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Invited and Keynote Speakers

Applications of AI for Personalised and Patient-Centred Healthcare

Prof. Maia Angelova

Sir Peter Rigby Digital Futures Institute, Aston University, Birmingham, UK

Abstract

Artificial Intelligence (AI) is rapidly becoming part of our lives. It has the potential to transform healthcare for people's benefit by enhancing the provision of personalised and precision healthcare, and the efficiency of its operational power and management. For example AI can enhance significantly the efficiency of the hospital systems, including doctor's appointments, operating rooms efficiency, providing information to patients, as well as early diagnosis of disease, prevention and management of chronic conditions such as diabetes, chronic back pain, cardiovascular disease, depression and others.

In this talk, I will give a short overview of our latest work, including Generative and Agentic AI, and discuss the benefits of using AI in healthcare and some of the issues associated with its ethical use. I will illustrate the applications of AI with case studies from our research, focusing on personalised approach to health conditions, such as insomnia, and patient-centred management of chronic conditions, such as diabetes, chronic back pain and cardiovascular disease.

Curriculum Vitae

Prof. Maia Angelova is a data scientist, applied mathematician and mathematical physicist. She has significant contributions to the area of data-driven models in healthcare, medicine and decision making. She joined Sir Peter Rigby Digital Futures Institute at Aston University in November 2023 as Professor and Programme Director of Artificial Intelligence in Health. Professor Angelova's research is interdisciplinary and multidisciplinary at the boundary between theory and application. Her expertise involves advanced data analytics, machine and deep learning, generative and agentic AI, mathematical modelling, dynamical systems, time series analysis, symmetry, and applications of artificial intelligence to complex systems in health, physiology, medicine, finance, defence and sport. Professor Angelova's long term research programme is in Precision Healthcare. She has strong research interests and track record in modelling of sleep and insomnia, diabetes, mental health, chronic back pain, individual and team performance of athletes, decision making for defence and finance. She has published over 200 papers in peer reviewed journals and conferences which have attracted a lot of interests from different domains. She has attracted over £7 Million research funding from the EPSRC, MRC, Innovate UK, Australian NHMRC, the European Commission and the Australian Defence. Professor Angelova has supervised more than 30 postdoctoral research fellows and PhD students. She has a significant experience in leading large and complex research projects.

Small Vessel Disease: Recent Advances and Future Directions

Prof. Evguenia Vassileva

University Hospital "Tsaritsa Yoanna – ISUL", Sofia, Bulgaria
Medical University of Sofia, Sofia, Bulgaria

Abstract

Cerebral small vessel disease (CSVD) represents a heterogeneous group of pathological processes affecting the brain's small arteries, arterioles, capillaries and venules, and is a leading cause of stroke, cognitive impairment, gait disturbances and vascular dementia. Over the past decade, significant advances in neuroimaging, molecular biology and vascular neuroscience have substantially improved our understanding of the underlying mechanisms of cerebral small vessel disease. Recent evidence highlights the central role of endothelial dysfunction, blood–brain barrier disruption, neuroinflammation, impaired cerebral autoregulation and glymphatic system dysfunction in disease initiation and progression. Advanced magnetic resonance imaging techniques, including diffusion tensor imaging, susceptibility-weighted imaging and ultra-high-field MRI, have enhanced the detection of both overt and subtle manifestations of CSVD, enabling earlier diagnosis and improved disease characterization. Recent research has also identified novel circulating and imaging biomarkers that may facilitate risk stratification, disease monitoring and therapeutic response assessment. Despite these advances, effective disease-modifying therapies remain limited, with current management focusing primarily on vascular risk factor control and secondary stroke prevention. Ongoing investigations are focused on endothelial-targeted therapies, anti-inflammatory strategies and neuroprotective agents.

Curriculum Vitae

Professor Evguenia Vassileva is a neurologist and Head of the Clinic for Intensive Treatment of Neurological Diseases at University Hospital "Tsaritsa Yoanna – ISUL" in Sofia, Bulgaria. She is also Head of the Department of Neurology at the Medical University of Sofia. She graduated in Medicine from the Medical University of Pleven in 1986 and joined the Clinic of Neurology at University Hospital "Tsaritsa Yoanna – ISUL" in 1990. She became Associate Professor in 2007 and Professor of Neurology in 2015.

Prof. Vassileva obtained her PhD in 2000 with research on transcranial Doppler monitoring of microembolic signals in patients with internal carotid artery atherosclerosis. In 2014, she was awarded the degree of Doctor of Medical Sciences for her research on the application of neurosonology in carotid atherosclerosis and ischemic stroke. Her postgraduate training includes specializations in neurosonology at Geneva

University Hospitals, in neurology at Pitié-Salpêtrière University Hospital in Paris, and in cerebrovascular diseases within the European Stroke Summer School in Helsinki. Her principal clinical and research interests include neurosonology, cerebrovascular disease, carotid atherosclerosis, ischemic stroke and intensive care in acute and life-threatening neurological conditions.

Prof. Vassileva has published extensively in the fields of neurosonology, cerebrovascular disease and clinical neurology, with contributions to Bulgarian and international scientific literature. She is also the author of monographic works in her field.

Responsible AI in Chest Diseases: From Innovation to Trustworthy Clinical Decision-Making

Dr Shereen Fouad

Aston University, Birmingham, UK

Abstract

Chest imaging offers major opportunities for clinical AI, but high benchmark accuracy alone does not ensure safe use in practice. This keynote explores responsible AI across pneumonia, COVID-19, and lung cancer, arguing that trustworthiness rests on three conditions: robust performance testing under real-world image variation; explainability designed with clinicians and embedded in workflow; and governance spanning regulatory alignment, lifecycle monitoring and an AI-literate workforce. Drawing on work in explainable AI and medical imaging with NHS partners, the talk examines equity, accountability and meaningful human oversight. Its central message is that trustworthy clinical AI is built through evidence, co-design and workforce capability and not accuracy figures alone.

Curriculum Vitae

Dr Shereen Fouad is a Senior Lecturer in Applied AI and Robotics at Aston University, where she leads the MSc AI for Health programme and serves as Healthcare and Partnerships Lead at the Aston Centre for Applied AI and Robotics. Her research spans medical imaging analysis, explainable AI and responsible AI adoption in healthcare, delivered through long-standing collaborations with NHS trusts. She is an expert member of the British Standards Institution and ISO, contributing to standards for AI in medical devices and post-market surveillance, and a Senior Fellow of the Higher Education Academy.

Beyond Traditional Entropy Biomarkers for Physiological Signals

Assoc. Prof. Dr Chandan Karmakar

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Abstract

Entropy-based measures, rooted in Kolmogorov–Sinai entropy, provide valuable tools for characterising the complexity and nonlinear dynamics of physiological time-series signals. However, conventional entropy measures are highly dependent on user-defined parameters, particularly the tolerance parameter, which can lead to inconsistent and potentially unreliable estimates. To address this limitation, we developed a data-driven entropy profiling approach that systematically quantifies entropy across the full range of tolerance values. Rather than representing a physiological signal by a single entropy value, the approach generates an enhanced entropy profile that captures the underlying complexity across different tolerance levels. This reduces dependence on parameter selection while enabling the extraction of secondary entropy descriptors from the profile. The proposed framework has been evaluated across diverse physiological signals and diagnostic scenarios, demonstrating its potential for robust nonlinear biomarker extraction and improved physiological characterisation.

