The presentation of these data at the 2017 International Conference on Martensitic Transformations, prompted a most successful international collaboration to measure c' versus temperature using resonant ultrasound spectroscopy on In-Tl crystals which we had confirmed exhibited the martensitic transformation, as the result of experiments on the Koala Laue diffractometer at OPAL. While a minimum in c' versus temperature has been observed at the transformation temperature using RUS, c' certainly does not go to zero.

More recent measurements of the temperature dependence of the [111]T phonons for our In-Tl crystal of best quality, have revealed a softening of the zone-boundary phonon. This observation supports an alternative mechanism for the transformation in In-Tl alloys, proposed some years ago.

Global water security knowledge overlooks Indigenous Peoples

Animish Gain

Murdoch University

Global assessments of water security have advanced understanding of where water is available, accessible and safe, yet they can obscure how water insecurity is experienced by Indigenous Peoples. Indigenous water security extends beyond material conditions to encompass relationships with Country and territory, cultural and spiritual values, ecological responsibilities, Indigenous knowledge, rights and self-determination. In this study, we bring together global patterns of water insecurity, the spatial distribution of Indigenous Peoples and evidence from Indigenous water-security scholarship to identify three interconnected blind spots in global water-security knowledge. Spatially, the geography of research and monitoring may not correspond with places where Indigenous presence intersects with water-security pressures. Conceptually, prevailing approaches can privilege measurable material conditions while inadequately representing relational, cultural and political dimensions of water security. Epistemically, increasing Indigenous participation in research and governance does not necessarily confer authority over how water security is defined, assessed or governed. These blind spots expose a participation–authority gap between inclusion in decision processes and enduring power over water and water-related knowledge. We propose an Indigenous Water Authority–Security Framework that conceptualises water security through interacting domains of material, relational and authority security. This reframing moves beyond securing water for Indigenous Peoples towards strengthening Indigenous relationships with water and authority over how water is known, valued and governed. It shifts the water-security question from whether water is available, accessible and safe to also asking whose relationships with water are secured, whose knowledge counts and who has authority to determine water futures.

Electromagnetism and Technology

David G Glynn

Flinders University

AvH was not afraid of new technologies, making daily geophysical measurements on his Spain-America expedition starting 5 June 1799, using the latest instruments such as a magnetic declinometer. Later he collaborated with Gauss and Weber in Göttingen to produce the first mathematical models of the earth's mysterious magnetic field, to realise that magnetic disturbances fed aurora, leading international teams that set up magnetic and optical observatories. The Gauss-Weber equations for electromagnetism, then Maxwell's improvements based on fluids, came soon. Magnetic and electric forces are related by Einstein's theory of time-dilation in special relativity. From 1926 Dirac improved Schrödinger's equation, describing the electron states (energies/ magnetisms/ spins) in the orbitals around atoms. People were feeling their way using all available methods. Here, we can add to electromagnetism with diagrams mapping the electron states in orbitals obtained from the Dirac equation to certain positions in a crystal lattice. There are fundamental numbers, the electronic shell level n, an integer k associated with energy and subshells, and a magnetic quantum number m. We see how these three are crystal properties. We surmise also that (up/down) quarks behave more like the hands and feet of protons and neutrons, not internal to them. Particles with higher quarks (e.g. kaons) might just be groups of closely related particles. The discovery of photography by Daguerre was announced by Arago on 7 January 1839. AvH and Arago attended a happy celebration of this with 800 others at the Science and Arts Academies in Paris on 19 April.

In-depth Structural Analysis of Thermotropic Liquid Crystals

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Thermotropic liquid crystals (TLCs) are a class of molecules that experience liquid crystal phases at specific temperatures without the aid of a solvent, giving them unique electrochemical and optical properties in a fluidic state. These properties are utilised in applications such as digital screens and biological and chemical sensors. Because TLC phases are inherently disordered, typical crystallographic techniques can be difficult. We therefore employed Fluctuation X-ray Scattering (FXS) and a novel analysis technique: Pair-Angle Distribution Function (PADF). The PADF maps three- and four-body correlations for atomic distribution and specialises in disordered-ordered systems where there is typically some nanostructure, such as proteins and liquid crystals, and provides information that cannot be obtained by other means.

