

International Conference
on
**Bio-AI Innovations for Sustainable
Biotechnology and Environment**

(BAISBE-2026)

21st-23rd August 2026

**Souvenir
and
Book of Abstracts**

Editor

Satya Prakash Verma

Co-Editors

Dr Chandrababu Rejeeth

Dr Gourav Mishra

Dr Ashima Kathuria

Organised by

Department of Biotechnology

Meerut Institute of Engineering and Technology (MIET)

Meerut-250005, Uttar Pradesh, India

Published by

Green Petals Trust

Centre of Excellence in Training and Research

Meerut-250103, Uttar Pradesh, India



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2026

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MEERUT INSTITUTE OF ENGINEERING & TECHNOLOGY

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Approved by AICTE, PCI, New Delhi & Affiliated to Dr. A.P.J. Abdul Kalam Technical University, Uttar Pradesh, Lucknow

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MESSAGE

It gives me immense pleasure to extend my warm greetings on the occasion of the **International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)**, being organized by the Department of Biotechnology, MIET, Meerut.

The rapid convergence of Biotechnology and Artificial Intelligence is redefining scientific discovery, healthcare, agriculture, environmental sustainability, and industrial innovation. BAISBE-2026 provides an outstanding platform for researchers, academicians, industry leaders, policymakers, and students to exchange ideas, showcase cutting-edge research, and establish meaningful collaborations that contribute to a sustainable future.

At MIET, we firmly believe that excellence in education and research can transform society. Conferences such as BAISBE-2026 reflect our commitment to fostering innovation, interdisciplinary research, and global academic partnerships.

I congratulate the organizing committee, distinguished keynote speakers, delegates, sponsors, and participants for their dedicated efforts in making this international conference a reality. I am confident that the deliberations and outcomes of BAISBE-2026 will inspire innovative solutions for the benefit of humanity and the environment.

I extend my heartfelt blessings and best wishes for the grand success of BAISBE-2026.

Vishnu Saran
Chairman

Meerut Institute of Engineering & Technology, Meerut
Chief Patron, BAISBE-2026

प्रो. जयप्रकाश पाण्डेय
कुलपति
Prof. Jai Prakash Pandey
Vice Chancellor



डॉ० ए०पी०जे० अब्दुल कलाम प्राविधिक विश्वविद्यालय
उत्तर प्रदेश, लखनऊ
Dr. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY
Uttar Pradesh, Lucknow

Dated: 28.07.2026

MESSAGE

It gives me immense pleasure to learn that the Department of Biotechnology, Meerut Institute of Engineering & Technology (MIET), Meerut, is organizing the International Conference on “Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)” from 21–23 August 2026.

The convergence of Biotechnology and Artificial Intelligence is creating unprecedented opportunities to address some of the most pressing global challenges related to healthcare, agriculture, environmental sustainability, and industrial development. The integration of advanced computational tools with biological sciences is transforming research, innovation, and decision-making processes, paving the way for a more sustainable and technologically empowered future.

I commend the organizers for selecting a highly relevant and contemporary theme that aligns with the vision of promoting interdisciplinary research, innovation, entrepreneurship, and industry-academia collaboration. Such international platforms provide valuable opportunities for scientists, academicians, researchers, industry experts, and students to exchange ideas, share knowledge, and develop collaborative solutions for societal advancement.

I am confident that BAISBE-2026 will foster meaningful scientific discussions and inspire young researchers to explore emerging frontiers in Biotechnology, Artificial Intelligence, and Environmental Sciences. The conference will undoubtedly contribute to strengthening the research ecosystem and promoting sustainable technological development.

I extend my best wishes to the organizers, participants, and delegates from India and abroad for the grand success of this conference.

(Prof. Jai Prakash Pandey)
Vice Chancellor

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MESSAGE

It is with immense pleasure and a profound sense of pride that I welcome all distinguished delegates, eminent scientists, academicians, industry leaders, researchers, policymakers, entrepreneurs, and students to the **International Conference on "Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)"**, organized by the Department of Biotechnology, Meerut Institute of Engineering & Technology (MIET), Meerut. This prestigious international conference serves as a vibrant platform for bringing together leading minds from across the globe to exchange knowledge, share pioneering research, foster interdisciplinary collaborations, and explore transformative innovations at the convergence of Biotechnology and Artificial Intelligence.

