ATHENS INSTITUTE

Abstract Book

14th Annual International Conference on Chemistry
20-24 July 2026, Athens, Greece

Edited by
Evangelia Kotsikorou & Olga Gkounta

2026

Abstracts
14th Annual International Conference on Chemistry

20-24 July 2026, Athens, Greece

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First published in Athens, Greece by the Athens Institute.
ISBN: 978-960-598-790-9

9 Chalkokondili Street
10677 Athens, Greece
www.atiner.gr

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Preface

This book includes the abstracts of all the papers presented at the *14th Annual International Conference on Chemistry* (20-24 July 2026), organized by the Athens Institute.

A full program can be found before the relevant abstracts. In accordance with Athens Institute's Publication Policy, the papers presented during this conference will be considered for inclusion in one of the Athens Institute's many publications only after a blind peer review process.

The purpose of this abstract book is to provide members of the Athens Institute and other academics around the world with a resource through which they can discover colleagues and additional research relevant to their own work. This purpose is in congruence with the overall mission of the association. Athens Institute was established in 1995 as an independent academic organization with the mission to become a forum where academics and researchers from all over the world can meet to exchange ideas on their work and consider the future developments of their fields of study.

To facilitate the communication, a references section includes all the abstract books published as part of this conference (Table 1). I invite the readers to access these abstract books –these are available for free– and compare how the themes of the conference have evolved over the years. According to the Athens Institute's mission, the presenters in these conferences are coming from many different countries, presenting various topics.

Table 1. *Publication of Books of Abstracts of Proceedings, 2013-2026*

Year	Papers	Countries	References
2026	27	16	Kotsikorou and Gkounta (2026)
2025	31	16	Kotsikorou and Papanikou (2025)
2024	78	25	Kotsikorou and Gkounta (2024)
2023	44	22	Sarafian and Gkounta (2023)
2022	35	24	Tratras Contis and Gkounta (2022)
2021	19	12	Papanikos (2021)
2020	31	10	Papanikos (2020)
2019	24	17	Papanikos (2019)
2018	28	14	Papanikos (2018)
2017	16	12	Papanikos (2017)
2016	11	9	Papanikos (2016)
2015	48	18	Papanikos (2015)
2014	23	16	Papanikos (2014)
2013	29	16	Papanikos (2013)

It is our hope that through Athens Institute's conferences and publications, Athens will become a place where academics and researchers from all over the world can regularly meet to discuss the developments of their disciplines and present their work. Since 1995, Athens Institute has organized more than 400 international conferences and has published over 200 books. Academically, the institute is organized into 7 divisions and 37 units. Each unit organizes at least one annual conference and undertakes various small and large research projects.

For each of these events, the involvement of multiple parties is crucial. I would like to thank all the participants, the members of the organizing and academic committees, and most importantly the administration staff of the Athens Institute for putting this conference and its subsequent publications together.

Gregory T. Papanikos
President

Editors' Note

These abstracts provide a vital means to the dissemination of scholarly inquiry in the field of Chemistry. The breadth and depth of research approaches and topics represented in this book underscores the diversity of the conference.

Athens Institute's mission is to bring together academics from all corners of the world in order to engage with each other, brainstorm, exchange ideas, be inspired by one another, and once they are back in their institutions and countries to implement what they have acquired. The *14th Annual International Conference on Chemistry,* accomplished this goal by bringing together academics and scholars from 16 different countries (Brazil, Canada, China, France, Hong Kong, India, Ireland, Mexico, Poland, Russia, Slovenia, Taiwan, Türkiye, UK, Ukraine, USA), which brought in the conference the perspectives of many different country approaches and realities in the field.

Publishing this book can help that spirit of engaged scholarship continue into the future. With our joint efforts, the next editions of this conference will be even better. We hope that this abstract book as a whole will be both of interest and of value to the reading audience.

Evangelia Kotsikorou & Olga Gkounta
Editors

14th Annual International Conference on Chemistry, 20-24 July 2026, Athens, Greece

Organizing & Scientific Committee

All Athens Institute's conferences are organized by the Academic Council. This conference has been organized with the assistance of the following academic members of Athens Institute.

Dr. Gregory T. Papanikos, President, Athens Institute & Professor (Adjunct), University of Tennessee, Knoxville, USA.

Dr. Evangelia Kotsikorou, Deputy Head, Natural Sciences Unit, Athens Institute & Associate Professor, The University of Texas Rio Grande Valley, USA.

Dr. Haiduke Sarafian, Head, Natural Sciences Unit, Athens Institute & Professor of Physics and Endowed Chair of John T. and Paige S. Smith Professor of Science, Pennsylvania State University, USA.

Dr. Nikolaos Dimakis, Deputy Director, Sciences Division, Athens Institute & Professor and Chair, Department of Physics and Astronomy, University of Texas Rio Grande Valley, USA.

Dr. Bala Maheswaran, Director, Engineering Division, Athens Institute & Professor, Northeastern University, USA.

Dr. Ampalavanar Nanthakumar, Director, Sciences Division, Athens Institute & Professor, State University of New York (Oswego), USA.

Dr. Andriana Margariti, Head, Medicine Unit, ATINER & Professor, Queen's University Belfast, UK.

Dr. Adrian Ionescu, Head, Computer Science Unit, Athens Institute & Professor, Wagner College, USA.

FINAL CONFERENCE PROGRAM

14th Annual International Conference on Chemistry, 20-24 July 2026, Athens, Greece

PROGRAM

Monday 20 July 2026

08:30-09:15
Registration
09:15-10:00 Opening Speech and Welcoming Remarks
Speakers: Gregory T. Papanikos, President, Athens Institute & Professor (Adjunct), University of Tennessee, Knoxville, USA.

10:00-11:30 Session 1
Moderator: Nikolaos Dimakis, Deputy Director, Sciences Division, Athens Institute & Professor and Chair, Department of Physics and Astronomy, University of Texas Rio Grande Valley, USA.

1. **Julia P. Shaw**, Professor, SUNY Empire State University, USA.
   Title*: Cognitive Foundations of STEAM Education: Tables of Ordered Pairs.*
2. **Donnell Layne**, Director, STEM Innovation, Career and Technical Education, Moreno Valley College, USA.
   Adrienne Coleman, Director of Diversity, Equity and Inclusion, Illinois Mathematics and Science Academy, USA.
   Title*: iMAKE Innovation Center: The Utilization of Experiential Learning to Drive STEM Interest in Diverse Populations.*
3. **Tom Wanyama**, Associate Professor, McMaster University, Canada.
   Michele Vaz, Business Manager, McMaster University, Canada.
   Title*: Expanding Engineering Education through Outreach at the SEPT Learning Factory.*
4. **Yelena Istileulova**, Researcher, University of Ljubljana and Head of STEAM Session of the Socratic Lectures Symposium, Slovenia.
   Veronika Kralj-Iglič, Professor, University of Ljubljana, Slovenia.
   Title*: Future of STEAM: Z-STEAM Health Foresight through SMS (Stories based on Music about Science): Three Case Studies in Biophysical Learning.*

11:30-13:00 Session 2
Moderator: Yelena Istileulova, Researcher, University of Ljubljana and Head of STEAM Session of the Socratic Lectures Symposium, Slovenia.

1. **Nikolaos Dimakis**, Professor & Chair, Department of Physics and Astronomy, University of Texas Rio Grande Valley, USA.
   Title*: Vacancies as a Route to Exciton Engineering in 2D TMDs.*
2. **Adalberto Fazzio**, Professor, CNPEM – Brazilian Center for Research in Energy and Materials, Brazil.
   Title*: Vacancy-Driven Topology in Low-Dimensional Materials.*
3. **Patrick Navez**, Researcher, University of Montpellier, France.
   Title*: Can Electrons Be in Love with Each Other, Especially in High-Temperature Superconductivity?*
4. **Shiping Feng**, Professor, Beijing Normal University, China.
   Title*: Impurity-Scattering Assisted Umklapp Scattering as the Origin of Low-Temperature Resistivity in the Normal-State of Cuprate Superconductors.*

13:00-14:00 Session 3 – Symposium on "Science and Technology in the Age of AI"
Moderator: Bala Maheswaran, Director, Engineering Division, Athens Institute & Professor, Northeastern University, USA.

Speakers:
1. **Nikos Mourtos**, Head, Mechanical Engineering Unit, Athens Institute & Professor, San Jose State University USA.