For this work, a collection of calamitic TLC-forming samples was chosen, and their phase behaviour characterised over a range of 20-100℃. The calamitic samples form a combination of nematic, smectic and chiral nematic mesophases, and thermal hysteresis was common. For these liquid crystal systems, the structure is important for all applications. While the ordering of liquid crystal phases is generally understood, local molecular coordination is difficult to characterise experimentally because of the liquid-like disorder at short-length scales. As such, we conducted powder X-ray diffraction experiments to determine the structure of the crystalline state, which thermally leads into the liquid crystal state, to gain insights into this structure. This FXS/PADF, methodology, along with atomistic molecular dynamics simulations, provides novel insights into these materials in the crystalline phase, liquid crystalline phases, and the transitions between them.

How to Quantify the Motion of Atoms and Molecules

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The stability of atoms and molecules depends on their interactions and motion, where interactions are quantified by energy and motion by entropy. Despite much progress in quantifying energy, it is a challenge to quantify entropy because of the complex nature of quantum-mechanical atomic motion. Here we present a solution to this problem called Multiscale Cell Correlation, first developed for liquids [1-2], proteins [3], complexes [4] and now freely available in software applicable to a broad range of systems [5]. The system is coarse-grained over multiple length-scales and partitioned into strongly and weakly correlated parts. All degrees of freedom are discretised into small regions called cells, within which local harmonic motion is assumed, so providing a viable way to determine the probability of quantum states. The frequencies of harmonic motion are derived from atomic forces averaged over system configurations generated in a computer simulation, and the numbers of cells are derived by coarse-graining the atomic coordinates. The predicted entropy closely matches experiment, is intuitively interpretable and requires no AI training on datasets.

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Building an AI System Is Not Necessarily Science: Distinguishing Mathematics, Empirical Science and Engineering

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The development of an artificial intelligence system is often presented as scientific research simply because it involves sophisticated algorithms, large datasets, and substantial computational resources. This classification is often unjustified. Science seeks to explain phenomena through testable hypotheses, controlled experimentation, reproducible evidence and theories capable of surviving attempts at falsification. Engineering, by contrast, seeks to construct systems that satisfy defined requirements under specified operating conditions. Much contemporary AI development accomplishes neither objective particularly well. Models are trained through empirical optimisation, selected by performance on narrow benchmarks, and reported without adequate mechanistic understanding, uncertainty quantification, independent validation, or failure analysis. A marginal increase in benchmark performance is treated as discovery, even when it produces no transferable knowledge.

At the same time, AI systems are frequently deployed without the requirements definition, verification, robustness testing, lifecycle monitoring and risk controls expected of mature engineering disciplines. The result is not a new form of science but an increasingly expensive form of trial-and-error construction. This Perspective makes a case that AI model building is principally an engineering activity; that the systematic investigation of learning, representation, reasoning and generalisation can constitute science; and that AI becomes scientifically valuable only when it generates and tests explanatory knowledge beyond the performance of a particular computational artefact.

A Deep Impression: Coins, Currencies and Collectables Honouring Alexander von Humboldt

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Alexander von Humboldt left an indelible mark on science, exploration, and our view of the natural world. But his legacy isn't just visible in his writing and travel records – it is struck in coins, medals, and printed on paper, polymers, cigarette cards, and more. These everyday artefacts are more than just curios; they reflect attitudes towards science, exploration, economics, colonialism and cultural heritage.

In a world dominated by digital transactions and cryptocurrencies, AI generated imagery and questionable NFT collectables, physical currency remains a fascinating intersection of art, metallurgy, chemistry, history, and value. Coins, notes and commemorative pieces are tangible objects composed of metals, alloys, paper, and polymers, with both intrinsic and symbolic worth.

In this presentation I will explore the diverse and numerous numismatic and collectable items featuring the likeness of Alexander von Humboldt. These objects show that more than 250 years after his birth, Humboldt is still travelling the world, one coin, note, medal, or collectible at a time.

Strange Hearts: Hyperons and H-Dibaryons Inside Neutron Stars

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Neutron stars hold the densest matter in the observable universe, reaching several times nuclear saturation density ($n_0 = 0.16$ fm^{-3}). At these densities, hyperons and possibly more exotic states such as the six-quark H-dibaryon (uuddss) are expected to appear. Including hyperons, however, softens the equation of state and lowers the maximum mass below the observed $M > 2$ solar masses. This is the "hyperon puzzle". Using the quark–meson coupling (QMC) model, in which baryon structure responds self-consistently to the surrounding medium, I show that quark-level short-distance repulsion resolves this tension. The repulsion is implemented either as a quark-overlap term or as an excluded-volume effect. Both give $M_{max} = 2.1$–$2.2\ M_\odot$ with hyperons present. Within the same framework, the H-dibaryon forms a bosonic condensate core extending to $r \approx 5.7$ km in the heaviest stars, while leaving the bulk constraints intact. Because masses and radii alone cannot distinguish these compositions, I also examine neutrino mean free paths and fundamental (f-mode) oscillation frequencies. These offer complementary, if modest, observational handles. Universal relations then link $\omega_f M$ to compactness, tidal deformability and moment of inertia, with little dependence on the equation of state.