Curriculum Vitae

Associate Professor Chandan Karmakar is a researcher in the School of Information Technology at Deakin University, Australia. He specialises in artificial intelligence, biomedical signal processing and digital health. His research focuses on the analysis of physiological time-series data and the development of machine-learning methods for health monitoring, clinical decision support and wearable technologies. His broader interests include pattern recognition, smart sensors, the Internet of Medical Things, data analytics and privacy-preserving health technologies.

He received his PhD from the University of Melbourne, Australia, where his doctoral research was in biomedical signal processing. He subsequently worked as a postdoctoral research fellow at the University of Melbourne before joining Deakin University as an Alfred Deakin Postdoctoral Research Fellow. At Deakin, he progressed through research and academic appointments, becoming Lecturer in 2018, Senior Lecturer in 2021 and Associate Professor in 2024.

His interdisciplinary research applies artificial intelligence and advanced signal-processing techniques to a wide range of biomedical and healthcare challenges, including electrocardiographic and electroencephalographic signal analysis, cardiovascular monitoring, sleep disorders, epilepsy, depression, diabetes and physiological fatigue. He has contributed extensively to international scientific literature, including more than 200 research articles.

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Session

Artificial Intelligence in Biology and Medicine

Quality of Collaboration: A Formal Metric for Human–AI Teaming in Medical Decision Support

Ioannis Patias

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Abstract: Human-AI teaming is rapidly emerging as a central paradigm in high-stakes domains such as healthcare, yet the field lacks a unified and operationalizable definition of teaming quality. Existing evaluations tend to focus on task performance alone, overlooking the interaction processes and human experience factors that shape real-world effectiveness. This paper introduces Quality of Human–AI Teaming (QoT), a mathematically grounded, multi-dimensional construct designed to capture the performance, coordination, and experiential aspects of human-AI collaboration. We formalize QoT as a composite function over three normalized components: task performance P(T), teaming process quality C(A), and human experience H(E), combined through interpretable weighting schemes informed by theory and domain constraints. We demonstrate the applicability of this framework through a medical decision-support use case, where clinicians collaborate with an AI diagnostic assistant under varying levels of AI reliability and transparency. Using controlled experimental scenarios, we show that QoT distinguishes between similar performance outcomes by recognizing differences in coordination efficiency, trust calibration, and cognitive workload. The framework also exhibits sensitivity to system-level manipulations, supporting its use for evaluating design interventions and guiding iterative development. By providing a formal, extensible, and empirically grounded metric, this work contributes a foundational tool for the systematic study of human-AI teaming and offers a pathway toward more accountable and human-centered AI systems in clinical practice.

Keywords: Human–AI teaming, Teaming quality, Medical decision support, Human factors, Evaluation methodology.

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Future Doctors, Future Machines: How Medical Students Weigh the Role of AI

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Abstract: Artificial Intelligence (AI) is rapidly transforming the landscape of healthcare, offering new opportunities for diagnosis, therapy selection, and patient care. As future medical professionals, medical students' perceptions of AI are critical in shaping its integration into clinical practice. This study investigates medical students' attitudes toward AI in medicine through a structured questionnaire comprising twelve statements rated on a five-point Likert scale. The results reveal a strong optimism regarding AI's potential to positively change medicine, find useful applications, and improve diagnostic accuracy. Respondents also expressed confidence in AI's role in enhancing therapy selection and patient care, though a significant proportion remained undecided, reflecting ongoing uncertainty. Concerns emerged around the potential reduction of medical staff jobs, the dehumanization of medicine, and negative effects on doctor–patient relationships and autonomy. Ethical considerations were a dominant theme, with broad consensus that AI will introduce new challenges requiring careful navigation.

Overall, the findings highlight a dual perspective: enthusiasm for AI's technological promise coupled with caution about its ethical and humanistic implications. These insights underscore the importance of incorporating AI literacy, ethical reflection, and patient-centered values into medical education. Preparing future physicians to critically engage with AI will be essential to ensure that technological innovation complements, rather than compromises, the human dimensions of healthcare.

Keywords: Artificial Intelligence in medicine, Medical education, Student perceptions, Ethics in healthcare, Doctor–patient relationship.

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Operationalizing XAI: A NIST AI RMF-Aligned Evaluation Methodology for Model-Based Systems

Ioannis Patias

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Abstract: Artificial intelligence systems increasingly influence high-stakes decisions, yet existing evaluation practices often treat explainability (model-level transparency) and explicability (system-level justification and communication) as separate or loosely defined concepts. This fragmentation limits the ability of organizations to assess whether AI systems are not only technically interpretable but also governable, trustworthy, and aligned with emerging regulatory expectations. The scientific question guiding this paper is therefore: How can explainability and explicability be jointly operationalized into a coherent, standards-aligned methodology for evaluating model-based AI systems? To address this question, the paper proposes a unified evaluation methodology grounded in the NIST Artificial Intelligence Risk Management Framework (AI RMF 1.0). The approach systematically maps explainability and explicability requirements onto the four NIST core functions (GOVERN, MAP, MEASURE, and MANAGE) thereby transforming abstract principles into actionable assessment steps. At the model level, the methodology specifies how to identify explanation needs, select appropriate XAI techniques, and evaluate explanation quality using fidelity, stability, comprehensibility, and actionability metrics. At the system level, it introduces explicability criteria related to documentation completeness, transparency, accountability structures, user-facing communication, and stakeholder understanding. The resulting methodology provides a structured, repeatable process for evaluating AI systems across their lifecycle, integrating technical interpretability with governance and risk management practices. By aligning explainability and explicability with a widely adopted standard, the paper contributes a practical tool for researchers, practitioners, and regulators seeking to operationalize trustworthy AI.

Keywords: Explainability, Explicability, AI risk management framework (NIST AI RMF), Evaluation methodology, Trustworthy AI.

Acknowledgements: The author gratefully acknowledges the support provided by the project UNITe BG16RFPR002-1.014-0004 funded by PRIDST.

From Spatiotemporal Data Streams to Cognitive Insights: A Semantic Agentic Framework for Multimodal Environmental Intelligence

Miroslav Markov [1], Todor Ganchev [1,2], Valentina Markova [1,2], Aleksandar Dimitrov [2], Evdokia Sotirova [2], Sotir Sotirov [2]

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Abstract: Environmental monitoring systems face challenges related to heterogeneous data sources, the absence of real-time semantic context, and the difficulty of transforming raw telemetry into actionable decision support. This paper presents a novel agentic framework that converts multimodal spatiotemporal data streams into high-level cognitive insights for intelligent environmental monitoring and governance. The proposed architecture employs a decentralized multi-agent system orchestrated through Apache Kafka to ingest, harmonise, and semantically align heterogeneous environmental observations, including water temperature and wind speed measurements. The processed data are integrated into a unified Neo4j Knowledge Graph serving as a persistent environmental memory. A key contribution is the integration of semantic knowledge representation with an autonomous cognitive layer and a human-oriented interaction interface powered by Large Language Models (LLMs). Specialised agents perform spatiotemporal alignment, semantic mapping, and contextual reasoning, enabling synchronisation of disparate data sources into a coherent machine-interpretable environmental representation. To support autonomous decision assistance, a Reporting Agent continuously queries the knowledge graph and generates human-readable advisories and situational reports, enabling proactive environmental reasoning and intelligent situational awareness. Experimental evaluation in a simulated marine monitoring scenario aligned with Burgas Bay demonstrates the framework's ability to perform autonomous datadriven reasoning and generate real-time environmental advisories. The results validate the effectiveness of the proposed approach in bridging raw sensor streams and cognitive environmental intelligence

Keywords: Knowledge graphs, Large language models (LLM), Environmental intelligence, Multi-agent systems.