Title: *AI in Science & Engineering Education: Navigating the Exciting and Dangerous Road Ahead.*

2. **Timothy M. Young**, Emeritus Professor, The University of Tennessee, USA & CEO and President, T.M. Young Institute, LLC, USA.
   Title: The Rapid Evolution of AI and Sustaining Human Intelligence.
3. **Kailash Narayan Pandey**, Professor, Motilal Nehru National Institute of Technology Allahabad, India.
   Title: Mechanical Engineering in the age of AI.
4. **Yelena Istileulova**, Researcher, University of Ljubljana and Head of STEAM Session of the Socratic Lectures Symposium, Slovenia.
   Title: Artificial Intelligence: from Historical Ideas to Modern Biophysics.

Interventions:

1. **Tom Wanyama**, Associate Professor, McMaster University, Canada.
2. **Andres Tremante**, Deputy Director, Engineering Division, Athens Institute & Professor, Florida International University, USA.
3. **Julia P. Shaw**, Professor, SUNY Empire State University, USA.
4. **Costa Karavas**, Assistant Professor, University Canada West, Canada.

14:00-14:30 Lunch

14:30-16:30 Session 4
Moderator: Nikos Mourtos, Head, Mechanical Engineering Unit, Athens Institute & Professor, San Jose State University USA.

1. **Assimina Pelegri**, Professor and Chair, Department of Mechanical and Aerospace Engineering, Rutgers, The State University of New Jersey, USA.
   Parameshwaran Pasupathy, Graduate Student, Rutgers, The State University of New Jersey, USA.
   Title: Deep Learning Surrogate Models for Brain White Matter Mechanics.
2. **Ching-Hwa Ho**, Distinguished Professor & Dean, College of Applied Sciences, National Taiwan University of Science and Technology, Taiwan.
   Title: Optical Band-Edge Properties of Multilayered MoTe2 and its Application in van der Waals-Stacked Heterojunction Devices.
3. **Bernard Liu,** Professor, National Cheng Kung University, Taiwan.
   Title: In Situ Atomic Force Microscopy for Real-Time Nanoscale Observation of Galvanic Corrosion in Liquid Environments.
4. **Andrii Pantus**, Professor, Ivano-Frankivsk National Medical University, Ukraine.
   Nataliia Kovalchuk, Associate Professor, Ivano-Frankivsk National Medical University, Ukraine.
   Title: Neuromorphic Gel-Like Architecture as a System for Encoding Photon Information.
5. **Iole Pecora**, Assistant Professor, San Jose State University, USA.
   Bilva Gummadi, Student, San Jose State University, USA.
   Sakhin Anooj Selvamani, Student, San Jose State University, USA.
   Title: Finite Element and Experimental Investigation of Plate Vibrations Using Chladni Techniques.

16:30-17:30 Session 5 – Meeting on the Athens Institute Undergraduate Physics Competition (AIUPC)

Presentation and Discussion

18:00-20:00 Session 6 – Visit Aristotle's Lyceum

This is not a guided tour, and participation in this visit is **not included in any conference registration fee**. **It requires pre-booking.** It includes visits to Aristotle's Lyceum, the Panathenaic Stadium (Kallimarmaro), the National Garden, the statues of Sophocles, Aeschylus, and Euripides, and Syntagma Square, where the tour concludes in front of the Hellenic Parliament. Click here for more details.

20:30-22:30 Athenian Early Evening Symposium (Sequence of Events: Ongoing Academic Discussions, Dinner, Wine and Water, Music, Dance)

Tuesday 21 July 2026

09:00-10:30 Session 7
Moderator: Bala Maheswaran, Director, Engineering Division, Athens Institute & Professor, Northeastern University, USA.

1. **Adalberto Fazzio**, Professor, CNPEM – Brazilian Center for Research in Energy and Materials, Brazil.
   Title: *Building Scientific Capacity for the 21st Century: A STEAM-Oriented Interdisciplinary Education Model at CNPEM.*
2. **Mairead Hourigan**, Associate Professor, Mary Immaculate College, Ireland.
   Anne Marie Morrin, Assistant Professor, Mary Immaculate College, University of Limerick, Ireland.
   Title: *Seeking, Exploring and Designing Shapes: Unpacking Synergies Between Mathematics and Visual Arts.*
3. **Anne Marie Morrin**, Assistant Professor, Mary Immaculate College, University of Limerick, Ireland.
   Title: *Studio Classroom: Cultivating Creative Inquiry, An A/R/Tographic, Arts Based Model for Art & STEM in an Initial Teacher Education Program.*
4. **Su-Hua Ho**, Associate Professor, National United University, Taiwan.
   Title: *Beyond Memorization: Integrating the 3SAI Immersive Teaching Methodology and Human Rights Education into Historical Thinking Courses to Fulfil University Social Responsibility.*

10:30-12:00 Session 8
Moderator: Patrick Navez, Researcher, University of Montpellier, France.

1. **Alejandro Ramirez-Rojas**, Professor & Researcher, Universidad Autónoma Metropolitana, Mexico.
   Title: *Fisher-Shannon Method Applied to Characterization of CO and O_3 Hourly Time Series in the Mexico City Metropolitan Area during the 2019-2023 Period.*
2. **Eleftherios Katelari Lambros**, Assistant Professor, California State University, Fullerton, USA.
   Title: *Solvent Effects on the Spin Dynamics of Radical Qubits.*
3. **Nina Sotina**, Senior Researcher (Retired), Lomonosov Moscow State University, Russia.
   Nadia Lvov, Associate Professor, Essex County College, USA.
   Title: *Causal Interpretation of Quantum Mechanics.*
4. **Roman Sverdlov**, Researcher, Strike Foundation, UK.
   Title: *Berezin Integral as a Limit of Riemann Sums.*

12:00-14:00 Session 9
Moderator: Nadia Lvov, Associate Professor, Essex County College, USA.

1. **Evangelia Kotsikorou**, Associate Professor, The University of Texas Rio Grande Valley, USA.
   Edgardo De Leon, PhD Student, The University of Texas Rio Grande Valley, USA.
   Title: *Chain Length–Dependent Allosteric Antagonism of the Androgen Receptor by Parabens: A Computational Study.*
2. **Dianjing Guo**, Associate Professor, The Chinese University of Hong Kong, Hong Kong.
   Title: *Role of AaWRKY14 in Linking AaHY5 and Artemisinin Biosynthesis Revealed by ChIP-Sequencing Technique.*

3. **Hamed Ghorbanpoor**, Lecturer, Eskişehir Osmangazi University, Türkiye.
   Title: *Hybrid Nanofiber Microfluidic Platform for Efficient Metal Ion Removal and Liver Cell Viability Evaluation.*
4. **Alicja Chromiec**, PhD Student, Jagiellonian University, Poland.
   Renata Wietecha-Posłuszny, Professor, Jagiellonian University, Poland.
   Title*: In-House Packed μ-SPE Columns as a Versatile Tool for the Extraction of Psychoactive Substances and their Metabolites from Biological Matrices.*
5. **Anna Bonczyk**, PhD Student, Jagiellonian University, Poland.
   Renata Wietecha-Posłuszny, Professor, Jagiellonian University, Poland.
   Title*: Electrochemical Sensor Dedicated to the Detection of Δ9 -THC in Saliva Samples for Forensic Purposes.*
6. **Maria Elena Campos Aldrete**, Professor, Instituto Politécnico Nacional (IPN), Mexico.
   Cristoper E. Ramirez Sandoval, Graduate Student, Instituto Politécnico Nacional (IPN), Mexico.
   Title*: From Traditional Medicine to Bioactive Hybrids: Agastache mexicana as a Source of Anti-Inflammatory Compounds.*

14:00-15:00 Lunch

16:45-20:30 Session 10
Old and New-An Educational Urban Walk

The urban walk ticket is not included as part of your registration fee. It includes transportation costs and the cost to enter the Parthenon and the other monuments on the Acropolis Hill. The urban walk tour includes the broader area of Athens. Among other sites, it includes: Zappion, Syntagma Square, Temple of Olympian Zeus, Ancient Roman Agora and on Acropolis Hill: the Propylaea, the Temple of Athena Nike, the Erechtheion, and the Parthenon. The program of the tour may be adjusted, if there is a need beyond our control. This is a private event organized by the Athens Institute exclusively for the conference participants.