Multi-level Random-Telegraph Noise Mitigation using a Single Spectator Qubit

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Preserving quantum coherence in the presence of environmental noise is a central challenge for quantum technologies. Noise mitigation using spectator qubits (SQs) has recently emerged as a promising approach, enabling indirect probing of the noise without disturbing the data qubit (DQ). However, existing analyses are largely restricted to two-level fluctuator models, typically described by random telegraph processes, which fail to capture the complexity of realistic noise environments arising from multiple fluctuators. In this work, we study SQ-based noise mitigation for DQs subject to general multi-level Markovian fluctuator noise. The noise is modeled as a finite-state stochastic process with arbitrary transition rates, encompassing ensembles of fluctuators and extending beyond the conventional two-level setting. We first derive the coherence dynamics of the DQ under such noise and characterize the resulting decoherence. Building on this framework, we develop a mitigation scheme in which information about the noise is inferred from sequential SQ measurements and used for phase correction. A heuristic adaptive protocol is proposed to dynamically select the measurement time and angle based on the current noise estimate. Numerical simulations demonstrate that the proposed strategy significantly suppresses decoherence under multi-level noise, achieving performance comparable to that in the two-level case despite the increased complexity of the noise process.

From Space to Surface: Leveraging InSAR Technology for Geohazard Risk Monitoring in Australia

Wasantha Liyanage

Victoria University

Ground deformation arising from both natural processes and human activity poses significant risks to infrastructure, communities, and the environment. Accurate, spatially extensive, and temporally consistent monitoring of such deformation is therefore critical for effective geohazard risk assessment and management. Differential Interferometric Synthetic Aperture Radar (DInSAR) offers a compelling solution, enabling millimetre-scale surface displacement measurements over large areas through the analysis of phase differences between repeat-pass satellite radar acquisitions. Despite its proven utility globally, the systematic application of DInSAR to geohazard monitoring in Australia has remained notably limited, with the country contributing a disproportionately small share of the international InSAR research literature.

This paper investigates the capability of DInSAR as a geohazard monitoring framework across diverse geological and land-use settings in Australia. Drawing on six case studies distributed across five Australian states, the study examines a broad spectrum of ground movement phenomena, encompassing subsidence, heaving, earthquake-induced deformation, slope instability, underground mining impacts, and urban tunnel construction. Satellite-derived displacement estimates are evaluated against independent field measurements to assess the reliability and accuracy of the DInSAR approach under Australian-specific conditions.

The findings demonstrate that DInSAR consistently produces robust deformation measurements across varied geohazard types and environments, affirming its suitability as a scalable monitoring tool for the Australian context. The study further identifies emerging frontiers for InSAR integration with machine learning and climate-informed hazard modelling. By bridging remote sensing and geotechnical disciplines, this work advocates for greater institutional adoption of satellite-based monitoring to strengthen Australia’s geohazard resilience.

‘German and British Approaches to the Pacific Labour Trade: Experiences from Fiji and Sāmoa

Anawaite Matadradra

University of the South Pacific

The Pacific labour trade was an important part of European colonial expansion during the nineteenth and early twentieth centuries. This paper compares British and German approaches to the recruitment and movement of Pacific Islanders, focusing on the experiences of Fiji and Sāmoa. It explores how different colonial systems shaped the movement and treatment of Pacific laborers and how these histories can be studied using both traditional and emerging research methods. The paper draws on colonial records, government eports, missionary writings, newspapers and other historical sources. These records provide valuable information about labour recruitment and colonial policies, but many were written from a European perspective. It is therefore important to read them critically and consider the experiences and voices of Pacific Islanders that may be missing from the historical record. In line with the theme of the symposium, the paper also considers how digital technologies and artificial intelligence could support research into Pacific history.

AI tools may assist historians in locating, organising and comparing large collections of historical records from different colonial settings. However, such tools must be used carefully because they cannot replace historical judgement, cultural knowledge or close reading of sources. The paper argues that responsible use of AI, combined with established historical methods, can create new opportunities for comparative Pacific research. Comparing Fiji and Sāmoa also demonstrates the value of looking beyond individual colonial histories to understand wider patterns of labour, migration and colonialism in the Pacific. Most importantly, Pacific experiences and perspectives must remain central to this scholarship.