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AI-Ready Framework for Water Quality Monitoring in Bulgaria: Proof-of-Concept in the Burgas Region

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Abstract: The integration of environmental monitoring into medical and public health Decision Support Systems (DSS) is fundamentally constrained by challenges of data interoperability and accessibility. While municipal drinking water quality is a critical determinant of population health, local monitoring data are frequently disseminated in unstructured, machine-unreadable formats, such as static PDF documents. These bureaucratic data silos inherently resist algorithmic extraction, longitudinal epidemiological tracking, and the application of predictive artificial intelligence (AI) models. To bridge this gap, this paper presents a proof-of-concept automated data engineering pipeline and Spatial Decision Support System (SDSS) utilising 2025 regional water utility data from Burgas, Bulgaria.

Our methodology directly addresses the data fragmentation challenge by programmatically extracting, standardising, and geocoding 54 distinct physicochemical and microbiological indicators from municipal reports. We implement rigorous preprocessing protocols to resolve typographical ambiguities and standardise censored data (e.g., limits of detection), transforming raw administrative inputs into computationally reliable arrays. Furthermore, we address data privacy and ethics by deploying automated filters to actively exclude personally identifiable information (PII) linked to private residential sampling nodes, preserving the utility of public monitoring without compromising individual privacy.

The resulting structured, FAIR-compliant database powers an interactive geospatial dashboard, enabling the rapid visual assessment of parameters such as free residual chlorine and potential pathogenic risks. By transforming static reports into AI-ready, high-fidelity datasets, this framework demonstrates a scalable informatics approach to democratising environmental data, supporting regulatory compliance with newly amended national directives, and enabling proactive, evidence-based public health interventions.

Keywords: Artificial Intelligence in medicine, Medical education, Student perceptions, Ethics in healthcare, Doctor–patient relationship.

Acknowledgements: This work is supported by the European Union through the Program "Research, Innovation and Digitalization for Smart Transformation 2021 – 2027", project Center of Competence "Blue Coastal Marine and Riverine Innovative & Sustainable Management of Environments and Resources (Blue Cristal)", contract #BG16RFPR002-1.014-0016-C01.

A Survey on the Bulgarian Segment of the Danube River

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Abstract: In the present paper, we consider the open data provided by the Executive Agency for Exploration and Maintenance of the Danube River, in particular, water level, river discharge, and temperature, for three selected locations on Danube River – Novo selo, Svishtov, and Silistra. Firstly, we analyse original data available, then intercriteria analysis approach is applied aiming at revealing possible relationships between the investigated parameters.

Keywords: Water monitoring, Bulgarian segment of Danube river, Correlation analysis, InterCriteria Analysis.

Acknowledgements: PV and TP thank the Bulgarian Ministry of Education and Science for the support provided via the Research Infrastructure for Advanced Studies of Biomolecules, Biomembranes and Biosignals (BioMMS) D01-279 from December 17, 2025, part of the Bulgarian National Roadmap for Scientific Infrastructures 2020–2027.

Intuitionistic Fuzzy Reliability Evaluation of Classification CNNs in Medical Diagnostics

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Abstract: This paper examines the fundamental limitations of conventional evaluation metrics, particularly discrete accuracy and the loss function, when assessing convolutional neural networks (CNNs) for medical image classification. While accuracy reduces the final decision to a binary match or mismatch, it ignores the probability distribution of the output and provides no explicit mechanism for representing algorithmic uncertainty. The loss function, although probabilistic, compresses prediction behavior into a global scalar and therefore does not adequately reflect the reliability of individual classifications.

To address these limitations, the paper proposes a formal evaluation framework based on intuitionistic fuzzy logic (IFL), introduced by Krassimir Atanassov. By defining threshold values for algorithmic confidence, CNN outputs are transformed into the three core parameters of the intuitionistic fuzzy setting: degree of membership (μ), non-membership (ν), and uncertainty (π). This enables the filtering of stochastic matches, the identification of high-confidence errors, and the formal introduction of a state of abstention in safety-critical diagnostic settings. The framework is further extended through the application of Atanassov's topological operators. At the macro level, these operators act as expert-defined risk-tolerance controls for adjusting the model's evaluation profile. At the micro level, coupling the local prediction probability to the operator parameters transforms the methodology into an instance-specific Clinical Decision Support System (CDSS) for diagnostic filtering. Finally, by aggregating local evaluations into a global Intuitionistic Fuzzy Set and applying the fundamental modal operators, the framework determines the theoretical lower and upper bounds of the model's clinical viability.

The proposed methodology provides a more informative and reliable basis for the comparative analysis and safety-oriented deployment of classification architectures in biomedical applications than conventional discrete evaluation alone.

Keywords: Convolutional neural network (CNN), Intuitionistic fuzzy logic (IFL), Medical image classification, Algorithmic reliability, Diagnostic uncertainty, Topological operators, Clinical decision support system (CDSS).

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Application of Intuitionistic Fuzzy Sets to Estimate Spatial Indeterminacy in Convolutional Neural Networks for Imaging Diagnostics

Daniel Stoyanov, Sotir Sotirov, Vladimir Kornovski

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Abstract: The present work investigates the methodological limitations of conventional convolutional neural networks (CNN) in medical image segmentation, with a focus on the diagnosis of aortic pathologies. The problem lies in the fact that standard probabilistic outputs (Softmax/Sigmoid) often generate computational overconfidence, ignoring the indeterminacy arising from the effect of image blurring. A new approach is proposed for quantitative assessment of spatial indeterminacy using the Intuitionistic Fuzzy Sets (IFS) apparatus, introduced by K. Atanassov. By applying intuitionistic fuzzy logic, probabilistic predictions are transformed into three key parameters: degree of membership (μ), non-membership (ν) and indeterminacy (π). The model introduces significance thresholds analogous to the filtering functions proposed by Sotirov et al., which allows the model to account for the hardware limitations of the scanner. Practical testing of the model on a real CT image proves its applicability. The results show that the proposed methodology successfully calculates and isolates areas with unclear boundaries, thus effectively protecting the diagnostic algorithm from categoricality.

Keywords: Intuitionistic fuzzy logic (IFL), Convolutional neural networks (CNN), Spatial indeterminacy, Imaging diagnostics, Aortic pathologies, Hardware tolerance, Partial volume averaging effect.

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Uncertainty-Aware Risk Assessment for Type 2 Diabetes Using Intuitionistic Fuzzy Sets

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Abstract: This report presents a computational approach for assessing the risk of developing type 2 diabetes, applying intuitionistic fuzzy set theory (IFS), developed by Krasimir Atanassov to overcome the limitations of conventional diagnostic systems in processing conflicting clinical data. The study analyzes a large-scale dataset of 100 000 patient records using three biomedical indicators: fasting blood glucose, glycated hemoglobin and body mass index. The algorithm developed in the MATLAB programming environment evaluates each indicator independently against medical thresholds to compute objective degrees of membership, non-membership, and intuitionistic uncertainty (π).To enable modeling, the study introduces a multidimensional cohort aggregation framework utilizing five fundamental algebraic and modal IFS operators [15, 16]. The results mathematically isolate a critical "vulnerability zone" (ranging from a guaranteed risk baseline degree of 0.3873 to a theoretical maximum of 0.7010), successfully quantifying latent borderline conditions. The proposed approach defines an algorithmic space for avoiding premature categorical classification, ensuring precise medical triage and establishing a robust conceptual foundation for expert systems in high-risk environments.