21:00-23:00
Closing Remarks by Gregory T. Papanikos: "<u>Wine, Words, and Wisdom: An Ancient Athenian Dinner Symposium</u>" followed by an Ancient Athenian Dinner

Wednesday 22 July 2026
An Educational Visit to Selected Islands
or Nafplio & Mycenae Visit

Thursday 23 July 2026
Visiting the Oracle of Delphi

Friday 24 July 2026
Visiting the Ancient Corinth and Cape Sounion

Anna Bonczyk
PhD Student, Jagiellonian University, Poland
&
Renata Wietecha-Posłuszny
Professor, Jagiellonian University, Poland

Electrochemical Sensor Dedicated to the Detection of Δ9 - THC in Saliva Samples for Forensic Purposes

Cannabis, according to the European Union Drug Agency (EUDA), remains one of the most widely used illicit drug in Europe. Δ^9-tetrahydroxycannabinol (Δ^9-THC) is its main psychoactive component and it is known for its effects, including altered perception, increased anxiety, euphoria, cognitive and speech impairment, short-term memory loss, motor coordination disorder, and, in severe cases, psychosis and hallucinations. Cannabis is typically used for recreational purposes and has become a sociocultural phenomenon, most commonly consumed via smoking or through ingestion in food or beverages. Despite the recognition of medical properties of marihuana, its negative impact on psychomotor functions and the nervous system impairment causes a significant threat to health and life, particularly in contexts such as traffic safety and forensic cases. Consequently, there is a growing demand for fast, simple and portable tools for qualitative and semi-quantitative detection of Δ^9-THC in biological samples. Due to the non-invasive and simple nature of saliva collection, it is an attractive sample for presumptive tests dedicated to the detection of illicit substances.

Recent technological development offers the solution to these challenges through miniaturization, functionality and compliance with the principles of Green Analytical Chemistry, all combined in a simple and low-cost device, such as sensors.

The aim of the research was to develop the analytical method for the detection and determination of Δ^9-THC in saliva samples using an electrochemical sensor based on a hand-made screen-printed electrode (SPE), with Differential Pulse Voltammetry (DPV) as the detection technique. Optimization of the measurement conditions and key method parameters (pulse potential, modulation time, scan rate, concentration parameters) was performed using the One-Variable-At-Time (OVAT) approach and multi-factor (DoE) strategy. Comparison of the results obtained from both optimization methodologies enabled the selection of optimal measurement parameters and taking into account their possible interactions. The electrochemical behavior of Δ^9-THC on the SPEs was investigated, and the analytical performance of the method was

evaluated. The developed method presents a low limit of detection and quantification, as well as an appropriate linear range, precision and accuracy, allowing reliable quantification of samples relevant to forensic applications. Repeatability studies confirmed the method's stability under varying experimental conditions.

A suitable extraction method was selected for the analysis of saliva samples. The developed method was applied to the analysis of saliva samples containing Δ^9-THC using SPEs. The determined concentration values of Δ^9-THC corresponded to levels reported in the literature as detectable in screening tests. The practical utility of the developed method highlights its potential for on-site forensic screening.

Maria Elena Campos Aldrete
Professor, Instituto Politécnico Nacional (IPN), Mexico
&
Cristoper E. Ramirez Sandoval
Graduate Student, Instituto Politécnico Nacional (IPN), Mexico

From Traditional Medicine to Bioactive Hybrids: *Agastache mexicana* as a Source of Anti-Inflammatory Compounds

Agastache mexicana and *Cedronella mexicana*, also known as toronjil purple and white, is a herbaceous, perennial, very aromatic plant native to the valley of Mexico, whose traditional use is widely known from records in the Badiano codex, for its relaxing and anti-inflammatory properties, and antioxidants, among others. These pharmacological properties have been based on the detection of certain secondary metabolites, such as tilianine flavonoids, acacetin and triterpenoid ac. ursolic.

It is grown mainly in the states of Puebla Oaxaca and the State of Mexico, from where it is distributed and even exported abroad. The variation of content is depending on harvest area, date and weather changes. However, currently at CEPROBI (Biotics Product Development Center, of the IPN) it has achieved the standardization of this crop production. In temporary immersion bio reactors for propagation in culture bottles, which has allowed the content of the metabolites of interest to be standardized.

The present work has focused on the use of this biotic resource due to its pharmacological properties with the fusion of azaheterocycles. The use of computer tools made it possible to establish that structural fusion. The use of bioinformatics tools made it possible to establish the structural fusion of flavonoids, such as acacetin and azaheterocycles like the 2-amino-5-arylthiazole system, and led to the obtaining of optimized hybrids. The bioinformatics study of hybrid compounds, considering the cyclooxygenase 1 and 2 as a pharmacological target, established that these hybrids are promising molecules for the treatment of chronic diseases such as gastric inflammation. The synthesis was performed under current trends of sustainable chemistry and characterized spectroscopically.

Alicja Chromiec
PhD Student, Jagiellonian University, Poland
&
Renata Wietecha-Posłuszny
Professor, Jagiellonian University, Poland

In-House Packed μ-SPE Columns as a Versatile Tool for the Extraction of Psychoactive Substances and their Metabolites from Biological Matrices

The diversity of biological matrices used in toxicology, such as urine and vitreous humour (VH), requires flexible and accessible sample preparation strategies. This is particularly important for the determination of psychoactive substances and their metabolites, which often demands sensitive and reliable analytical methods.

This study presents a unified approach based on micro-solid phase extraction (μ-SPE) using in-house packed columns operated in a standard laboratory centrifuge. The proposed strategy eliminates the need for dedicated SPE manifolds, making it readily implementable in most laboratories. Miniaturisation of the procedure reduces not only sample volume requirements but also the consumption of solvents and reagents, contributing to a cost-efficient and more environmentally friendly workflow.

An important feature of the approach is the flexibility in sorbent design. The same extraction platform allows the use of both commercially available materials in modified form (like C18 discs) and custom-developed sorbents (like electrospun polystyrene fibres with nickel(II) oxide nanoparticles). This enables adaptation of the extraction system without changing the overall procedure or instrumentation.

The approach was evaluated for a group of psychoactive substances and their metabolites in urine and VH samples using μ-SPE coupled with LC-MS/MS. Despite the use of simple, laboratory-prepared columns, the developed methods demonstrated satisfactory precision, accuracy and sensitivity for toxicological applications.

The results confirm that centrifuge-based μ-SPE with in-house packed columns constitutes a versatile and practical alternative to conventional SPE procedures. The proposed platform combines analytical reliability with low cost, reduced environmental impact and high adaptability, enabling consistent analysis of psychoactive substances across different biological matrices using widely available laboratory equipment.

Nikolaos Dimakis
Professor & Chair, Department of Physics and Astronomy, University of Texas Rio Grande Valley, USA

Vacancies as a Route to Exciton Engineering in 2D TMDs

We employ advanced first-principles computational approaches to systematically explore how atomic-scale point defects modify the electronic and optical properties of monolayer transition metal dichalcogenides (TMDs), focusing on MoS_2, $MoSe_2$, and WSe_2. Due to their reduced dimensionality and weak dielectric screening, these atomically thin materials exhibit exceptionally strong Coulomb interactions between electrons and holes, giving rise to tightly bound excitons with large binding energies on the order of 0.5 eV. In their pristine form, these monolayers are direct-bandgap semiconductors with bandgaps close to 2 eV, making them highly attractive for applications in optoelectronics, photonics, and quantum technologies. To understand the impact of defects, we systematically investigate the removal of one or two sulfur atoms, generating several distinct vacancy configurations. These defects are modeled using supercells of increasing size to accurately capture defect–defect interactions, localization effects, and finite-size corrections. The electronic band structures are corrected using the many-body G_0W_0 approximation, which provides reliable quasiparticle energies beyond standard density functional theory. Excitonic effects, including both neutral and charged excitations, are explicitly treated by solving the Bethe–Salpeter equation, allowing us to account for electron–hole interactions that dominate the optical response of these systems. Our results demonstrate that sulfur vacancies introduce nearly flat, defect-induced electronic states within the pristine bandgap, leading to pronounced modifications of the optical spectra. These in-gap states act as localization centers for excitons, giving rise to defect-bound excitonic states that are spatially confined around the vacancy sites and energetically well separated from free excitons. The nature and energetic position of these excitonic states are found to depend sensitively on the type of vacancy and the defect concentration, providing a means to systematically tune the excitonic landscape. Overall, this study highlights the crucial role of atomic-scale defects as an effective tool for engineering the optoelectronic properties of two-dimensional TMDs. By carefully controlling the type and density of vacancies, it is possible to design localized excitonic states with tailored optical emission characteristics. These findings offer important insights for the development of next-generation quantum optoelectronic devices,

including single-photon emitters, nanoscale light sources, and defect-based quantum emitters operating in two-dimensional materials.