The sea and the silicon: Pathways to antimicrobial discovery from natural products

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Antimicrobial resistance (AMR) in medical and agricultural sectors poses one of the most critical threats to global public health, driving an urgent need for novel therapeutics with distinct mechanisms of action. Marine organisms represent a vast, underexplored repository of structurally unique bioactive compounds, with marine proteins and peptides remaining largely uncharacterized compared to their terrestrial counterparts.

As filter feeders, oysters continuously encounter and eliminate pathogenic marine bacteria while maintaining a complex microbiome that actively competes with ingested microbes. The goal of this research is the discovery and characterisation of novel antimicrobial molecules from Sydney Rock Oysters effective against drug-resistant ESKAPE pathogens using bioassay-guided fractionation, transcriptomics, and metagenomics. Using this approach, we have identified two candidate antimicrobial peptides with anti-bio film activity against Staphylococcus aureus. Integrating AI into future studies will refine and accelerate the discovery of novel putative antimicrobial compounds.

Structurally Resilient MOF for Efficient CO2 Capture from Flue Gas

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In the current context of increasing global energy needs met by burning fossil fuels, the concentration of carbon dioxide (CO2) is rising at an alarming rate. To address this pressing challenge, capturing CO2 from anthropogenic sources holds great promise. Metal-organic frameworks (MOFs), a class of crystalline, porous materials, owing to their tunable pore architecture, have garnered significant attention for their energy-efficient capture of CO2 from gaseous mixtures. In the present work, a new two-fold interpenetrated bimetallic MOF has been rationally designed with ultramicroporous channels for CO2 capture. The adsorbent exhibits impressive CO2/N2 separation performance and excellent structural robustness to water, conc. acid vapor, and elevated temperatures. Dynamic breakthrough experiments were performed under various conditions with a CO2/N2 (10/90) mixed gas feed, where a modest decline of 20.7 % for CO2 uptake was observed upon increasing the temperature from 298 K to 328 K. This minimal reduction in the CO2 uptake as compared to the top-performing adsorbents highlights the framework's tolerance towards temperature fluctuations encountered in industrial flue gases. Furthermore, theoretical calculations were performed to identify the most probable CO2 binding sites within the framework in pristine as well as hydrated form for understanding the gas sorption behaviour.
Keywords: Bimetallic MOF, CO2 capture, Flue gas

Mineral processing as the enabler of energy transition and the emerging role of AI in this sector

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Energy transition requires metals-intensive technologies. A wind turbine requires about 9 tons of copper, while a typical electric car needs an average of 207 kg of critical minerals and metals for its battery, motors, and wiring - roughly six times more than a standard petrol-powered car. Mineral processing is the workhorse in the production of minerals and metals in the world and, thus, serves as an enabler of the energy transition. Many key mineral processing technologies have been operating successfully for decades, yet the industry is facing emerging sustainability challenges related to the ongoing decline in the grades of the available resources (ores) and the increasingly stringent regulations about environmental protections. How can AI help the mineral processing industry tackle these challenges? This talk provides a high-level discussion on the state-of-the-art of the mineral processing, its role in the energy transition, the sustainability challenges and the emerging roles of AI in this strategic industry.

Peptide and Protein Drug Discovery

Christoph Nitsche

Australian National University

Peptides and small proteins are increasingly transforming modern drug discovery. Recent advances in molecular engineering, directed evolution and chemical biology have expanded the scope of these therapeutics far beyond their traditional roles as biologics. This lecture will discuss emerging approaches for the discovery and engineering of functional peptides and small proteins, with a particular focus on the integration of synthetic chemistry and biotechnology. It will highlight research on metal-functionalised peptides and proteins engineered for targeted therapeutics, molecular imaging and radiopharmaceuticals. These examples demonstrate how introducing new chemical functions into biomolecules can create opportunities for next-generation therapeutics and diagnostic agents.

The Citizen-Scholar in the Age of Artificial Intelligence: A Humboldtian Perspective

Nancy November

The University of Auckland

Artificial intelligence is transforming how scholars formulate questions, assemble evidence, generate interpretations and communicate knowledge. What might Humboldtian scholarship contribute to understanding these transformations, and what kinds of intellectual capabilities should universities cultivate in response?

Alexander von Humboldt's intellectual curiosity, interdisciplinary imagination and international networks offer a useful starting point. Together with Wilhelm von Humboldt's conception of Bildung, they invite us to reconsider the relationship between knowledge, intellectual independence and the formation of the citizen-scholar.