The world today stands at the threshold of a new era where scientific innovation, digital intelligence, and sustainable technologies are reshaping the future of healthcare, agriculture, environmental conservation, industrial biotechnology, and the global bioeconomy. The integration of Artificial Intelligence with Biotechnology has unlocked unprecedented opportunities to accelerate scientific discovery, enhance precision in research, optimize biological processes, and develop innovative solutions to some of humanity's most pressing challenges. In this rapidly evolving landscape, platforms such as BAISBE-2026 play a pivotal role in promoting intellectual exchange, encouraging collaborative research, and strengthening partnerships between academia, industry, government, and society.

At MIET, we are committed to fostering a culture of academic excellence, innovation, and research-driven learning. We firmly believe that institutions of higher education have a vital responsibility not only to impart knowledge but also to inspire creativity, nurture future leaders, and contribute meaningfully to national and global development. BAISBE-2026 reflects this commitment by providing an inclusive forum where experienced researchers, young innovators, industry experts, and students can engage in meaningful discussions, exchange diverse perspectives, and collectively envision sustainable solutions for a better future. I am confident that the scientific deliberations, keynote addresses, technical sessions, and collaborative interactions throughout the conference will generate impactful ideas, establish enduring partnerships, and inspire innovations that will contribute significantly to scientific advancement and the well-being of society.

With my best wishes and blessings,


Prof. (Dr.) Sanjay Kumar Singh
Campus, Meerut Institute of Engineering & Technology (MIET), Meerut
General Chair, BAISBE-2026



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MESSAGE

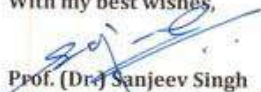
It is with great pleasure that I extend my warm greetings and heartfelt welcome to all distinguished delegates, eminent scientists, academicians, industry professionals, innovators, research scholars, and students participating in the International Conference on "Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)." Organized by the Department of Biotechnology, Meerut Institute of Engineering & Technology (MIET), Meerut, this conference represents a significant step towards fostering excellence in research, innovation, and interdisciplinary collaboration at the global level.

In the present era of rapid technological advancement, the convergence of Artificial Intelligence and Biotechnology has emerged as one of the most promising frontiers of scientific research. This integration is transforming healthcare, agriculture, environmental management, industrial biotechnology, and the bioeconomy by enabling intelligent, data-driven, and sustainable solutions. As the world faces increasingly complex challenges related to climate change, food security, public health, and environmental sustainability, collaborative scientific efforts have become more important than ever. BAISBE-2026 provides an ideal platform for exchanging innovative ideas, disseminating cutting-edge research, and strengthening partnerships among academia, industry, research organizations, and policymakers.

At MIET, we are committed to creating an academic environment that encourages innovation, critical thinking, and lifelong learning. We believe that higher education institutions play a pivotal role in nurturing future scientists, technologists, entrepreneurs, and leaders who can contribute meaningfully to society through knowledge and innovation. Conferences like BAISBE-2026 not only enrich academic discourse but also inspire young researchers to pursue excellence, embrace interdisciplinary approaches, and translate scientific discoveries into practical applications for societal benefit.

I wish all the delegates an intellectually stimulating, professionally rewarding, and memorable conference experience. May BAISBE-2026 serve as a catalyst for pioneering research, enduring collaborations, and transformative innovations that benefit humanity and contribute to a more sustainable and prosperous future.

With my best wishes,


Prof. (Dr.) Sanjeev Singh

Dean Academics, Meerut Institute of Engineering & Technology (MIET), Meerut
General Co-Chair, BAISBE-2026



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MESSAGE

On behalf of the Organizing Committee, it is my privilege to extend a warm and cordial welcome to all distinguished delegates, eminent scientists, esteemed academicians, industry professionals, researchers, and students to the **International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)**, organized by the Department of Biotechnology, Meerut Institute of Engineering & Technology (MIET), Meerut, from 21st to 23rd August 2026.

The integration of **Artificial Intelligence and Biotechnology** is transforming the way we address global challenges in healthcare, agriculture, environmental sustainability, and industrial biotechnology. BAISBE 2026 has been envisioned as an international platform to promote scientific excellence, encourage interdisciplinary collaboration, and facilitate the exchange of innovative research and emerging technologies among academia, industry, and research organizations.

This conference brings together renowned experts and young researchers to share knowledge, exchange ideas, and build meaningful collaborations that will contribute to sustainable scientific and technological advancements. I am confident that the technical sessions, keynote lectures, and interactive discussions will inspire new perspectives and create opportunities for future research partnerships.