Adalberto Fazzio
Professor, CNPEM - Brazilian Center for Research in Energy and Materials, Brazil

Vacancy-Driven Topology in Low-Dimensional Materials

Recent advances in condensed matter physics have revealed that topology plays a central role in determining the electronic properties of materials. While topological phases are often associated with intrinsic band-structure characteristics driven by spin–orbit coupling and crystal symmetry, an emerging perspective highlights the decisive role of defects—particularly vacancies—as active agents in engineering topological states.

In this presentation, we discuss a comprehensive theoretical investigation of vacancy-driven topology in low-dimensional materials, based on first-principles calculations within the framework of density functional theory. We demonstrate that controlled introduction of atomic vacancies can fundamentally alter electronic band structures, induce band inversions, and promote the emergence of nontrivial topological phases. Rather than being treated merely as sources of disorder, vacancies are shown to act as tunable parameters capable of driving quantum phase transitions.

Our results reveal that vacancy ordering and concentration strongly influence electronic localization, magnetic moments, and symmetry breaking, leading to the stabilization of topologically protected states in systems that are otherwise topologically trivial. In particular, we show that defect-induced modifications in orbital hybridization and symmetry can generate Dirac-like dispersions and open topological band gaps under appropriate conditions. The interplay between structural relaxation, electronic reconstruction, and symmetry constraints is central to this mechanism.

Beyond fundamental interest, vacancy-driven topology provides a realistic pathway for material design. Defect engineering is experimentally accessible through irradiation, chemical substitution, or controlled growth conditions, making it a practical strategy for tailoring quantum properties. The ability to induce topological behavior via vacancy manipulation opens new opportunities for nanoelectronics, spintronics, and quantum devices, especially in two-dimensional and nanostructured systems.

The broader significance of this work lies in reframing defects from passive perturbations to active design elements in quantum materials. By combining predictive computational modeling with physically realizable

defect configurations, we provide a conceptual and methodological framework for exploring topology beyond ideal crystalline systems.

This contribution aims to stimulate interdisciplinary dialogue between condensed matter physics, materials science, and nanotechnology—aligning with the spirit of the classical symposium—by presenting defect engineering as a unifying concept connecting structure, symmetry, and topology in quantum materials.

Adalberto Fazzio
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Building Scientific Capacity for the 21st Century: A STEAM-Oriented Interdisciplinary Education Model at CNPEM

Nations increasingly face complex challenges — including the energy transition, advanced materials, artificial intelligence, climate change, and technological sovereignty. Addressing these problems requires scientists capable of working across disciplinary boundaries and translating knowledge into innovation. In Brazil, as in many countries, the traditional pathway to becoming an independent researcher is long and highly specialized, often delaying exposure to frontier research environments and the development of scientific autonomy. To address this gap, the National Center for Research in Energy and Materials (CNPEM) launched in 2022 a three-year interdisciplinary Bachelor's program in Science aligned with the principles of STEAM education (Science, Technology, Engineering, Arts and Mathematics). The program integrates education with direct exposure to cutting-edge research.

Ilum – School of Science operates within the CNPEM national laboratory campus, which hosts large-scale facilities such as synchrotron light sources and advanced laboratories, allowing students to interact with researchers and experience state-of-the-art scientific exploration. The program is guided by three objectives: (i) accelerate scientific maturity through early engagement with research; (ii) integrate disciplines by combining Life Sciences, Materials Science, Mathematics, Data Science and Humanities; (iii) strengthen innovation ecosystems by preparing graduates for academia, national laboratories and technology-based industries.

The curriculum emphasizes interdisciplinary courses, project-based learning, computational and AI training, and laboratory immersion. Each year, 40 students are admitted through Brazil's national high school examination followed by a selective interview process. With approximately 50 applicants per seat, the program has rapidly become one of the most competitive science undergraduate programs in Brazil.

Shiping Feng
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Impurity-Scattering Assisted Umklapp Scattering as the Origin of Low-Temperature Resistivity in the Normal-State of Cuprate Superconductors

The transport experiments reveal that the low-temperature resistivity in the normal-state of cuprate superconductors is quadratic in temperature (T-quadratic) in the underdoped pseudogap phase, while it is linear in temperature (T-linear) in the overdoped strange-metal phase, however, the full understanding of these different behaviours is still a challenging issue. Here starting from the microscopic electronic structure of cuprate superconductors, the low-temperature resistivity in the normal-state is investigated from the underdoped pseudogap phase to the overdoped strange-metal phase. It is shown that the mechanism requires both the impurity scattering and the umklapp scattering: the impurity scattering is needed to restrict the modification of the distribution function to at around the antinodal region, while the impurity-scattering assisted umklapp scattering from a spin excitation is at the heart of the behaviour in the low-temperature resistivity, where the doping dependence of the temperature scale exists, and presents a similar behavior of the antinodal spin pseudogap crossover temperature. In the low-temperature region above the temperature scale in the overdoped strange-metal phase, the resistivity is T-linear, however, in the low-temperature region below the temperature scale in the underdoped pseudogap phase, the opening of the spin pseudogap lowers the spin excitation density of states at around the antinodal region, which reduces the strength of the electron umklapp scattering from a spin excitation associated with the antinode, and thus leads to a T-quadratic behaviour of the resistivity.

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Hybrid Nanofiber Microfluidic Platform for Efficient Metal Ion Removal and Liver Cell Viability Evaluation

Heavy metal contamination in aquatic systems poses a significant hazard to environmental and human health, primarily through hepatotoxic and endothelial damage. This study aimed to design and evaluate electrospun thermoplastic polyurethane (TPU) nanofibers incorporated with titanium dioxide (TiO_2) nanoparticles integrating microfluidic remediation platform integrating for the selective and efficient removal of Cu^{2+} and Ni^{2+} ions from aqueous solutions, while also assessing its cytoprotective effects in a liver-mimetic co-culture model.

TPU/TiO_2 nanofibers membranes were produced by electrospinning and incorporated into a microfluidic chip to be used in continuous flow filtration at neutral pH. To determine the cytotoxicity and morphological changes in the treated and untreated water samples, the water samples were subjected to a co-culture of hepatocytes and endothelial cell lines.

The system was able to remove the Cu^{2+} (97.8%) and Ni^{2+} (96.2%) ions very effectively when incorporated in the microfluidic filtration unit, in just a few minutes. Cytotoxic effects and morphological deformation in the cells were significantly caused by exposure to untreated metal-containing solutions, as compared with cells exposed to the filtered effluents, which maintained more than 95% viability and presented morphologically normal cells-and confirms the highly

protective capacity of the device. The performance of TiO_2-enhanced electrospun nanofibers integrated into a microfluidic chip can be an efficient, scalable, and biocompatible method of real-time purification and toxicity-sensing of water. The system provides a small and sustainable means to handle decentralized remediation of water contaminated with heavy metals, which is a promising move towards bioengineered filtration systems in the next generation.

This study was supported by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) under grant numbers 20AG003, 20AG031, 222M468, 123E013 and 225S581. This work has been also supported by Health Institutes of Türkiye (TUSEB-32056) and Eskisehir Osmangazi University Scientific Research Projects Coordination Unit under grant numbers TOA-2022-2307, FOA-2025-3201, FYL-2025-3442, FYL-2025-3450, FYL-2025-3402, FYL-2025-3430.

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Role of AaWRKY14 in Linking AaHY5 and Artemisinin Biosynthesis Revealed by ChIP-Sequencing Technique

Artemisinin from Chinese herb *Artemisia annua* is the fastest-acting anti-*Plasmodium falciparum* malaria drugs among all drugs today, thus artemisinin combination therapy (ACT) is now the standard method for the treatment of *Plasmodium falciparum* malaria worldwide. However, despite its importance, the artemisinin abundance in *Artemisia annua* is too low (about 0.1-1.0% dry weight) to meet the increasing demands. *Artemisia annua* plants are still the main source for artemisinin production and thus a comprehensive understanding of artemisinin biosynthesis regulation is of great significance.

ChIP-seq (Chromatin immunoprecipitation with sequencing), is the gold standard for determining genome wide in vivo transcription factor binding sites, which is the first step for whole genome targets prediction and network construction. For non-model plant, it is difficult to impose ChIP-seq due to the difficulty in generating stable transgenic plant. AaHY5 is a positive regulator in artemisinin biosynthesis whose detailed mode of action remains elusive. Here, we established a protoplast transformation procedure for *Artemisia annua* and performed AaHY5 ChIP-seq using transient expression system. An AaHY5 target AaWRKY14 was found highly expressed in glandular trichome and can be induced by light and AaHY5. Furthermore, AaWRKY14 showed transcriptional activity on artemisinin biosynthetic gene CYP71AV1. Together, AaWRKY14 was identified as a potential transcription factor linking AaHY5 and the artemisinin biosynthetic gene regulation.