This paper explores how artificial intelligence might enter into productive conversation with other forms of intelligence: disciplinary, historical, creative, relational and collective. An imagined dialogue between Humboldt and AI provides a means of examining the possibilities and limitations of machine-generated knowledge, including questions of interpretation, evidence, cultural difference and scholarly responsibility.

Such an experiment is necessarily double-edged. A language model trained on Humboldt's writings might illuminate his habits of questioning, comparing and connecting, while also inventing a coherence his texts do not possess. What could 'Humboldt' ask of AI about observation, evidence and intellectual independence? And what should we ask of this digital Humboldt about the Indigenous and local knowledge that shaped his work? The point is to make questioning itself visible as a scholarly practice. Drawing on research into collaborative digital literacy, culturally sustaining pedagogy and academic citizenship, I consider how universities might develop scholars capable of working across disciplines, knowledge traditions and technologies. The Humboldtian legacy offers a productive framework for understanding intellectual formation in an era of increasingly distributed knowledge and intelligence.

Metalloid and Non-Metal Functionalization of Janus WSeTe for CO and CO_2 Sensing: A DFT Study

Baishali Paul, Sai Varun Ragi, Sayan Kanungo, Ravichandar Babarao

Royal Melbourne Institute of Technology (RMIT)

In this work, a density functional theory (DFT)- based study is performed to investigate the adsorption and transduction characteristics of CO and CO2 on B, C, Si, Ge, N, P, and As -doped Janus WSeTe monolayers. The work emphasizes doping feasibility, adsorption energetics, charge transfer, and electronic-structure modulation. The feasibility of doping is assessed using WSe2 and WTe2 as reference synthesis pathways for WSeTe under chalcogen-rich and chalcogen-poor conditions. The effect of CO adsorption on NM-doped WSeTe is examined using total and projected density-of-states profiles. The transduction mechanism is further analyzed using the charge difference density profile, the electron localization function, and atomic orbital hybridization. The results reveal that B-, Si-, and Ge-doped WSeTe exhibit significantly stronger interactions with CO than with CO2. Among these, B-doped WSeTe shows the highest adsorption energy and charge transfer, followed by Si and Ge, indicating superior sensing performance toward CO. The adsorption energy ratio further confirms that B-doping offers the highest selectivity for CO over CO2. Recovery time analysis suggests that B-doped WSeTe exhibits the most stable CO adsorption at room temperature but suffers from slower desorption kinetics. In contrast, Si-doped WSeTe offers a more balanced adsorption–desorption profile with improved recovery. The dopant species screening suggests that Si-doped WSeTe is the most suitable candidate for CO sensing with a reasonably high formation energy, marginal clustering tendency, stable adsorption, practical recovery time at elevated temperature, and preferential (comparable) CO adsorption in the presence of H2, H2O, CO2, N2 (NO and O2) interfering species.

Humboldtian Bildung, Gen Z, and the Age of Artificial Intelligence

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The paper is inspired by my personal experience teaching an on-campus law unit, Corporate Law, beginning of 2026. My experience, after about three weeks, was that I have probably lost my ability to communicate clearly and in an engaging way, as I just got almost zero facial expressions or other forms or positive body language from the students. It was upsetting as I received excellent student satisfaction for my face-to-face teaching my entire career. “I was steering off at a disaster, this Trimester”, I thought! I shared my experience with my son, now in his mid-thirties. He mentioned the “Gen Z Stare” (“Gen Z” referring to “Generation Z”). I had no idea what it was. So, he directed me to non-academic internet references to the “Gen Z Stare” (https://en.wikipedia.org/wiki/Gen_Z_stare). It was an eye-opener, making me realise that I need to adjust my teaching to the current needs of Gen Z – a deeper understanding of Gen Z should guide the way for 21st Century Teaching Pedagogy.

The focus of the paper will be on what the Gen Z stare is; on some scholarly evidence of how Gen Zers learn; the concept of Bildung, as Alexander von Humboldt’s fundamental, and still relevant approach to the unity of teaching and research in the service of self-formation; and making suggestions how universities will have to embrace AI and multimodal learning to stay relevant. The paper will conclude with some core recommendations regarding assessment reform and pedagogical renewal to avoid becoming irrelevant institutions soon.

Humboldtian observation in the age of AI: designing cooler, more liveable cities

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Alexander von Humboldt viewed nature as a connected whole, using careful observation to understand relationships across complex systems. Today, as cities face rising temperatures and biodiversity loss, this perspective remains relevant. Urban trees are essential infrastructure, but increasing canopy cover alone cannot guarantee cooler, healthier cities. Benefits depend on tree traits, canopy structure, water availability, and interactions with buildings and other vegetation.