Keywords: Intuitionistic fuzzy sets, Type 2 diabetes, Risk assessment.

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Session

Bioinformatics and Computational Biology

A Dual-Partition Ensemble Deep Learning Model for Chlorophyll Forecasting in Non-Stationary Environments

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Abstract: Accurate forecasting of chlorophyll-a concentrations is critical for the early detection of algal blooms and the effective management of aquatic ecosystems. However, predicting these events remains highly challenging due to the non-linear, chaotic nature of bio-geochemical interactions and the non-stationary properties of environmental time-series data, often characterized by seasonal regime shifts. Furthermore, conventional regularized training algorithms, such as Levenberg–Marquardt, frequently encounter Jacobian singularities (exploding parameters) when applied to noisy, multidimensional sensor data, while standard neural networks suffer from severe chronological overfitting.

In this paper, we introduce AlgaeSense tool, a robust deep learning framework designed to process multi-sensor water quality time-series. The core of the tool utilizes a deep Feedforward Neural Network configured with a [48, 30, 30, 20, 10] topology and trained via the Scaled Conjugate Gradient (SCG) algorithm, which effectively bypasses Jacobian instability. To mitigate the effects of seasonal regime shifts and sensor uncertainty, we propose a novel dual-partition ensemble strategy. The framework aggregates the predictions of two topologically identical sub-models trained under contrasting data-splitting paradigms: a sequentially-partitioned model that preserves temporal autocorrelation, and a stochastically-interleaved model designed to extract invariant, season-agnostic biogeochemical relationships. Experimental results demonstrate that this ensemble approach significantly mitigates temporal bias, reduces the risk of instant overfitting, and demonstrates improved generalization capabilities across varying seasonal conditions, providing a highly reliable early-warning computational tool for bio-medical and ecological monitoring.

Keywords: Deep ensemble learning, Time series forecasting, Chlorophyll-a prediction, Water quality monitoring, Non-stationary environments, Scaled Conjugate Gradient (SCG), Algal bloom early warning.

Acknowledgements: This research and the subsequent development of the web portal were supported by the AlgaeRevive project (Grant No. BSB00091). The authors would like to express their gratitude for the funding and logistical support that made the real-world deployment of the AlgaeSense Tool possible.

High-Throughput Genomic Analysis Using Sketch Algorithms

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Abstract: Recent advancements in DNA sequencing enable the rapid generation of vast genomic datasets that require analysis and alignment to a reference genome, necessitating efficient algorithms that scale across the full memory and compute resources of modern multi-socket systems. This work presents a hardwareaware k-mer counting implementation that combines SIMD-accelerated encoding with a NUMA-aware parallel execution model, utilizing enforced thread affinity and memory locality optimizations. Empirical results demonstrate that the explicit co-design of algorithmic structure and hardware topology yields substantial throughput improvements over naive approaches on modern multisocket server hardware.

Keywords: k-mer counting, High-throughput sequencing, Non-Uniform Memory Access (NUMA), Flat array indexing, SIMD vectorization, Thread affinity, Memory locality, Work stealing, Bioinformatics, Genome analysis.

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Sequence Search and Matching Algorithms Inspired by Seed Strategies and Frequency-Guided Progressive Filtering

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Abstract: Two sequence search and matching approaches are discussed in the presented investigation. The proposed algorithms compare strings with patterns using different methodologies. The first approach is a novel filtering algorithm inspired by the seed-based strategy employed in the PatternHunter algorithm. It searches for the positions of the first, second, and subsequent occurrences of different characters in the sequence. The second approach is progressive filtering algorithm inspired by frequencybased search strategies. It starts by searching for the least frequent characters in the read and progressively includes more frequent characters, comparing their positions with those in the genome sequence.

Keywords: Sequence search and matching algorithm, String searching problem, Sequence matching methods.

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Multiple Linear Regression Modeling of Gibbs Free Energy in Silica Gel Absorption Systems

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Abstract: The recovery of waste from restaurants and agriculture and the implementation of the European Circular Economy Directive are priorities. On the other hand, the cleaning of oil spills from aquatic ecosystems is also of paramount importance. A multiple linear regression model with an interaction term was developed and estimated using ordinary least squares for a dataset corresponding to three groups of silica gel samples. Overall, the results demonstrate that the proposed model provides an effective empirical description of the relationship between Gibbs free energy, temperature, and time. Differences among the three groups further illustrate how dataset quality influences model reliability, coefficient stability, and the interpretation of the estimated regression coefficients.

Keywords: Gibbs free energy, Multiple regression, Predictive modelling.

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GPU-Accelerated FASTQ Preprocessing for Clinical Genomics: Verified Correctness and Reduced Turnaround Time

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Abstract: Clinical next-generation sequencing pipelines depend on fast, reproducible FASTQ preprocessing as their first stage. We present fastpgpu, a drop-in replacement for fastp v1.3.3 that reduces preprocessing wall time by up to 3.00× on a 38.5 GB paired-end whole-genome dataset (722.6M reads, 150 bp) while producing bit-identical FASTQ output and numerically identical JSON quality reports. The speedup comes from a parallel decompression and compression pipeline, not from per-read GPU compute. Six compliance properties are verified automatically on every build: determinism, cross-thread consistency, version auditability, read conservation, paired-end synchronisation, and graceful failure on malformed input. The validation suite meets IEC 62304 and EU IVDR 2017/746 requirements for software contributing to an in-vitro diagnostic result. fastp-gpu is implemented in C++17/CUDA 12, licensed under MIT, and available at https://github.com/d0bromir/fastp-gpu (v1.3.3-d0bromir), with pre-built binaries archived at Zenodo (https://doi.org/10.5281/zenodo.20094436).

Keywords: FASTQ preprocessing, GPU acceleration, Clinical genomics, Quality control, Reproducibility.

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Session

Technologies and Innovations in Healthcare

Process-Centric Agent Orchestration: An APQC-Aligned Framework with a Healthcare Use Case

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Abstract: The rapid emergence of AI agents in operational environments has created a pressing need for structured, process-aligned integration models. While most agent deployments remain tool-centric and ad hoc, organizations increasingly require systematic approaches that ensure reliability, governance, and interoperability across complex workflows. This paper proposes a process-centric agent orchestration framework grounded in the APQC Process Classification Framework (PCF), enabling AI agents to function as explicit process participants with defined roles, responsibilities, and handoff rules. By aligning agent capabilities to standardized process categories, the framework supports scalable adoption, cross-functional consistency, and transparent human–AI collaboration.

To demonstrate its applicability, the paper presents a detailed use case in patient intake & triage, a domain characterized by high-stakes decision-making, strict regulatory requirements, and tightly coupled human-machine interactions. We map APQC PCF Category 4.0 (“Deliver Healthcare Services”), and 5.0 (5.0 Deliver Services (Patient Care Services)) to a multi-agent ecosystem. The orchestration model illustrates sequential and parallel agent collaboration, human-in-the-loop checkpoints, and governance mechanisms essential for safe deployment in healthcare settings.