I sincerely thank our distinguished speakers, organizing committee members, sponsors, and all participants for their valuable support and contribution to the success of BAISBE-2026. I wish every delegate a rewarding, enriching, and memorable conference experience.

May this conference inspire innovative ideas, foster lasting collaborations, and contribute towards building a sustainable future through the convergence of Biotechnology and Artificial Intelligence.

Prof. (Dr.) Avinash Singh

Professor & Head, Department of Biotechnology

Organizing Convener, BAISBE-2026

Meerut Institute of Engineering & Technology (MIET), Meerut



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MESSAGE

It is my privilege to welcome all distinguished delegates, eminent scientists, academicians, industry experts, researchers, and students to the **International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)**.

BAISBE-2026 will serve as a dynamic platform to explore the convergence of biotechnology and artificial intelligence in addressing global environmental and sustainability challenges. The conference aims to promote interdisciplinary research, innovation, knowledge exchange, and meaningful collaborations among academia, industry, and research organizations.

I sincerely thank our distinguished speakers, participants, sponsors, and the organizing team for their invaluable support. I wish all delegates a productive conference, engaging discussions, and a memorable experience at M.I.E.T., Meerut.

Dr. Gourav Mishra

Associate Professor

Organizing Secretary, BAISBE-2026

Department of Biotechnology

Meerut Institute of Engineering & Technology (M.I.E.T.), Meerut

Meerut Institute of Engineering and Technology, Meerut *29 Years of Excellence in Education, Innovation, and Leadership*

Established in 1997, Meerut Institute of Engineering & Technology (MIET), Meerut, is a leading institution of higher education in North India, committed to academic excellence, innovation, research, entrepreneurship, and holistic development. In the last 29 years, MIET has developed a dynamic academic ecosystem supported by state-of-the-art infrastructure, industry-oriented programmes, experienced faculty, Centres of Excellence, and a strong culture of research and innovation. The Institute is strengthened by **11+ Central Facilities, 12+ Centres of Excellence, 98+ Start-ups, and 82+ IARC & ICC initiatives**, reflecting its commitment to fostering collaboration among Academia, Industry, and Research.

MIET provides an environment that promotes quality education, practical learning, creativity, entrepreneurship, and professional development. The Institute brings together students, faculty, researchers, industry professionals, and entrepreneurs through academic programmes, training initiatives, research activities, innovation platforms, and professional engagements. Its multidisciplinary academic environment enables learners to develop strong technical competencies along with essential future-ready skills.

Education, Research & Innovation

A key strength of MIET is its emphasis on connecting classroom learning with practical application. Students are encouraged to explore emerging technologies, undertake innovative projects, participate in technical activities, and develop solutions to real-world challenges. Through research- and innovation-oriented initiatives, the Institute provides opportunities for students and faculty to engage with contemporary developments across science, engineering, technology, biotechnology, management, and interdisciplinary domains.

Emerging Technologies & Future-Ready Learning

Recognising the rapid transformation driven by technology, MIET encourages students to engage with emerging areas such as Artificial Intelligence, Data Science, digital technologies, automation, biotechnology, sustainability, and interdisciplinary technological applications. The Institute strives to nurture graduates who combine technical knowledge with critical thinking, creativity, communication, collaboration, problem-solving, and entrepreneurial abilities—qualities essential for the future workforce and innovation ecosystem.

Industry & Institutional Collaboration

MIET places strong emphasis on collaboration among Academia, Industry, researchers, entrepreneurs, and professional organisations. With **126+ Memoranda of Understanding (MoUs)** with reputed academic institutions, industries, research organisations, and professional bodies. These collaborations facilitate knowledge exchange, capacity building, research, innovation, joint initiatives, and exposure to real-world challenges. *Through its continued pursuit of excellence, innovation, and societal impact, MIET remains dedicated to nurturing future-ready professionals, innovators, entrepreneurs, and responsible leaders.*

“At MIET, education is viewed not merely as the acquisition of knowledge, but as a pathway towards innovation, professional excellence, entrepreneurship and meaningful contribution to society.”

Vision and Mission of MIET, Meerut

Vision

To be an outstanding institution in the country imparting technical education, providing need-based, value-based and career-based programs, and producing self-reliant, self-sufficient technocrats capable of meeting new challenges.