Drawing on field measurements and comparative research in Melbourne, Munich, and Hong Kong, I examine how tree physiology and vegetation structure shape urban heat exposure. The findings highlight an important distinction: how vegetation functions matters as much as its presence. Layered vegetation, combining trees with shrubs and groundcover, can reduce pedestrian heat stress more effectively than trees alone while providing habitat for urban biodiversity. However, benefits depend on local climate, humidity, airflow, and water availability.

Artificial intelligence, remote sensing, and spatial modelling offer opportunities to extend these insights from individual trees to entire cities. Yet reliable predictions require field observations, ecological understanding, and validation across contrasting environments to distinguish biological mechanisms from statistical associations.

As a Humboldt Research Fellow (2015-2018), I experienced the value of international collaboration in advancing science and its practical applications. I argue that combining Humboldt's tradition of systematic observation with emerging analytical tools can move urban greening beyond simply counting trees towards designing vegetation that delivers measurable benefits for people and biodiversity. The challenge is not merely to make cities greener, but to understand what makes urban greening work.

Nanophotonics meets with AI

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Nanophotonics enables precise control of light at the wavelength and sub-wavelength scale, offering powerful platforms for imaging, sensing, communications, and quantum technologies across physics, materials science, chemistry, and engineering. By structuring matter at the nanoscale, we can sculpt optical fields, enhance light–matter interactions, and realise compact, multifunctional photonic devices that speak to a broad research community.

As these systems become more complex, artificial intelligence and machine learning are transforming how we design and understand nanophotonic structures. Data-driven inverse design now routinely navigates vast parameter spaces to discover non-intuitive devices with tailored spectral, spatial, and polarization responses. Machine-learning-enabled inverse design has been used to realise three-dimensional vectorial holography, where metasurfaces generate fully controlled 3D polarization-structured holograms. Building on these advances, our recent work demonstrates an inverse-designed wavelength demultiplexing waveguide that sorts excitonic photoluminescence from WS_2/WSe_2 heterostructures into three distinct channels. We present an inverse-design wavelength demultiplexing waveguide capable of separating three distinct wavelengths.

This presentation will use these case studies to illustrate how AI is reshaping nanophotonics - from holography and structured light to integrated excitonic photonics - and to discuss emerging opportunities where machine learning unlocks photonic functionalities beyond conventional design intuition.

Creative Mathematical Sciences Communication: A Humboldtian Perspective in the Age of AI

Michael Fellows and Frances Rosamond

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Alexander von Humboldt's scientific legacy was characterized by an extraordinary breadth of vision, seeking connections among different fields of knowledge with the belief that scientific understanding should be communicated beyond narrow disciplinary boundaries. In the age of artificial intelligence, this Humboldtian spirit has new relevance. Computational science is transforming almost every area of human activity, yet the ideas underlying computation remain inaccessible to much of the public—and particularly to children.

Creative Mathematical Sciences Communication (CMSC) is an international initiative that brings computational scientists, mathematicians, educators and communicators together to develop hands-on activities through which children and the public can encounter contemporary ideas in mathematics and computer science. Rather than simplifying science into a collection of facts, CMSC asks researchers to find ways of communicating genuine scientific ideas through exploration, experimentation and play; opening up opportunities for children to engage with "What nobody knows".

This paper explores CMSC through a Humboldtian lens. The CMSC goal is not simply science outreach, but the creation of connections between mathematics and computer science, researchers and teachers, scientific ideas and society, and increasingly between computational thinking and the emerging world of artificial intelligence.

In an age in which AI is rapidly becoming part of everyday life, communicating the ideas behind computation may be one of the most important forms of science communication. CMSC offers one possible model for carrying this Humboldtian vision into the future.

AI/IoT and Decision Support Systems for Flood Monitoring and Prediction

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Pekalongan, Semarang, and Demak are three major cities on the north coast of Central Java, Indonesia, heavily affected by tidal and riverine flooding. Tidal floods occur almost daily while riverine floods occur when rivers overflow into surrounding lowlands, often following several days of heavy rainfall and exacerbated during high tides. These floods damage infrastructure and productive land, seriously affecting the livelihoods of approximately 3.3 million residents across the three cities.