The proposed framework contributes a reusable methodology for identifying agent-ready subprocesses, defining agent archetypes, and designing orchestration patterns that preserve accountability and auditability. By embedding agents within a standardized process architecture, organizations can accelerate AI adoption while maintaining operational integrity. The healthcare use case demonstrates the framework’s potential to enhance efficiency, reduce variability, and support more consistent outcomes.

Keywords: AI agents, Process orchestration, APQC PCF, Healthcare, Workflow automation.

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From IoMT to Agentic AI: Enabling Secure Agentic Payments and Autonomous Procurement via an Intelligent Middleware Framework

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Abstract: The evolution from traditional Internet of Medical Things (IoMT) to Agentic Artificial Intelligence (AI) marks a paradigm shift in healthcare operations, transitioning medical devices from passive monitoring tools to active operational agents, capable of initiating autonomous payment transactions. Traditional healthcare infrastructures are deterministic and require manual human payment authorization, which delays clinical urgency and limits AI autonomy. This paper presents an extended theoretical framework based on the Intelligent Payment Gateway Middleware (IPGM), specifically adapted to facilitate secure agentic payments in healthcare. It is proposed a "Bounded Medical Autonomy" paradigm that safely bridges probabilistic AI procurement intent with rigid hospital administrative and financial rails. The framework addresses complex clinical constraints, such as the requirement for dual-layer authorization (clinical mandate vs. financial approval) and the distinction between general-purpose procurement and patient-specific needs integrated with Electronic Health Records (EHR). The governance model utilizes Isolation Forests for unsupervised semantic anomaly detection to prevent erroneous AI-driven financial actions and Federated Learning (FedAvg) for decentralized model adaptation without compromising data privacy. To resolve the "Transparency Paradox" between clinical privacy (GDPR/HIPAA) and administrative auditability, the architecture integrates Zero-Knowledge Proofs (zk-SNARKs). This architecture is designed to theoretically allow the Agentic AI to cryptographically validate the medical necessity of an agentic payment before a health insurance fund or a hospital board without disclosing Protected Health Information (PHI). Through a conceptual use case of an autonomous smart laboratory, this study establishes a conceptual algorithmic and architectural foundation for deploying secure and compliant agentic payments in biomedicine, outlining a clear methodology for future empirical validation.

Keywords: Agentic AI, IoMT, Agentic payments, Bounded medical autonomy, IPGM.

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Generalized Net Model of a Patient–Robot Interaction for Home Care Assistance

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Abstract: Humanoid robots can transform patient care by offering new, personalized and innovative solution for home assistance and improvement of the quality if life. This paper outlines an application of the generalized nets in Healthcare Services and we propose a model, describing the interaction between a patient and a humanoid robot in home settings. The different transitions of the proposed model are representing the different scenarios of patient–humanoid robot interaction during daily activities, physiotherapy routines and medical treatment. The so described model can be implemented in patient-centered healthcare delivery and provides a formal framework for modelling patient–humanoid robot interaction in home care assistance.

Keywords: Humanoid robot, Patient–robot interaction, Generalized nets, GN-model.

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Generalized Net Model of the Diagnostic Process of Lower Urinary Tract Symptoms in Men

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Abstract: Lower urinary tract symptoms (LUTS) in men may arise from several coexisting functional, structural, inflammatory, neurological, or neoplastic conditions. Their diagnostic evaluation therefore requires the integration of heterogeneous clinical information and the conditional activation of multiple diagnostic pathways. This paper proposes a Generalized Net model of this process. Unlike previous models describing anatomical or physiological processes of the urinary system, the proposed model represents the patient-specific flow, validation, and interpretation of diagnostic information. It contains ten transitions, 25 places, and six token types carrying structured clinical data, measurement values, validity states, activated pathways, working hypotheses, and unresolved information. The model supports parallel information acquisition, synchronization of examination results, non-exclusive diagnostic branching, and distinction between negative, invalid, unavailable, pending, and clinically unnecessary data. Its output is a set of terminal tokens containing the working diagnostic profile, supporting evidence, remaining uncertainty, and the next clinical step. The model provides a formal basis for future implementation and clinical validation of a computer-assisted diagnostic workflow for male LUTS.

Keywords: Generalized net model, Lower urinary tract symptoms, Prostate gland.

Acknowledgements: The authors gratefully acknowledge the support of the Bulgarian National Science Fund under Grant KP-06-N43-7/30.11.2020 "Creating a prognostic model predicting life expectancy in prostate cancer patients and providing better quality of life after definitive surgical treatment"

A Portable Platform for Instrumented Footwear Sensor Calibration and Data Acquisition

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Abstract: Instrumented footwear integrating plantar pressure and inertial sensing is central to real-world gait assessment, yet its reliable and practical use remains challenging. Force-sensitive resistors exhibit nonlinear characteristics and limited repeatability, requiring careful calibration, while data acquisition, visualization, preprocessing, and analysis are often distributed across fragmented, vendor-specific tools.

We present a portable desktop platform that unifies instrumented footwear data processing. The system supports real-time acquisition and recording of plantar pressure and inertial data from both feet, as well as replay of previously recorded sessions. Built around a unified, source-agnostic data model, it ensures that live acquisition and replay follow the same processing pipeline and produce reproducible analyses. The platform provides visualization of all acquired signals, including interactive three-dimensional representations of plantar pressure data, together with specialized processing and analysis tools. It is extensible through plugins, and an integrated, context-aware knowledge base incorporates theory, formulae, and interactive widgets directly into the application.

A guided calibration workflow ensures accurate and reliable plantar force measurements. Instrumented footwear devices are described through versioned hardware profiles specifying sensor count, anatomical placement, and measurement units, ensuring that measurements remain comparable across device variants. Calibration datasets are stored as uniquely identified records, each associated with a particular device, while strict metadata management prevents the use of incompatible sensor configurations or acquisition settings.

Future work will add intelligent processing capabilities to support the development and evaluation of machine-learning algorithms for gait event detection, foot and gait functional analysis, and sports metrics assessment.

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Keywords: Instrumented footwear, Wearable-based gait analysis platform, Plantar pressure sensing, Force-sensitive resistors, Inertial measurement units, Sensor calibration, Multimodal wearable sensing, Data acquisition.

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Thyroid Dysfunction and Recurrent Pregnancy Loss: A Retrospective Case-Control Study

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Abstract:

Background: Thyroid dysfunction, including both overt and subclinical forms, has been associated with adverse pregnancy outcomes, particularly recurrent pregnancy loss (RPL).

Aim: To evaluate the relationship between thyroid dysfunction and recurrent pregnancy loss and its impact on pregnancy outcomes.

Methods: This retrospective case-control study included 250 pregnant women: 150 with thyroid dysfunction and a history of RPL (clinical group) and 100 age-matched healthy pregnant women without thyroid disease or miscarriage history (control group). Thyroid parameters (TSH, FT3, FT4, and TPO antibodies) were analyzed. Pregnancy outcomes and complications were assessed, and multivariate logistic regression was performed to determine independent risk factors.