Mission

The mission of the institute is to educate young aspirants in various technical fields to fulfil the global requirement of human resources by providing sustainable quality education, training, and an invigorating environment, besides moulding them into skilled, competent, and socially responsible citizens who will lead the building of a powerful nation.

Vision and Mission of the Department of Biotechnology, MIET

Vision

To be a leading department in the country imparting biotechnological education and problem-solving skills to the budding biotechnocrats capable of meeting emerging challenges in the area of inter-disciplinary education and industries.

Mission

Educating young aspirants in the field of biotechnology and allied fields to fulfil national and global requirements of human resources. Generating trained man-power with advanced techniques in order to meet the professional responsibilities. Imparting social and ethical values in graduates for progressive attainment at the social level.

UG Program Educational Objectives (PEOs)

The Biotechnology Department of Meerut Institute of Engineering & Technology, Meerut produces graduates with a strong foundation of scientific and technical knowledge and who are equipped with problem-solving, teamwork, and communication skills that will serve them throughout their career. The specific program educational objectives (PEOs) are:

PEO1: Pursue a career as biotechnocrats in core and allied biotechnological fields all over the world.

PEO2: Undertake advanced domain research and development in the field of translational research, in a sustainable, environment-friendly, and inventive manner.

PEO3: Become an entrepreneur to meet the expectations and demand of modern industrial technologies and the health care system.

PEO4: Carry out professional leadership roles in industries as well as academics with a commitment to continuous learning.

PEO5: Serve society as a bonafied global citizen with a strong sense of professional responsibility and ethics.

UG Program Outcomes (POs)

- ❖ *Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.*
- ❖ *Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)*
- ❖ *Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)*
- ❖ *Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).*

- ❖ *Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling, recognising their limitations to solve complex engineering problems. (WK2 and WK6)*
- ❖ *The Engineer and the World: Analyse and evaluate societal and environmental aspects while solving complex engineering problems for their impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).*
- ❖ *Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)*
- ❖ *Individual and Collaborative Teamwork: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.*
- ❖ *Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, and make effective presentations considering cultural, language, and learning differences*
- ❖ *Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects in multidisciplinary environments.*
- ❖ *Life-Long Learning: Recognise the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)*

UG Program Specific Outcomes (PSOs)

- ❖ *An ability to apply biotechnology skills (including molecular & microbiology, immunology & genetic engineering, bioprocess & fermentation, enzyme & food technology and bioinformatics) and its applications in core and allied fields.*
- ❖ *An ability to integrate technologies and develop solutions based on interdisciplinary skills.*

PG Program Educational Objectives (PEOs)

After 3 years from completion of post-graduation, the student will:

PEO1: Establish themselves as skilled biotechnology professionals, contributing to core and interdisciplinary domains globally, through innovative problem-solving and technical expertise.

PEO2: Engage in advanced research and development, focusing on sustainable and eco-friendly biotechnological solutions for societal and industrial challenges.

PEO3: Innovate and lead entrepreneurial ventures, addressing emerging demands in biotechnology, healthcare, and allied industries.

PEO4: Assume leadership roles in academia, research, and industry, while demonstrating a commitment to lifelong learning and professional growth.

PEO5: Serve society as responsible global citizens, upholding ethical practices and contributing to the betterment of humanity through biotechnological advancements. Pursue lifelong learning and continuous skill enhancement.

PG Program Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

PO4: Demonstrate the ability to independently conduct research, investigate complex problems, and develop innovative solutions to address real-world challenges in biotechnology and related fields.



Green Petals Trust (GPT), Meerut



Academic Partner–BAISBE-2026

Green Petals Trust (GPT) is a registered, non-profit educational and research organisation based in Meerut (NCR), Uttar Pradesh, India, dedicated to promoting *quality education, scientific research, innovation, entrepreneurship, environmental sustainability, and capacity building*. Guided by the vision of creating a knowledgeable, skilled, and environmentally responsible society, the Trust works collaboratively with educational institutions, researchers, industries, government agencies, and civil society organisations.

Recognising the growing importance of interdisciplinary learning, GPT established the ***Centre of Excellence in Training & Research (CoETR)*** as its academic and professional development wing. Through CoETR, the Trust organises conferences, faculty development programmes, workshops, teacher training, student engagement initiatives, research publications, and institutional collaborations in emerging areas such as *Artificial Intelligence, Biotechnology, Environmental Education, Entrepreneurship, Sustainability, Quality Management, and Future Skills*.