Ching-Hwa Ho
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Optical Band-Edge Properties of Multilayered MoTe2 and its Application in van der Waals-Stacked Heterojunction Devices

$MoTe_2$ distinguishes as a promising two-dimensional (2D) material in solar energy and optoelectronics applications due to its suitable bandgap value and the specific excitonic behaviors. However, its band edge and excitonic transitions are not yet explored clearly to date. In this paper, micro-thermoreflectance (μTR) spectroscopic result showed that multilayered (ML) 2H-$MoTe_2$ exhibits multiple excitonic features including A_{1s}, B_{1s}, A′, C, D, E, F, and G excitons as well as one indirect-gap related feature of E_g^{ind}-related peak presented in a 500-nm nanoflake at 300 K. Thickness-dependent micro-photoluminescence (μPL) measurement revealed that the PL emission is undetectable at t~40 nm (28L), while it is initially detected at approximately 20 nm (14L) at 0.944 eV, and finally it shifts to 1.042 eV and presents the highest PL intensity when its thickness decreases to 5 nm (4L). Density-function-theory (DFT) band-structure calculations revealed that monolayer $MoTe_2$ is a direct semiconductor with the highest bandgap whereas it will become lowered and finally converted to indirect band with t > 20L, matching well with the thickness-dependent μPL result. According to the DFT calculations, the band-edge excitons of A_{1s}, B_{1s}, A′, C, D, E, F, and G of μTR features in the ML $MoTe_2$ are successfully verified and assigned. A porotype of p-SnS/n-$MoTe_2$ stacking heterojunction device is fabricated. The built-in potential (V_{bi}) of the heterojunction diode is approximately 0.62 V, matching well with the measured work function difference between the two materials of the p-SnS/n-$MoTe_2$ heterojunction device.

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Beyond Memorization: Integrating the 3SAI Immersive Teaching Methodology and Human Rights Education into Historical Thinking Courses to Fulfil University Social Responsibility

History education in Taiwan has been widely critiqued for reinforcing linear, single-dimensional thinking, wherein students acquire isolated historical terminology without developing the interpretive or analytical capacities essential to critical citizenship. This study responds to this pedagogical gap by designing, implementing, and evaluating the 3SAI Immersive Teaching Methodology within a university-level "Historical Thinking" general education course at National United University — an institution serving both senior high school and vocational school graduates, with approximately 400 students enrolled annually.

Pre-course diagnostic data revealed that 78% of students perceived history as primarily a memorization exercise, while only 12% demonstrated the capacity to analyze the power structures underlying historical events, indicating a significant gap between surface-level knowledge acquisition and deeper historical consciousness. To address this, the 3SAI framework operationalizes five interconnected pedagogical dimensions: Story (narrative-driven emotional engagement), Subject (structural and institutional contextualization), Source (primary document analysis via a four-stage decoding model), Action Plan Design (immersive civic simulation activities), and Issue Understanding (human rights value construction and contemporary application). The framework is further integrated with the ARCS motivational model (Attention, Relevance, Confidence, Satisfaction) to scaffold progressive learner engagement from initial curiosity through analytical competence to public knowledge production.

The 18-week curriculum incorporates thematically sequenced human rights case studies spanning transitional justice, refugee crises, racial discrimination, colonial history, and gender rights, drawn from Taiwanese, German, American, and global contexts. Instructional strategies include role-play simulations, mock tribunals, historical drama performance, primary source decoding exercises, and collaborative media production through a student-generated "Human Rights Weekly Report." Learning outcomes are assessed via a competency-based system comprising source analysis assignments (20%), historical drama and

textual analysis (25%), the Human Rights Weekly Report (30%), classroom participation (15%), and peer and self-evaluation (10%). Pre- and post-course questionnaires serve as the primary instruments for measuring shifts in students' historical awareness, human rights sensitivity, and civic engagement motivation.

This study contributes to the scholarship of teaching and learning by proposing a replicable, evidence-informed pedagogical model that bridges historical thinking, human rights education, and University Social Responsibility (USR). The findings are expected to demonstrate that immersive, issue-centered instructional design can effectively transform students from passive recipients of historical knowledge into active, reflective, and socially engaged citizens — capable of connecting historical experience to contemporary human rights challenges and fulfilling the university's broader mission of humanistic education and community responsibility.

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Seeking, Exploring and Designing Shapes: Unpacking Synergies Between Mathematics and Visual Arts

STEAM education is an evolving area that is being explored and unpacked in education systems internationally. This presentation reports on the STEAM education journey of a mathematics teacher educator and a visual arts teacher educator as they engage in a process of collaborative self study to explore the possibilities for authentic STEAM education. In particular, rather than merely using the arts to promote communication of STEM knowledge, the STEAM teacher educators sought to engage in authentic integration of mathematics and the arts, with a concomitant focus on developing knowledge and dispositions in both the arts and STEM disciplines.

This presentation focuses on a particular project, that uses the geometric shapes and patterns that are created within Pascal's triangles as an initial stimulus to design and craft an original piece of art, with meaningful and authentic learning outcomes for both visual arts and mathematics education. The designs are developed and constructed based on rules rooted in the mathematical shapes and calculations discovered within Pascal’s triangle. Shapes and variations of shapes and patterns are identified, assigned a code, and used to form a uniquely designed tessellation. The overall design will emphasize the use of semi-regular and irregular shapes. Additionally, colour theory is applied to enhance the aesthetic quality of geometric shapes and further advance mathematical concepts.

This process of collaboration between the arts and STEM educator supports the promotion of a shared understanding of the possibilities for meaningful and authentic STEAM education within the Irish educational context as well as the design of high-quality STEAM education for initial teacher education and primary education that targets the development of sought after knowledge, skills, and dispositions.

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&
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Future of STEAM: Z-STEAM Health Foresight through SMS (Stories based on Music about Science): Three Case Studies in Biophysical Learning

This paper proposes the Z-STEAM (Z-Science, Technology, Engineering, Arts, Mathematics) approach as an interdisciplinary educational framework integrating Health Sciences, SMS (Stories based on Music about Science), biophysics, music composition, scientific storytelling, and foresight methodologies. The concept of "Z" derives from the Slovenian word *zdravje* (health), positioning health-oriented inquiry at the centre of the framework. The paper argues that the future of STEAM education will increasingly depend upon the integration of ancient systems of knowledge with emerging technologies, interdisciplinary artistic-scientific methodologies, and innovative approaches developed through the practices of the LKBF Z-STEAM Platform (lkbf.si/Z-STEAM).

Developed through artistic research and health-oriented educational practices, the paper investigates how future STEAM education may evolve through embodied, dialogical, and multisensory learning environments responsive to scientific, technological, and societal change. In this context, music operates not only as artistic expression, but also as a historical and cognitive medium reflecting memory, perception, social transformation, and anticipatory tendencies associated with SMS, biophysics, music composition, scientific storytelling, and foresight (Weak Signals and Wild Cards, Trends and Emerging Issues Analysis, Horizon Scanning Scenario) methodologies. The artistic research practices have been developed within the framework of the Socratic Lectures Symposium, through which Z-STEAM explores educational models connecting historical scientific thought with contemporary artistic and scientific practices.

The paper demonstrates the Z-STEAM framework through three interdisciplinary case studies developed by scientists and artists affiliated with the Z-STEAM Platform. The first case presents membrane-enclosed vesicles through a musical composition, with future possibilities for development toward choreographic interaction and

movement-based learning (immersive) practices. The second case examines the composition The First Open Reading Frame of SARS-CoV-2, performed by the Spectrum Quintet. The third case explores Lucretian atomism from De Rerum Natura

as an early philosophical model of scientific imagination whose understanding of matter continues to resonate within contemporary STEAM discourse and foresight-oriented educational thinking. This case further demonstrates how artistic-scientific methodologies may connect historical knowledge, Health Sciences, and future-oriented educational frameworks through embodied and interdisciplinary learning environments.

The project argues that the future of STEAM education depends not only on technological innovation, but also on historically informed, embodied, and foresight-responsive methodologies capable of integrating science, health, philosophy, music, and human experience into new interdisciplinary ecosystems of learning. In this sense, the future of STEAM is understood not as a departure from the past, but as a renewed integration of ancient knowledge, scientific imagination, artistic practice, and contemporary technologies within evolving educational environments.