Results: Women in the clinical group showed a significantly higher prevalence of elevated TSH (>4.0 mIU/L) (65.3% vs. 10%, p<0.001), positive TPO antibodies (40% vs. 5%, p<0.001), subclinical hypothyroidism (44% vs. 5%, p<0.001), and overt hypothyroidism (28% vs. 2%, p<0.001). Adverse pregnancy outcomes were markedly increased, including preterm birth (25.3% vs. 10%, p=0.003), low birth weight (30% vs. 12%, p<0.001), gestational hypertension (20% vs. 8%, p=0.01), and spontaneous abortion (63.3% vs. 0%, p<0.001). Multivariate regression analysis identified elevated TSH (OR=1.45, p=0.002) and TPO antibody positivity as independent predictors of miscarriage, preterm birth (OR=1.48, p=0.008), and low birth weight (OR=1.50, p<0.001). Additionally, FT4 levels were inversely associated with gestational hypertension (OR=1.65, p=0.014).

Conclusion: Thyroid dysfunction, particularly elevated TSH and thyroid autoimmunity, is strongly associated with recurrent pregnancy loss and adverse obstetric outcomes. These findings support routine thyroid screening and early intervention in women with RPL to improve pregnancy outcomes.

Keywords: Thyroid dysfunction, Recurrent pregnancy loss, TSH, FT4, TPO antibodies, Pregnancy outcomes.

Trends in Maternal Obesity and Gestational Weight Gain During Pregnancy in Southeastern Bulgaria

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Abstract:

Background: Maternal overweight, obesity, and inappropriate gestational weight gain (GWG) are increasingly recognized as major contributors to adverse pregnancy outcomes worldwide. Elevated pre-pregnancy body mass index (BMI) is associated with gestational diabetes mellitus (GDM), hypertensive disorders, cesarean delivery, fetal overgrowth, and long-term cardiometabolic risks for both mother and child. Regional contemporary data from Bulgaria remain limited.

Objective: To evaluate trends in maternal obesity and gestational weight gain among pregnant women in Southeastern Bulgaria between 2021 and 2025, using a regional cohort from Burgas, and to assess associations with maternal and neonatal outcomes.

Methods: This retrospective cohort study included 1,176 singleton pregnancies registered for antenatal follow-up at MC Prime Clinic – Dr. Kirovakov Ltd, Burgas, Bulgaria, between January 2021 and December 2025. Women were classified according to World Health Organization BMI categories as underweight, normal weight, overweight, and obese. Gestational weight gain was categorized as below, within, or above Institute of Medicine recommendations. Maternal and neonatal outcomes were analyzed using comparative statistics and multivariable logistic regression.

Results: The mean maternal age was 30.8 ± 5.4 years, and the mean pre-pregnancy BMI was 25.1 ± 4.8 kg/m². BMI distribution was: underweight 7.6%, normal weight 49.8%, overweight 27.9%, and obesity 14.7%. Overall, 42.6% of women entered pregnancy overweight or obese. Mean total GWG was 13.2 ± 5.6 kg. Excessive GWG occurred in 39.0% of women, while only 39.6% remained within recommended ranges. Excessive GWG was significantly more common among obese women (52.8%) than among women with normal BMI (34.7%, $p<0.001$). Compared with women of normal BMI, obese women had significantly higher rates of gestational diabetes mellitus (16.7% vs 5.8%), hypertensive disorders (12.9% vs 4.2%), preeclampsia (8.4% vs 2.1%), cesarean delivery (47.4% vs 28.6%), macrosomia (14.5% vs 6.1%), and preterm birth (10.7% vs 6.9%) (all $p<0.05$). In multivariable analysis, maternal obesity independently predicted GDM (aOR 2.94, 95% CI 1.82-4.73), preeclampsia (aOR 3.18, 95% CI 1.87-5.39), cesarean delivery (aOR 2.11, 95% CI 1.42-3.14), macrosomia (aOR 2.46, 95% CI 1.51-4.01), and preterm birth (aOR 1.67, 95% CI 1.02-2.74).

Conclusions: Maternal obesity and excessive gestational weight gain were highly prevalent among pregnant women in Southeastern Bulgaria during 2021-2025 and were strongly associated with adverse maternal and neonatal outcomes. These findings support the need

for preconception counseling, individualized antenatal weight management, and targeted regional public health strategies.

Keywords: Maternal obesity, Gestational weight gain, Body mass index, Pregnancy outcomes.

Session

Biomolecues and Tissue Engineering

Polyfluoroalkyl Substances: Molecular Mechanisms of Interactions with Lipid Membranes and Toxicity

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Abstract: Polyfluoroalkyl substances (PFAS) are ubiquitous, highly persistent pollutants that accumulate at biological interfaces, yet their molecular-level effects on membrane organization and electrostatics remain poorly resolved. Here, we systematically dissect the interactions of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) with model lipid membrane, 1-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine large unilamellar vesicles. Using Laurdan and di-8-ANEPPS fluorescence spectroscopy, we demonstrate that both compounds significantly disrupt lipid packing and markedly reduce membrane dipole potential in a strongly concentration-dependent manner. These effects are substantially stronger for PFOS, revealing pronounced perturbation of interfacial water-lipid coupling and membrane polarization. PFAS exposure further reshapes vesicle surface electrostatics and compromises colloidal stability, as evidenced by zeta potential and dynamic light scattering measurements, consistent with their preferential partitioning into lipid assemblies and redistribution of interfacial charge. Notably, PFOS consistently exerts a stronger impact than PFOA across all measured parameters. Collectively, these findings establish a robust physicochemical framework for PFAS-membrane interactions driven by interfacial accumulation and dipole potential modulation, with direct implications for their biological persistence and toxicity.

Keywords: PFAS, Model lipid membranes, Lipid order, Dipole potential, Zeta potential.

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Non-Disruptive Membrane Modulation by Clozapine and Chlorpromazine: Evidence from Erythrocyte Models

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Abstract: Antipsychotic drugs are widely recognized for their receptor-mediated effects, yet their interactions with lipid membranes remain insufficiently understood. Here, we show that clozapine and chlorpromazine induce subtle but consistent changes in membrane organization, pointing to a lipid-mediated component of their activity. Both compounds increase lipid order, indicative of reduced lipid mobility. Clozapine exerts a markedly stronger effect than chlorpromazine, suggesting a greater capacity to perturb membrane structure and organization. Notably, these changes occur without detectable alterations in membrane surface charge, as reflected by stable zeta potential values. This combination of increased lipid order and preserved electrostatic properties reveals a non-disruptive mode of membrane interaction. Rather than compromising membrane integrity, the drugs appear to fine-tune lipid organization, a mechanism that may be sufficient to modulate membrane-associated processes.

Although erythrocytes are not involved in neuronal signaling, their membranes provide a minimal and well-defined model to capture lipid-specific drug effects. The ability of antipsychotics to alter lipid order and packing in this system suggests that similar membrane-mediated mechanisms may contribute to the modulation of receptor activity in the brain, complementing direct ligand-receptor interactions. Together, these findings highlight that even modest changes in membrane organization can contribute to the pharmacodynamic profile of antipsychotic agents, offering a complementary perspective to classical receptor-centric models.

Keywords: Erythrocytes, Clozapine, Chlorpromazine, Lipid order, Zeta potential.

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Petasin Alters Lipid Order and Dipole Potential without Disrupting Bilayer Integrity of Biomimetic Mast Cell Membranes

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Abstract: Membrane lateral heterogeneity is a key determinant of mast cell signaling and activation, making membrane physicochemical properties important targets in the modulation of allergic responses. Here, large unilamellar vesicles (LUVs) modeling resting and activated mast cell membranes were used as biomimetic systems to investigate the membrane-level effects of petasin.