To mitigate tidal flooding, the Indonesian government has constructed 3-m-high seawalls, extensive water-storage reservoirs, and large pumping stations. When reservoir water levels become too high, pumps discharge water to rivers or the sea. However, monitoring of tidal and reservoir water levels is currently performed manually by the Pemali-Juana River Basin Office (BBWS). The lack of continuous, real-time monitoring limits the timeliness and efficiency of flood management and can result in delayed pumping decisions. For riverine floods, the existing monitoring and warning system operated by the Regional Disaster Management Agency (BPBD) in Semarang is affected by false alarms, faulty devices, and untimely warnings, impeding effective flood preparedness and mitigation.

Our two DFAT-funded projects, Tide Eye and Flood Eye, address the needs of BBWS and BPBD by digitally transforming flood monitoring, early warning, prediction, and decision-support systems. Tide Eye focuses on tidal flood monitoring and early warning, while Flood Eye enhances riverine flood monitoring, prediction, and decision support. Together, the projects aim to strengthen flood management, improve the reliability and timeliness of flood information and warnings, and enhance community resilience.

Development of biocatalytic processes for the biobased production of chemicals and materials – HI, AI or brute force

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The development of efficient biocatalytic processes is a key element in establishing sustainable routes to chemicals and materials. However, turning promising enzymatic reactions into technically and economically viable processes remains challenging, with the engineering and optimization of enzymes at the heart of it. Success in the past was often relying on the design of smart assays followed by extensive experimental screening and selection of optimized variants, such being a combination of human intelligence (HI) and brute force approaches.

Recent advances in artificial intelligence (AI) have significantly improved and accelerated these processes. AI based protein structure prediction has revolutionized protein chemistry and stabilized enzymes can be generated easily. But when it is about activity conventional approaches still outperform computational predictions. Drawing on examples from our work on enzyme engineering for multienzyme cascades and the conversion of renewable feedstocks into chemicals and polymers, this presentation will discuss both successes and failures in biocatalytic process development.

From Humboldt's Vision of Nature to AI-Driven Biological Discovery

Sarah Turpin-Nolan

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Alexander von Humboldt recognised that nature is an interconnected system and that understanding individual components requires us to consider how they interact. His approach combined observation, measurement and knowledge from different disciplines to understand the natural world. This philosophy remains highly relevant to modern biological research, particularly as artificial intelligence (AI) becomes increasingly integrated into scientific discovery.

My research focuses on lipid metabolism, particularly how lipids are synthesised, transported and distributed between organs, and how these processes contribute to health and disease. Although we understand many individual metabolic pathways, we still know relatively little about how lipids move throughout the body and how different organs influence one another. Emerging technologies, including stable-isotope tracing and spatial lipidomics, are helping us investigate these complex processes. AI offers opportunities to integrate large datasets, identify previously unrecognised relationships and suggest new directions for investigation. However, identifying a relationship does not establish its biological significance.

Drawing on my own research, I will explore how Humboldt’s approach remains relevant in an increasingly AI-driven research environment. AI can support scientific discovery, but scientists must remain responsible for asking the questions, designing experiments and critically interpreting results. Just as Humboldt relied on observation and measurement to understand the natural world, we must continue to generate the experimental evidence needed to understand complex biological systems. AI may help us identify connections we have not previously considered, but it is the researcher who must establish whether those connections are biologically meaningful.

AI meets Criminal Law: The challenges of a criminal justice response to “rogue” AI agents

Gregor Urbas

Charles Sturt University, ACT Magistrates' Court

Artificial intelligence (AI) is increasingly being used by cybercriminals to conduct hacking and ransomware attacks, internet fraud and range of other online offending. AI tools are also available for other forms of offending, including planning, preparation and recruitment for crimes, with online tools offered for sale or rent on websites or the dark net. Where an AI agent is used to commit a criminal act, or in support of a criminal act, existing legislation and law enforcement powers are likely sufficient to meet the challenge of prosecuting persons responsible. However, the appearance of “rogue” AI agents capable of performing similar activities without human control poses different challenges. Criminal law imposes liability only on persons, whether natural or legal, and this approach also limits the application of doctrines of derivative liability, such as counselling or procuring, aiding or abetting, or using an “innocent agent” to commit a crime. Criminal liability for an omission, such as creating or deploying an AI agent with insufficient protections, requires a legal duty rather than mere risk of harm. Corporate criminal liability might also provide a mechanism for attributing responsibility for harms caused by AI agents, but establishing appropriate fault elements such as intention, recklessness or criminal negligence would be far from straightforward. This presentation reviews the potential application of Australian criminal law to AI agents, considering whether any amendments might assist in meeting the criminal liability challenges. It also reflects of the capacity of law enforcement to use AI in responding to criminal offending.