Eleftherios Katelari Lambros
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Solvent Effects on the Spin Dynamics of Radical Qubits

Quantum computing is still very much in an early stage, where ultracold temperatures and highly specialized equipment are needed to make even simple quantum computers function. This is because qubits are very fragile; they encode information into the quantum state of an atom or molecule, and any sort of interference from heat, light, or the surrounding environment can collapse the qubit, effectively deleting any stored information. This makes it difficult to build quantum computers with a sufficient number of qubits while maintaining reliable performance. A certain class of molecules known as organic radicals may provide a solution to this problem. The advantage of these molecules over other molecules that have been used as qubits is that their stability can be controlled by systematically changing their molecular structure. These molecules do not exist in isolation, but in solution at room temperature, and unlike standard qubits, where their environment is detrimental to stability, these molecular qubits strongly interact with their surrounding environment. We examine the relationship between the solvent and the spin dynamics of these molecular qubits. In particular, the solvent effect on spin lifetimes and spin orbit coupling is examined.

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Chain Length–Dependent Allosteric Antagonism of the Androgen Receptor by Parabens: A Computational Study

The androgen receptor (AR) regulates signaling by endogenous androgens but this function can be disrupted by endocrine-disrupting chemicals. Parabens, widely used preservatives, inhibit AR signaling in cell-based assays, and recent protein-based studies indicate that this antagonism increases with alkyl chain length. Longer-chain parabens, such as heptylparaben, show stronger inhibitory effects than shorter-chain analogs such as methylparaben.

We hypothesized that chain length–dependent AR antagonism results from allosteric binding of parabens at the AR Binding Function 3 (BF-3) site, which destabilizes dihydrotestosterone (DHT) binding in the orthosteric ligand-binding pocket. To test this, we docked methylparaben and heptylparaben to antagonist-bound AR structures and performed molecular dynamics simulations of selected docked complexes.

Methylparaben did not remain stably bound at the BF-3 site, whereas heptylparaben formed persistent hydrophobic interactions that stabilized its binding. Heptylparaben binding disrupted hydrogen bonds that normally stabilize DHT and increased the orthosteric ligand-binding pocket volume. In contrast, an additional AR/heptylparaben complex where the molecule had different orientation in the BF-3 site failed to engage a key hydrophobic BF-3 subpocket and did not produce similar conformational changes. These results suggest that productive engagement of the BF-3 hydrophobic subpocket is critical for allosteric communication between the BF-3 site and the DHT-binding pocket.

We further evaluated DHT unbinding using random accelerated molecular dynamics to identify exit pathways and steered molecular dynamics to estimate unbinding energetics. DHT required less work to exit the binding pocket in the heptylparaben-bound system, consistent with reduced ligand stability. Combining exit frequencies with free-energy estimates identified the most probable DHT unbinding pathway.

Together, these results support a chain length–dependent allosteric mechanism in which longer paraben alkyl chains promote stable BF-3 binding, weaken DHT-stabilizing interactions, and facilitate DHT unbinding. This mechanism helps explain the greater AR inhibitory

potency of longer-chain parabens and highlights alkyl chain length as an important factor in assessing endocrine-disruption potential and may help design safer preservative alternatives.

Donnell Layne
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iMAKE Innovation Center: The Utilization of Experiential Learning to Drive STEM Interest in Diverse Populations

Persistent inequities continue to limit STEM participation and success for historically underrepresented and low-income learners. Moreno Valley College's HSI STEM & Articulation Project addresses this challenge through an experiential learning model anchored in the iMAKE Innovation Center—expanding makerspace-enabled applied learning, integrating VR/AR into historically challenging courses (including mathematics), strengthening data science/statistics/biology pathways with research and work-based learning connections, and using place-based/project-based learning to connect theory to real-world relevance.

This presentation shares findings from an external mixed-method evaluation conducted across Phase 1–2, including structured makerspace observations, stakeholder interviews (students, faculty, staff, and administrators), and an equity assessment to examine implementation quality, barriers, and early outcomes. Observations occurred near semester-end when typical iMAKE usage averages 287 unique users per month.

Evaluation results indicate strong progress toward project goals, including 72% achievement for iMAKE utilization/resources (13/18) and 90% for interview-based impact of experiential learning (54/60), with an overall STEM equity assessment average of 3.38/4 (85%) and an overall average score of 88% across measures. Reported course-level impacts included ~70% retention in courses with hands-on projects and 95% of surveyed students indicating they would have dropped without hands-on learning. A newly launched Data Science course (Fall 2024) enrolled 7 students and retained 6 (86%), attributed to iMAKE collaboration and applied research.

Participants will leave with an evaluation-informed, scalable framework and practical implementation guidance—including a roadmap for expanding makerspace-based AI desktop computing and machine learning instruction as the next phase of the model.

Bernard Liu
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In Situ Atomic Force Microscopy for Real-Time Nanoscale Observation of Galvanic Corrosion in Liquid Environments

Understanding galvanic corrosion at the nanoscale is essential for predicting material degradation and improving corrosion-resistant design, yet direct observation of corrosion processes under realistic liquid-phase conditions remains technically challenging. Conventional approaches often rely on ex situ characterization after corrosion has occurred, which obscures early-stage dynamics and introduces artifacts associated with drying, surface alteration, or post-treatment. In this study, we present an in situ, real-time atomic force microscopy (AFM) methodology that enables continuous monitoring of metal surface morphological evolution during electrochemical corrosion reactions in a liquid environment.

The core innovation of this approach lies in maintaining probe–sample positional stability during the transition from ambient to liquid-phase measurement. Instead of removing or lifting the AFM probe—an action that frequently causes lateral drift and loss of the original imaging area—the corrosive liquid is introduced directly during scanning. Combined with optimized AFM stage and scanner configuration, this strategy minimizes mechanical disturbance and ensures that the same surface region can be observed continuously throughout the corrosion process. As a result, nanoscale surface changes associated with the onset and progression of galvanic corrosion can be captured with both high spatial and temporal resolution.

Using this technique, we successfully observed early-stage corrosion phenomena that are typically inaccessible with conventional post-mortem methods. AFM topography images obtained in air establish the initial surface morphology, while subsequent imaging under liquid-phase corrosive conditions reveals progressive nanoscale alterations over time. Representative results demonstrate clear morphological differences after 20 minutes of exposure, including localized surface roughening and feature evolution attributable to galvanic interactions. These observations directly visualize corrosion-induced changes as they occur, providing valuable insight into dynamic surface processes.

Beyond topographical imaging, nanomechanical AFM measurements were incorporated to enhance sensitivity to surface responses during corrosion. Changes in local mechanical properties can precede or accompany visible morphological transformation, offering an

additional dimension for probing corrosion mechanisms at the nanoscale. Such multimodal data significantly enrich the interpretation of corrosion behavior and may help distinguish between different degradation pathways.

Furthermore, we discuss the potential of integrating machine learning techniques with in situ AFM datasets. Automated feature extraction, pattern recognition, and data-driven modeling could enable more objective analysis of complex surface evolution and facilitate the identification of subtle, time-dependent trends. In the long term, this integration may support predictive frameworks for corrosion behavior based on nanoscale observations.

Overall, this work demonstrates that liquid-phase in situ AFM is an effective and robust platform for investigating galvanic corrosion mechanisms in real time. By enabling continuous observation without probe repositioning, combining morphological and nanomechanical measurements, and exploring data-driven analysis strategies, this approach advances nanoscale corrosion characterization and lays the groundwork for future predictive corrosion studies.

Anne Marie Morrin
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Studio Classroom: Cultivating Creative Inquiry – An A/R/Tographic, Arts Based Model for Art & STEM in an Initial Teacher Education Program

This paper reports on the development and ongoing piloting of Studio Classroom: Cultivating Creative Inquiry, a pedagogical model for initial teacher education (ITE) in Art & STEM that has evolved over twenty years of studio-based teaching, practitioner reflection, and iterative stakeholder review. The model positions the classroom as an adaptive studio ecology in which creative inquiry emerges through dialogic making, collaborative critique, and authentic problem framing. Within the initial teacher education context, learning begins in the art studio, where exploratory engagement with materials and artistic inquiry catalyse the development of STEM concepts, connections, and ways of thinking.

Methodologically, the study integrates arts-based research (ABR) with a/r/tography, an arts-based praxis that interweaves the identities of artist, teacher and researcher (A/R/T). Within this orientation, a/r/tography understands inquiry as a *living, relational and rhizomatic process*: the artist enacts curiosity, material engagement and imaginative risk; the teacher cultivates inclusive, dialogic and process rich conditions; and the researcher traces emergent disciplinary and conceptual connections. Rather than operating as a linear sequence, the model embodies a way of being in Art & STEM education, where the artist's dispositions coexist with the teacher's pedagogical commitments and the researcher's analytic sensibilities.