GPT actively promotes research dissemination through the publication of *conference proceedings, edited books, ISBN publications, and scholarly journals*, while encouraging collaboration among researchers, educators, entrepreneurs, and policymakers. The Trust believes that innovation flourishes through partnerships that bridge academia, industry, government, and society.

Green Petals Trust has organised and supported several national academic programmes on entrepreneurship, environmental education, artificial intelligence, quality education, and sustainable development. It is also working towards strengthening institutional networks through initiatives such as teacher capacity building, entrepreneurship education, school innovation programmes, and collaborative research projects aligned with the *National Education Policy (NEP 2020)* and the *United Nations Sustainable Development Goals (SDGs)*.

As the **Academic Partner** of the **International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)**, Green Petals Trust is pleased to contribute to the publication of the ***Souvenir & Book of Abstracts*** and the ***Conference Proceedings***, thereby supporting the dissemination of quality scientific research and encouraging interdisciplinary dialogue among researchers, academicians, industry professionals, and students.

GPT firmly believes that integrating ***Artificial Intelligence, Biotechnology, Environmental Sustainability, and Innovation*** will play a transformative role in addressing global challenges and shaping a healthier, more sustainable future. The Trust remains committed to fostering excellence in education, advancing research, and building collaborative platforms that empower future generations of scientists, educators, innovators, and responsible global citizens.

Vision Statement

"Collaborating for Knowledge, Innovation and Sustainable Development."

About the Conference

International Conference on “Bio-AI Innovations for Sustainable Biotechnology and Environment” (BAISBE–2026)

The International Conference on “Bio-AI Innovations for Sustainable Biotechnology and Environment” (BAISBE–2026) is being organised from 21st to 23rd August 2026 by the Department of Biotechnology, Meerut Institute of Engineering and Technology (MIET), Meerut, and Green Petals Trust, Meerut (Academic Partner) in Hybrid Mode (Offline and Online). The conference is conceived as a platform for bringing together researchers, academicians, scientists, biotechnology professionals, industry experts, research scholars and students to deliberate on emerging developments at the interface of Artificial Intelligence, Biotechnology, Sustainability and Environment.

The rapid advancement of Artificial Intelligence is transforming the way biological systems are studied, designed and applied. The convergence of Bio-AI, computational biotechnology, sustainable bioprocessing, healthcare, nanobiotechnology, plant and animal biotechnology, biopharmaceuticals and bioeconomy is creating new opportunities for scientific discovery and technology-led solutions to contemporary challenges. BAISBE–2026 seeks to provide an interdisciplinary forum for sharing recent research findings, innovative ideas, emerging technologies and practical applications in these rapidly developing areas. The conference also aims to encourage interaction among academia and industry to strengthen the motto: ***“Bridging Bio-AI, Innovation and Sustainability for a Better Future.”***

Objectives of the Conference

The conference aims to:

- ❖ provide an international platform for presenting and discussing recent advances in **Bio-AI and biotechnology**;
- ❖ promote interdisciplinary exchange among researchers, academicians, students and industry professionals;
- ❖ explore the role of AI in developing **sustainable biotechnological and environmental solutions**;
- ❖ highlight emerging innovations in healthcare, agriculture, industrial biotechnology, nanobiotechnology and bioeconomy;
- ❖ encourage research collaboration, knowledge sharing and technology development;
- ❖ provide opportunities for young researchers and students to present their work and interact with experts; and
- ❖ strengthen the connection between **scientific research, innovation and real-world applications**.

The programme features lectures by eminent speakers, oral and poster presentations, best oral/poster awards and a cross-sector expert panel session focusing on bridging academia and industry. Selected papers may also be considered for publication in Scopus-indexed journals, subject to peer review and the applicable publication process.

BAISBE–2026 brings together diverse but interconnected areas of biotechnology and AI under a common vision: *to encourage innovative, responsible and sustainable approaches to biological and environmental challenges*. The conference therefore provides not only an opportunity to present research, but also a forum to connect ideas, people and institutions for future research, innovation and collaboration.

THEMES OF THE CONFERENCE

Seven Major Tracks of BAISBE–2026

The conference has been structured around **seven interconnected tracks**, covering major emerging areas of Bio-AI, biotechnology, healthcare, environment and sustainable innovation.