Optimising quantum correlation microscopy by utilising Fisher information metrics

Jaret Vasquez-Lozano, Qiang Sun, Andrew Greentree

RMIT University

Quantum correlation microscopy (QCM) utilises higher order photon statistics to extract spatial information about single-photon emitters that is not obtainable with only conventional imaging techniques. This information can provide high precision emitter localisation, which can be useful in particle tracking in life science applications. QCM measurements are typically obtained using the Hanbury Brown and Twiss (HBT) experiment, which uses multiple detectors to detect photons in coincidence. One weakness of HBT is the low probability of detecting coincident photon events, meaning extended measurement times are required to obtain an improved localisation precision than from the conventional imaging approach. This limits the time resolution that could be achieved in live imaging, preventing the understanding of biological molecule dynamics that happen over short time periods. To combat this, we investigate how the Fisher information of a HBT system can be used to optimise measurement locations, reducing the amount of time required to achieve high precision localisation. We demonstrate a theoretical approach where measurements are performed in an ellipse configuration, with the optimal dimensions predicted by maximising the Fisher information metric. After each measurement, it is possible to iteratively update the optimal location of the following measurement based on the predicted distance between emitters, maximising the precision of the localisation.

Pinch-off in the lab: from geometric evolution to singularities

Glen Wheeler

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Why can a thin solid wire break into particles even when no material is lost? Surface diffusion offers a striking answer: atoms move along an interface in response to curvature, reducing surface area while preserving enclosed volume. A process that smooths some features can therefore sharpen a neck until it pinches off.

I will discuss a rigorous construction of this phenomenon for the surface diffusion equation. Smooth, closed, embedded tori evolve to a singularity at one point in finite time, while remaining smooth elsewhere. The narrowing waist follows a quarter-power law, and its rescaled shape approaches a universal conical profile previously identified in numerical studies.

An interactive virtual laboratory makes these ideas accessible through computational visualisations and carefully identified published experimental images. It also highlights a crucial distinction: similar-looking pinching events can arise from different transport mechanisms. In bulk-diffusion experiments, material moves through a phase rather than along its surface, and the characteristic length follows a one-third-power law instead.

By bringing mathematical proof, computation and observation into dialogue, the talk will explore what each can establish, how they inform one another, and which questions remain open. In particular, extending the rigorous construction to bulk-diffusion-driven pinchoff remains a research direction.

The Origin and End of Natural Intelligence

Peter R Wills

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The genetic code represents the first known occasion when symbolic reference emerged from matter and mechanism. It heralded a new form of causation whereby information, arbitrary correspondences between patterns in nature, subjected local material processes to intrinsically purposeful constraints. The serendipitous circumstances that potentiated molecular biological coding on our planet made possible the first spark of intelligence whose operation has burgeoned in multifarious forms and processes that have transformed the planet into a living habitat. Very recently, life has needled its way into the near reaches of the solar system and is currently being facilitated, through artificial "large language models", to seize human lingual communication, as a kind of food, for the nourishment of goals and institutions to which the last decades of political history has handed the power of life and death. The age of Nature and enquiry as Humboldt knew life will soon be at an end unless humanity takes the power to create back from our own unbridled creations. I will discuss this problem from the perspective of what our recent work on the origin of genetic code has taught us about the roots of intelligence in nature.
Wills PR (2023) Origins of Genetic Coding: Self-Guided Molecular Self-Organisation. Entropy 25: 1281 doi.org/10.3390/e25091281

Towards Intelligent, Secure, and Ultra-Reliable Internet-of-Vehicle Communications

Phee Lep Yeoh

University of the Sunshine Coast

The Internet-of-Vehicles (IoV) is a powerful data-driven system of interconnected cooperative vehicles that can transmit wireless data across diverse aerial, terrestrial, and remote wireless environments. The IoV is designed to enable fully autonomous driving systems with vehicles transmitting a wide range of situational awareness and perception data from their onboard wireless sensors (e.g. cameras, GPS, and LiDAR) to other vehicles and roadside infrastructures. The IoV is uniquely different from existing communication systems due to its extremely mobile nature – requiring vehicles to establish and maintain secure data connections with massive numbers of vehicles and rapidly changing wireless channels. The massive amounts of vehicle, traffic, and environmental data exchanged in the IoV will allow individual vehicles as well as traffic management systems to obtain a holistic view of traffic conditions and support accurate decision making in complex driving scenarios. Towards this end, my aim is to develop new IoV communications frameworks based on recent developments in wireless physical-layer security techniques that are empowered by machine learning models to improve secure resource allocation and performance optimization of IoV systems in diverse communication s