Design-based research (DBR) guides the iterative refinement of the learning environment and integrates multiple data sources: (i) longitudinal practitioner observations and reflective analyses; (ii) a voluntary alumni survey exploring the perceived personal and professional impact of the studio elective; and (iii) an expert survey and workshop series with STEAM educators focused on creative pedagogy and effective STEAM practice. The framework was further refined through an arts-based making-plus-dialogue focus group in which participants collaboratively interrogated developing principles.

Through this process, the model articulates a constellation of mutually reinforcing roles, routines and pedagogical commitments that support the cultivation of creative inquiry, including curiosity driven

exploration, collaborative critique, material thinking, reflective practice and assessment for/through/as learning. Early implementation with a visual art elective cohort suggests enhanced learner agency, increased tolerance for ambiguity and a growing capacity for both problem finding and problem solving, indicating the framework's potential to support creative and critical thinking across STEAM contexts.

Adopting a post-structural, Deleuzian lens, the framework reads identity as multiplicity and practice as rhizomatic becoming. The paper contributes a theorised, practitioner-generated model and a set of actionable design principles that offer new insights for creative Art & STEM teacher education, programme design and pedagogical research.

Patrick Navez
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Can Electrons Be in Love with Each Other, Especially in High-Temperature Superconductivity?

Despite the repulsive Coulomb law and the Pauli statistics that do not favor bound states, attraction between electrons or holes is nevertheless possible in the context of many body interaction and of valley potential landscapes, reminiscent of exotic superconducting materials. In particular, in 1965, Kohn and Luttinger published a note revealing that the dynamical screening of the repulsive Coulomb interaction leads, under certain conditions, to an effective attraction necessary for the formation of Cooper pairs. We propose such a formalism adapted to the cuprates, where the screening arises from the superexchange dynamics of virtual holes in the oxygen orbitals of the CuO2 plane. Using an appropriate Schrieffer–Wolff transformation, the basic Hartree–Fock–Bogoliubov method, and the ab initio data on orbitals (energy, hopping, interaction), we derive some predictions for the temperature-doping phase diagram (pseudo-gap, strange metal, antiferromagnetism, superconducting, and normal states) and for the doping-dependent band energy spectrum in semi-quantitative agreement with observations.

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Neuromorphic Gel-Like Architecture as a System for Encoding Photon Information

Next-generation photonics envisages electronics without microcircuits, capable of processing optical signals and reorganising at the molecular level, mimicking the work of the brain's neural network. However, progress has so far been limited by the need for reversibly responsive materials that can respond to light and reconfigure quickly.

That is why the goal of our work was to create such a neuromorphic material and study its properties for processing and encoding photon information.

The non-flowing gel-like material we developed changed the profile of the laser beam when activated by a 532 nm wavelength laser. This change in the laser beam profile changed dynamically over time and formed a pattern or optical code unique to each section of the material. After conducting a series of tests, we concluded that the nature and frequency of changes in such an optical code depended on the frequency and duration of photonic activation, as well as the number and duration of relaxation periods. Thus, with a photonic activation time of 2 seconds and a 5-second pause (relaxation), the laser beam profile changed 68 times within 2 seconds in the time interval from 0 to 28 seconds. From 28 seconds to 01:05 minutes, the frequency of optical code changes ranged from 56 to 44 changes per 2 seconds. Analysis of the last time interval from 01:10 to 02:00 minutes showed the lowest frequency of laser beam profile changes, which was only 33.82–50% of the initial frequency. When the time between periods of material activation was reduced to 3 and 1 second, the frequency of change in the laser beam profile was the highest (68 changes per 2 seconds) during the entire 2-minute testing period. It should be noted that reducing the time between periods of photonic stimulation affected not only the frequency but also the nature of the change in the laser beam profile. A detailed analysis of the laser beam profile at all test times (2 seconds of activation at 5, 3 and 1 second relaxation) revealed a non-chaotic but cyclical and logical type of optical code rearrangement, which changed significantly every 12–30 seconds. Thus, in a series of tests with 5-second relaxation in the middle of each

30-second time cycle, the same type of code usually prevailed, with minor changes, which changed significantly in the next time cycle. However, with 1 and 3-second relaxation within each 12 and 20-second time cycle (with an 8-second activation cycle), up to 20 previous and new combinations of 272 optical codes were observed, which changed significantly in each subsequent time cycle.

The dynamic change in the laser beam profile, which forms the specified combination of previous and new optical codes within each subsequent time cycle, in our opinion, may be a sign of molecular changes in the material and indicate the formation of associative connections also at the molecular level, similar to the connections in the brain's neural network.

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Finite Element and Experimental Investigation of Plate Vibrations Using Chladni Techniques

Introducing students to the fundamentals of vibration and modal behavior can be challenging without engaging and intuitive methods. This study presents an approach to initially engage students in vibration concepts through the use of Chladni plates, which visually demonstrate mode shapes and resonance patterns. By exciting a plate at various frequencies, students can directly observe nodal lines and the formation of distinct geometric patterns, fostering a deeper conceptual understanding of vibrational phenomena.

To complement this hands-on experience, modal analysis is introduced as a theoretical framework for understanding natural frequencies, mode shapes, and system response. Furthermore, numerical simulation using ANSYS is incorporated to provide students with initial exposure to computational tools widely used in engineering practice. By comparing experimental Chladni patterns with simulation results, students gain insight into the relationship between physical behavior and numerical models.

This combined approach—integrating experimental visualization, theoretical analysis, and computational simulation—enhances student engagement and promotes a deeper understanding of vibration behavior, while also familiarizing students with industry-standard simulation tools.

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Deep Learning Surrogate Models for Brain White Matter Mechanics

Predicting the mechanical response of brain white matter (BWM), even in the limit of small strains is challenging owing to the inherent anisotropy of the three-dimensional microstructure and the various interactions between the heterogeneous structural components of brain tissue. Given the large number of simulations required to capture the wide variations in BWM geometry and microstructural properties—such as axon density, diameter, tortuosity, myelin content and its composition, the computational cost of traditional approaches for material characterization such as the finite element (FE) method can become prohibitive.

In this study, we aim to develop a surrogate deep learning neural network model for characterizing BWM mechanical response under specified quasi-static loading. The forward problem of predicting the evolution of stress for a given geometry—typically performed using FE modeling—is replaced by recurrent neural network (RNN) architectures that learn the structure–property relationship between BWM microstructure, material properties, and stress-strain behavior. Using a Sobol sequence for sampling the material-geometry feature hyperspace, we generate a diverse dataset of microstructure geometries comprising axon, myelin, and an extracellular matrix (ECM). We conduct a comparative evaluation of two prominent RNN architectures: (1) Long Short-Term Memory (LSTM) networks with separate input, output, and forget gates controlling an explicit memory cell, and (2) Gated Recurrent Unit (GRU) networks with a simplified gating mechanism that merges memory and hidden states. Both models are trained on identical datasets, with architecture-specific hyperparameter tuning. Comparative metrics include mean absolute percentage error (MAPE), computational cost per forward pass, and scalability to higher-resolution microstructures. Once trained, the optimal network significantly accelerates the prediction of stress-strain response. When integrated into an optimization workflow for estimating homogenized BWM properties, the selected RNN architecture permits rapid evaluation of forward predictions at a fraction

of the computational cost, enabling near-real-time estimation of BWM material properties.

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Fisher-Shannon Method Applied to Characterization of CO and O_3 Hourly Time Series in the Mexico City Metropolitan Area during the 2019-2023 Period

The main anthropogenic sources of air pollution in big cities are vehicular traffic and industrial activities. Secondary pollutants, such as tropospheric ozone (O_3), are produced from precursors like carbon monoxide (CO), as well as from meteorological factors, such as radiation. Considering that the lockdown period due to the pandemic was declared from March to October 2020 in Mexico, the onset of lockdown measures led to a significant reduction in industrial activity and vehicular traffic. Consequently, primary emissions were also reduced; however, ozone concentrations remained almost constant. In this study, we analyze CO and O_3 concentration time series monitored by the RAMA program between 2019 and 2023 in the southwestern Mexico City metropolitan area using the Fisher-Shannon (FIM-Nx) method and the network constructed for each series using the Visibility Graph (VG) method. The combined informational and topological analysis revealed different underlying structures. CO exhibited localized, intermittent emission patterns, leading to greater structural complexity. In contrast, O_3 displayed smoother, less organized variability. Additionally, temporal variation in FIM and NX provides a means to monitor the evolving statistical behavior of CO and O_3 time series. Finally, the Visibility Graph method shows a behavioral trend similar to that shown by the informational quantifiers, revealing a significant change in CO levels during the lockdown, though O_3 levels remained almost stable.