1. Bio-AI and Computational Biotechnology: Artificial Intelligence and computational approaches in biotechnology, including machine learning, computational biology, bioinformatics, predictive modelling, biological data analysis and AI-enabled biological discovery.

2. Sustainable Biotechnology & Environment: Innovative biotechnological approaches for environmental protection and sustainability, including bioremediation, waste utilisation, pollution control, resource conservation, climate-related challenges and environmentally responsible biological processes.

3. AI-Driven Healthcare and Industrial Bioprocessing: Applications of AI in healthcare, biomedical research, drug discovery and therapeutic development, along with AI-enabled optimisation of industrial biotechnology, bioprocesses, fermentation and production systems.

4. Advancements in Nanobiotechnology: Emerging developments at the interface of nanotechnology and biotechnology, including nanomaterials, nanomedicine, biosensors, targeted delivery systems and other nano-enabled biological applications.

5. Innovations in Animal and Plant Biotechnology: Recent advances in plant and animal biotechnology, including crop improvement, stress tolerance, molecular approaches, agricultural biotechnology, animal health and AI-supported biological research.

6. Translational Research and Bioeconomy: Research that bridges laboratory discoveries and practical applications, including technology translation, commercialisation, bio-based products, circular bioeconomy, entrepreneurship and pathways from research to societal impact.

7. Biopharma Innovations and AI: Emerging innovations in pharmaceuticals and biotechnology supported by Artificial Intelligence, including drug discovery, molecular design, therapeutic development, biopharmaceutical research and AI-enabled healthcare solutions.

Thematic Convergence

Although the seven tracks cover diverse areas, they are connected by a common objective: *to harness the convergence of Artificial Intelligence and Biotechnology for sustainable, innovative and impactful solutions.*

The conference encouraged contributions that cross traditional disciplinary boundaries and demonstrate how **AI, biotechnology, environmental sustainability, healthcare, agriculture, industrial applications and bioeconomy** can work together to address emerging challenges.

From Research to Innovation

BAISBE–2026 aims to encourage a progression from:

Scientific Knowledge → Artificial Intelligence → Biotechnology → Innovation → Sustainable Application → Societal Impact

Through its scientific sessions, oral and poster presentations, expert interactions and academia–industry interface, the conference seeks to create opportunities for knowledge exchange, collaboration and future-oriented research.

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Organising and Conference Management Team MIET

1. Dr Avinash Singh, Professor
2. Dr Ashima Kathuria, Professor
3. Dr Nitin Verma, Professor
4. Dr Gourav Mishra, Associate Professor
5. Dr Neha Singh, Associate Professor
6. Dr Nitika Vats, Associate Professor
7. Dr Neha Verma, Associate Professor
8. Dr Chandrababu Rejeeth, Associate Professor
9. Dr Divya Chaudhary, Associate Professor
10. Dr Shipra Choudhary, Associate Professor
11. Dr Sonia Sharma, Associate Professor
12. Dr Deepak Verma, Associate Professor
13. Dr Subir Kumar Bose, Associate Professor
14. Dr Nikesh Kumar, Assistant Professor
15. Dr Ashna Siddiqui, Assistant Professor
16. Dr Chandni Verma, Assistant Professor
17. Dr Rekha Yadav, Assistant Professor
18. Dr Rinni Sehrawat, Assistant Professor
19. Dr Robin Pundir, Assistant Professor
20. Dr Kritika Sharma, Assistant Professor
21. Dr Rekha Jhakar, Assistant Professor
22. Dr Vartika Dhyani, Assistant Professor
23. Dr Shweta Chand, Assistant Professor
24. Ms Aditi Tiwari, Assistant Professor
25. Ms Yogita Sharma, Assistant Professor
26. Ms Rachna Kaushik, Assistant Professor

Conference Schedule

International Conference on 'Bio-AI Innovations for Sustainable Biotechnology and Environment
(BAISBE-2026)'