Membrane dipole potential was assessed using di-8-ANEPPS-labeled LUVs, while dynamic light scattering and zeta potential measurements were used to evaluate vesicle size and surface electrostatics. Lipid order was investigated by Laurdan fluorescence spectroscopy. Petasin decreased membrane dipole potential in both membrane models, consistent with altered interfacial electrostatics and hydration. Simultaneously, Laurdan measurements indicated increased bilayer order in the presence of petasin, supporting a dual effect on membrane organization and electrostatic properties. No significant changes in LUV size were observed, indicating preserved vesicle integrity and absence of major structural perturbation, fusion, or destabilization. Petasin-containing LUVs exhibited only a slight shift in zeta potential, consistent with subtle changes in membrane surface properties.

These findings demonstrate that petasin modulates membrane order, dipole potential, and interfacial electrostatics without disrupting bilayer integrity. Given the sensitivity of membrane protein function and signaling to lipid organization and dipole potential, these effects may contribute to altered mast cell responsiveness. This work provides mechanistic insight into petasin as a membrane-active modulator and highlights biomimetic membrane models as valuable tools for studying bioactive regulation of membrane-associated signaling.

Keywords: Petasin, Biomimetic membranes, Lipid order, Dipole potential, Bilayer integrity.

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Effects of Selected Thieno[2,3-*d*]pyrimidine Derivatives on Breast Cancer Cell Proliferation and Membrane Organization

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Abstract: Breast cancer heterogeneity and the limited selectivity of conventional chemotherapy highlight the need for new compounds with multimodal anticancer activity and reduced effects on non-malignant cells. Selected thieno[2,3-*d*]pyrimidine derivatives were evaluated in non-malignant MCF-12F mammary epithelial cells and in MCF-7 and MDA-MB-231 breast cancer cells. Doxorubicin was included as a clinically established positive control. Antiproliferative activity and selectivity were determined by MTT assay and selectivity ratios. Clonogenic survival was assessed by colony-formation assay, migration by wound-healing assay, plasma membrane lipid order assessed by Laurdan fluorescence, and cell–cycle distribution by flow cytometry. The derivatives inhibited cell proliferation in a concentration-dependent manner, with compounds 2 and 4 showing the strongest overall activity. Compound 6 exhibited the highest selectivity toward MCF-7 cells, whereas compound 2 combined pronounced anticancer activity with relatively limited effects on non-malignant MCF-12F cells. Treatment reduced colony-forming capacity and delayed wound closure, indicating persistent suppression of cell growth and migration. Laurdan generalized polarization analysis revealed increased membrane order, particularly after treatment with compound 2 in the malignant cell lines. Cell–cycle analysis demonstrated compound- and cell-line-dependent redistribution across the S and G2/M phases, consistent with impaired cell–cycle progression. Doxorubicin showed strong inhibitory activity and provided a clinically relevant benchmark, while the tested derivatives displayed distinct selectivity profiles. Overall, compound 2 emerged as the most promising multitarget candidate, whereas compound 6 demonstrated notable selectivity toward MCF-7 cells.

Keywords: Breast cancer cells, Thieno[2,3-*d*]pyrimidine scaffold, Selective cytotoxicity, Cell–cycle arrest, Plasma membrane organization.

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Oxidative Remodeling of Neuronal Membrane Models Modulates Amyloid-β-Membrane Interactions

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Abstract: Oxidative modification of membrane lipids is an early event in Alzheimer's disease that may influence amyloid-β (Aβ)-membrane interactions. This study investigated how oxidized phosphatidylcholines (OxPCs) affect the biophysical properties of neuronal membrane models and their interactions with Aβ oligomers. Large unilamellar vesicles composed of POPC:cholesterol: sphingomyelin (70:20:10 mol%) served as a neuronal plasma membrane model. Oxidative remodeling was induced by incorporating POVPC, PGPC, or both oxidized lipids. Native Aβ(1–42) and reverse-sequence rAβ(42–1) oligomers were examined in DMEM using Laurdan generalized polarization (GP), ζ-potential, and dynamic light scattering (DLS). OxPC incorporation altered membrane organization, surface electrostatics, and vesicle size distribution in a lipid-dependent manner. PGPC produced the strongest effects, increasing membrane order, negative ζ-potential, hydrodynamic diameter, and polydispersity, whereas POVPC caused more moderate changes. Membranes containing both oxidized lipids exhibited intermediate properties, indicating a distinct membrane state. Both peptides increased membrane lipid order, but Aβ(1–42) consistently exerted stronger effects. Oxidative remodeling enhanced the ordering effect of Aβ(1–42) by 35–45%, whereas rAβ(42–1) showed significant enhancement only in membranes containing both oxidized lipids. Aβ(1–42) also induced approximately 40% greater negative ζ-potential shifts than the reverse peptide. The combination of POVPC and PGPC reduced the functional differences between the peptides, suggesting that lipid oxidation decreases the sequence dependence of peptide-membrane interactions. These findings identify oxidized lipids as active regulators of Aβ-membrane interactions and support lipid oxidation as a contributor to early molecular events in Alzheimer's disease.

Keywords: Oxidized phosphatidylcholines, Amyloid-β, Alzheimer's disease, Neuronal membrane model, Lipid order, ζ-potential.

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Chitosan-Based Nanocomposites in Cancer Nanomedicine: Functionalization with Metallic Nanoparticles and Drug Delivery Strategies

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Abstract: Cancer remains a major global health challenge, highlighting the need for safer and more selective therapeutic strategies. Despite substantial advances in cancer treatment, limited selectivity, multidrug resistance, and systemic toxicity continue to restrict the efficacy of conventional therapies. Chitosan has emerged as a promising natural biopolymer for cancer nanomedicine owing to its biocompatibility, biodegradability, low toxicity, and versatile chemical functionality. Its reactive amino and hydroxyl groups enable incorporation of metallic nanoparticles and metal oxides, including gold, silver, selenium, iron oxide, zinc oxide, and titanium dioxide, generating multifunctional nanocomposites with tunable physicochemical and biological properties. These hybrid systems offer significant potential for targeted drug delivery, controlled release, enhanced cellular uptake, and improved anticancer activity. Beyond their role as carriers for conventional chemotherapeutics, chitosan-based nanocomposites may directly modulate cancer cell responses through interactions with the plasma membrane, alterations in membrane organization and permeability, oxidative stress, mitochondrial dysfunction, and activation of apoptotic pathways. This review summarizes recent advances in chitosan-based nanocomposites incorporating metallic nanoparticles and metal oxides, focusing on their physicochemical properties, membrane interactions and cellular uptake, targeted drug delivery, anticancer mechanisms, and current challenges toward their translation into effective cancer therapies.

Keywords: Chitosan, Cancer nanomedicine, Metallic nanoparticles, Drug delivery, Apoptosis, Lipid rafts.