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Cognitive Foundations of STEAM Education: Tables of Ordered Pairs

One direction to explore in the future of Steam is the foundation of cognitive processes common to all modes of scientific thinking, with the assumption that students who succeed in one area of STEAM succeed in other areas. A premise here is that one common cognitive skill crossing all STEAM domains is the ability to organize relevant data into tables/matrices of ordered pairs.

1- **Level 1 Integration:** Students, in teams, first experience the value of tables of ordered pairs in exploration of each area of STEAM. **Age: Upper Elementary**

   a. **Science:** Replicate Galileo's Inclined Plane experiment creating a table recording time for four balls of different weights/sizes to traverse 1^{st} and 2^{nd} half of an inclined plane, concretely demonstrating concept of acceleration.
   b. **Technology**: Create process chart to plan a children's party, considering roles and activity sequences.
   c. **Engineering**: Relate gear ratios of interlocking input and output gears discovering relationships between speed and torque.
   d. **Arts**: Relate story plot sequence with key story characters to analyze characters' emotional shifts with plot progression.
   e. **Mathematics**: Determine probabilities for roles of 2 sided coins and 3 sided die, then chart results of actual roles.

2- **Level 2 Integration:** Students then view and analyze how organization into their five tables helped to solve a scientific problem. They see how organizing ordered pairs into tables facilitates solutions in each area. They then create a schedule of their school activities on a calendar.
Age: Upper Elementary/Middle School

3- **Level 3 Integration:** Students now applies the concept of tables of ordered pairs to new problems, such as graphing the time for two runners to complete a race. This demonstrates the transition –

transformation, perhaps – from the concrete exploration of scientific phenomena to the organization of those experiences into patterns that can be described by mathematics.
Age: Middle School or Beyond

Piaget well-established that the capacities for categorization, ranking, and sequencing of data are foundational cognitive skills that develop across childhood into early adulthood. Students make use of these interdisciplinary cognitive skills in increasingly complex ways when they create tables of ordered pairs in pursuit of answers to scientific questions. Effective use of tables indicates that they recognize that data can be categorized, ranked, and sequenced to create dimensional patterns in time and space.

Photos of students engaging in these tasks will be presented, and the audience will be encouraged to consider other foundational skills that cross interdisciplinary boundaries.

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Causal Interpretation of Quantum Mechanics

The causal interpretation of quantum mechanics differs from the probabilistic interpretation. According to the causal interpretation, classical notions such as the trajectory and position of a particle can be applied to quantum particles.

The causal interpretation is usually associated with the works of D. Bohm and de Broglie. In this work, we show that the reasoning underlying Bohm's model contains mathematical errors. Regarding de Broglie's hypothesis of a wave associated with a quantum particle, this idea appears to be in tension with modern concepts of the physical vacuum. A real wave, if it exists, must propagate in a material medium; in other words, it should correspond to a structure in such a medium. Note that the existence of spatially extended structures is not consistent with the theory of relativity. Attempts by de Broglie's collaborators to resolve this difficulty by introducing a subquantum medium were not fully developed. As a result, the causal interpretation of quantum mechanics has ceased to be a promising direction of research.

In this work, we propose modifications to the causal approach and obtain the following interesting results: (1) the Schrödinger equation is a necessary condition for the stability of electron motion in the hydrogen atom; (2) electron motion along Bohr orbits is stable; (3) the electron spin exhibits precession along these orbits; and (4) the energy of this precessional motion is described by the Rydberg formula for atomic spectra.

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Berezin Integral as a Limit of Riemann Sums

Properties of Berezin integral contradict what we know of Riemann integrals. Integrals of even functions are zero while integrals of odd functions are non-zero (while for Riemann integrals it's the other way around) and also integral of $e^{k\theta}$ is k rather than k^{-1}. Apart from this, it is also seemingly impossible for Riemann sum involving products of Grassmann numbers to ever return real or complex number. For that reason, it is conventionally assumed Grassmann numbers are just symbols, that don't exist outside of integration sign. This view, however, clashes with the notion of superspace where Grassmann numbers are used as coordinates. Conventional response to this might be that superspace itself is only symbolic and the observable results are devoid of it.

However, I am strongly opposed to this viewpoint. I would like to define Grassmann numbers as literal mathematical objects, its integral a literal Riemann sum and superspace as literal geometric space. I have written a joint paper with Thomas Scanlon where it was done *J. Math. Phys.* 61, 063505 (2020) https://doi.org/10.1063/1.5144877 which was also listed on his university website as BIRS-9May2020.pdf The key ideas of that paper are the following:

1) Instead of having two product signs (scalar product and anticommuting wedge product) we have three product signs: namely, we have Clifford product in addition to the above two and we define anticommuting product as antisymmetrization of Clifford product. In Berezin integration, we put Clifford product sign between infinitesimal part and finite part of the integral. This is how we enable a real or complex outcome. At the same time, we keep anticommuting wedge product within the finite part of the integral. Thus, definition of exponentiation and other similar "finite" operations remains untouched.
2) We view Grassmann numbers as vectors in a space with very large dimension D (Berezin integral will emerge in a limit of D approaching infinity). In that space, we either integrate over closed hypersurface that encloses volume 1/D (thus breaking scale invariance by specifying the volume) or integrating over volume but making the measure of integration decay further away from the origin (thus breaking scale invariance in this way).

Since integration of $e^{k\theta}$ being k^{-1} is the consequence of scale invariance, the fact that we break it implies we no longer have any reason to believe it is k^{-1} Thus, we find a way for it to be k in a way free of mathematical contradictions

3) dθ has a direction. In case of surface integral, its direction is borrowed from conventional multivariable calculus: it is orthogonal to the surface. In case of volume integral, we introduce a new notion of ``directed volume" with the direction pointing away from the origin. In both cases, the direction would make dθ an odd function. Thus, if f(θ) is even, dθ* f(θ) will be odd, and if f(θ) is odd, dθ* f(θ) will be even, which explains why integral of even function is zero and integral of odd function is non-zero.

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Expanding Engineering Education through Outreach at the SEPT Learning Factory

This paper presents a case study on the strategic deployment of the W. Booth School of Engineering Practice and Technology (SEPT) Learning Factory at McMaster University as a platform for community engagement, experiential learning, and the cultivation of socially conscious engineers. Traditionally, learning factories are designed as controlled environments where students simulate industrial practices, explore smart manufacturing, and apply Industry 4.0 principles. While these uses remain valuable, they often overlook the potential to connect technical education with pressing societal needs. The SEPT Learning Factory extends the conventional model by embedding outreach-driven product development into both curricular and co-curricular activities. In doing so, it demonstrates that technical training and community engagement can coexist as mutually reinforcing elements of engineering education.

Projects developed within the Learning Factory intentionally address authentic community challenges while building technical competencies. For example, students design and manufacture walking canes, which serve as exercises in user-centered design while also enhancing accessibility for underserved populations. Water filtration systems, created in collaboration with health initiatives in East Africa, provide practical experience in low-resource innovation and technology transfer. Similarly, the design of radio-controlled (RC) cars for high school STEM outreach allows students to apply mechatronics and systems integration while also practicing leadership, mentorship, and science communication. Collectively, these initiatives highlight the versatility of the Learning Factory as a site for both technical mastery and civic engagement.

The model is anchored in experiential, situated, and transformational learning theories. Students learn by doing, reflecting, and iterating; they gain knowledge in authentic contexts shaped by community needs; and they develop broader ethical and professional perspectives as their assumptions about engineering are challenged. The approach fosters social cohesion, motivation, persistence, and deeper

technical learning, while simultaneously strengthening teamwork, communication, problem solving, innovation, and professional identity. In this way, the Learning Factory helps students cultivate both technical expertise and civic responsibility.

This outreach-centered pedagogy also aligns with global imperatives such as the UN Sustainable Development Goals and the competencies demanded by Industry 4.0. Engineers today must design smart, interconnected systems that are not only efficient but also equitable and inclusive. The SEPT Learning Factory prepares students for this hybrid skill set by merging digital fluency with social awareness. Its role in international collaborations—such as the Learning Factories World-Wide (FWW) project under the International Association of Learning Factories—further demonstrates the scalability of this model across diverse contexts, including institutions in the Global South.

In conclusion, the SEPT Learning Factory illustrates how outreach-driven product development can serve as both a pedagogical innovation and a mechanism for social impact. By integrating technical excellence with empathy, ethical reasoning, and interdisciplinary collaboration, the model produces graduates who are not only technically proficient but also deeply aware of the societal contexts in which engineering solutions operate.

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