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Beyond Cytotoxicity: Membrane Lipid Organisation as an Early Target of PFAS

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Abstract: Per- and polyfluoroalkyl substances (PFAS) comprise a large family of highly persistent environmental contaminants that have attracted increasing attention due to their widespread distribution and potential adverse effects on human health. Although numerous studies have focused on PFAS-induced oxidative stress, inflammation, metabolic disruption, and cell death, growing evidence suggests that alterations in plasma membrane organization represent one of the earliest molecular events following PFAS exposure. Owing to their amphiphilic nature, PFAS readily interact with biological membranes, modifying lipid packing and consequently affecting membrane structure and function. This literature review highlights current knowledge on PFAS-induced changes in membrane lipid order and discusses their implications for cellular physiology. Particular emphasis is placed on the influence of PFAS molecular structure, including carbonchain length and functional head groups, on their interactions with lipid bilayers. Studies employing model membrane systems and living cells are summarized, demonstrating that PFAS can alter membrane fluidity, surface charge, permeability, and membrane mechanical properties. The contribution of complementary biophysical techniques – including Laurdan fluorescence spectroscopy, fluorescence anisotropy, zeta-potential analysis, differential scanning calorimetry, atomic force microscopy, and molecular dynamics simulations – is also discussed as a powerful approach for characterizing these membrane alterations. Collectively, the available evidence supports the concept that disruption of membrane lipid organization precedes many classical toxicological endpoints and may represent a key initiating event in PFAS-induced cellular dysfunction. Understanding these early membrane-associated processes may provide new mechanistic insights into PFAS toxicity and establish membrane physicochemical alterations as sensitive biomarkers for the early assessment of PFAS exposure.

Keywords: PFAS, Membrane organization, Cytotoxicity.

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Quercetin as Functional Food Supplement

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Abstract: Quercetin is a naturally occurring flavonoid widely distributed in fruits, vegetables, and medicinal plants. In recent years, it has attracted considerable scientific interest due to its diverse biological activities and potential application as a functional dietary supplement. The present review summarizes the chemical nature, natural sources, biological effects, and health benefits of quercetin based on recent scientific evidence. Quercetin belongs to the flavonol subgroup of flavonoids and possesses strong antioxidant properties due to its polyphenolic structure. Rich dietary sources include onions, apples, berries, grapes, broccoli, kale, and tea. Numerous studies demonstrate that quercetin exhibits significant antioxidant, anti-inflammatory, antiviral, and antimicrobial activities. It can scavenge reactive oxygen species, modulate inflammatory signaling pathways, and inhibit the production of pro-inflammatory cytokines. Furthermore, quercetin has shown promising antiviral effects against influenza viruses, SARS-CoV-2, hepatitis viruses, and other pathogens. Additional evidence suggests cardioprotective, neuroprotective, and anticancer properties. Despite its therapeutic potential, the low bioavailability of quercetin remains a major challenge. Overall, quercetin represents a promising natural bioactive compound with potential applications in disease prevention and health promotion.

Keywords: Quercetin, Oxidative stress, Antioxidant, Anti-inflamatory, Flavonoid.

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Mycotoxins in Food: Distribution, Toxicity and Oxidative Stress-Mediated Biological Effects

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Abstract: This review critically systematizes current evidence on the principal foodborne mycotoxins—aflatoxins, ochratoxin A, trichothecenes, and fumonisins—with particular emphasis on oxidative stress as a unifying mechanistic determinant of their toxicological profiles. Aflatoxin B1 undergoes cytochrome P450–mediated bioactivation to highly reactive epoxide intermediates, promoting DNA adduct formation, lipid peroxidation, and disruption of cellular redox equilibrium, thereby contributing to hepatotoxicity and carcinogenesis. Ochratoxin A is associated predominantly with nephrotoxicity, mediated by excessive reactive oxygen species generation, mitochondrial impairment, and inhibition of protein synthesis. Trichothecenes exert ribotoxic stress through interaction with the 60S ribosomal subunit, triggering oxidative imbalance, apoptosis, and immunomodulatory effects. Fumonisins interfere with sphingolipid metabolism via ceramide synthase inhibition, leading to oxidative dysregulation and hepato-renal toxicity. Collectively, oxidative mechanisms emerge as a central pathogenic axis in mycotoxin-induced cytotoxicity, genotoxicity, and tumorigenesis. The metabolic conversion of aflatoxin B1 to aflatoxin M1 and its excretion in milk is discussed as a biomarker of systemic exposure and biotransformation. The available data underscore the necessity for integrated oxidative stress–oriented risk assessment and comprehensive control strategies along the food chain.

Keywords: Mycotoxins, Oxidative stress, Food safety.

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Rapid Detection of Mycotoxins and Foodborne Pathogens: Advances in Immunoassays and Nanoparticle-Based Analytical Methods

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Abstract: Food contamination with bacterial pathogens (*Staphylococcus aureus*, *Escherichia coli*) and mycotoxin-producing fungi (*Fusarium*, *Aspergillus*, *Penicillium*) poses serious health risks, including gastrointestinal disorders, immunosuppression, nephrotoxicity, and carcinogenic effects. Rapid detection is essential, as traditional culture methods are slow. Immunoassays, particularly ELISA and fluorescent immunoassays (IFA), provide faster alternatives, with sensitivity and specificity further enhanced by nanoparticles. Antibody-functionalized magnetic nanoparticles enable rapid pathogen separation and concentration, followed by detection with fluorescent conjugates in competitive or sandwich formats. These nanoparticle-based IFA systems allow detection of pathogens such as *E. coli O157:H7* and *Salmonella typhimurium* with low detection limits (≈10 CFU/mL) and short analysis times (12 min–2 h), offering a promising platform for fast, sensitive, and reliable food safety monitoring.

Keywords: Mycotoxins, Pathogens, Oxidative stress; HPLC, LC-MS/MS, Immunoassays.

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Comparative Analysis of Methods for Extraction of Collagen from Pork By-products

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Abstract: Collagen is a major structural protein in the extracellular matrix and a key biomaterial with widespread applications in tissue engineering and regenerative medicine. The quality of the collagen obtained depends on the extraction method, which necessitates a comparative analysis of different approaches.

In the present study, a comparison was made between a chemical (acid-alkaline) and a thermal (hydrolytic) method for isolating collagen from pork by-products (ears and feet). After pretreatment (defatting with ethanol and alkaline treatment with 0.5 M NaOH), the samples were subjected to extraction with 0.5 M CH_3COOH or thermal hydrolysis (60–100°C, 4–12 h), followed by dialysis and lyophilization. The obtained samples were analyzed by FTIR, UV/VIS spectroscopy, and SDS–PAGE.

FTIR analysis shows that chemically extracted collagen exhibits characteristic amide bands at Amide I (1636–1637 cm^{-1}) and Amide II (1542–1543 cm^{-1}), close to the reference standard (1630/1525 cm^{-1}), indicating a preserved triple helical structure. The absence of a lipid peak (~1740 cm^{-1}) confirms a high degree of purity. UV/VIS spectroscopy shows a maximum at 225 nm, corresponding to peptide bonds, with a minimally pronounced peak at ~272 nm, associated with the limited presence of non-collagen impurities.

In contrast, heat-treated samples show a shift of Amide I to 1654 cm^{-1}, the presence of lipid signals (~1741–1743 cm^{-1}), and the absence of a characteristic UV maximum below 230 nm, which indicates structural denaturation and contamination. SDS–PAGE analysis showed a low concentration of intact α-chains and the presence of low-molecular-weight fragments (<50 kDa), suggesting proteolytic degradation.

In conclusion, the chemical method yields collagen with greater structural integrity and purity than the thermal approach, making it more suitable for biomedical applications.

Keywords: Collagen, Pork by-products, FTIR, UV/VIS, SDS–PAGE, Extraction.

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