Venue: Auditorium 3 & 4, MIET, Meerut, UP, India

21 – 23 August, 2026

Time		Events	Felicitor
Day-01 (Friday) Date: 21.08.2026 (09.00am-12.20pm)			
09.00 am	Registration		Conference kit distribution
Breakfast 10.00 am			
Inaugural Session (10.30am)			
10.30am	Welcome Address		Dr. Avinash Singh, Organizing Convener
10.40 am	Welcome of the Dignitaries & Felicitation of the Guests		Conference Organizing Committee (BAISBE-2026)
10.50 am	Lighting of Lamp		Hon’ble Guests & Dignitaries of Dias
11.00 am	Saraswati Vandana		By Volunteers
11.10 am	Release of Souvenir and Book Of Abstracts		Hon’ble Dignitaries on the Dias
11.15 am	About the Conference		Dr. Gourav Mishra, Organizing Secretary
11.20 am	Address by Academic Partner		Dr. Satya Prakash Verma, Director, Green Petals Trust, Meerut
11.25 am	Address by Guest of Honor		Dr Subhash C. Chauhan, <i>Professor and Chief, Cancer Immunology and Microbiology Division, University of Texas Rio Grande Valley (TRGV)</i>
11.35 am	Address by Chief Guest		Prof. JP Pandey, Vice Chancellor, AKTU, Lucknow, Govt. of UP
12.10 pm	Vote of thanks		Dr. Alok Sharma, MIET, Meerut
12.20 pm	National Anthem		By Volunteers
Tea Break 12.20 pm			
Day-01 (Friday) Date: 21.08.2026 (12.30 pm- 02.00 pm)			
Technical Track- 01 [Bio-AI and Computational Biotechnology]			
Invited Speakers Presentations			
Chairperson: Prof. Jitender Singh, Head, Department of Microbiology, Ch. Charan Singh University, Meerut			
Co-chairperson: Dr Ashima Kathuria, Professor, MIET, Meerut			
Rapporteur: Dr Kritika Sharma, Assistant Professor, MIET, Meerut			
Lead Paper Presentation by Invited Speakers			
S.N.	Time (pm) (12.30-2.00 pm)	Keynote Lecture/Invited Speakers	Presentation Title
1	12.30-12.50	Dr Rajesh Pandey, PhD Senior Principal Scientist, CSIR-Institute of Genomics and Integrative Biology (CSIR-IGIB)	Pushing the Single Cell Multiomics Envelope
2	12.50-1.10	Dr. Anoop Singh Scientist-E Ministry of Science &Technology, DSIR, Government of India	Sustainable Bioenergy and Waste Management

3	01.10-01.30	Dr Amarpreet Singh Arora Professor (Research), Construction and Environment Research Centre, Sungkyunkwan University, Republic of Korea	Sustainable Wastewater Treatment and Resource Recovery
Oral Presentations			
Lunch 02.00 pm			
Day-01 (Friday) Date: 21.08.2026 (02.30 pm-05.00 pm)			
Technical Track - 02[Sustainable Biotechnology & Environment]			
Invited Speakers Presentations			
Chairperson: Prof. Shailendra Sharma, Department of Genetics & Plant Breeding, CCSU, Meerut, India. Co- chairperson: Dr Neha Verma, Associate Professor, MIET, Meerut Rapporteur: Dr Shipra Chaudhary, Associate Professor, MIET, Meerut			
Lead Paper Presentation by Invited Speakers			
S.N.	Time (pm) (2.30-5.00)	Keynote Lecture/Invited Speakers	Presentation Title
1	2.30-2.50	Dr .Kavya Dashora, Professor, Centre for Rural Development & Technology and Associate Faculty, Yardi School of Artificial Intelligence, IIT Delhi	Plant-Based Innovations for Sustainable Food Systems and Climate Resilience
2	02.50-03.10	Prof. Anil K. Gupta Founder, Honey Bee Network	Biodiversity, biotechnology and benefit-sharing with the communities
3	3.10-03.30	Prof. Mohammed Zafar, Department of Applied Biotechnology, University of Technology & Applied Sciences -Sur, Sultanate of Oman	Artificial Intelligence-Driven Industrial Bioprocessing for Sustainable Bioeconomy: Machine Learning Techniques and Applications
Oral Presentations by the registered participants			
Evening Tea (5.00 pm)			
Day-02 (Saturday) Date: 22.08.2026 (9.30 am-12.00 pm)			
Technical Track - 03[AI-driven Healthcare and Industrial Bioprocessing]			
Invited Speakers Presentations			
Chairperson: Dr Udai Pratap Singh, Medsource Ozone Biomedicals Pvt. Ltd., Faridabad, Haryana, India. Co-chairperson: Dr Vipin Kumar Garg, Professor, MIET, Meerut Rapporteur: Dr Sonia Sharma, Associate Professor, MIET, Meerut			
Lead Paper Presentation			
S.N.	Time (9.30-12.00)	Keynote Lecture/Invited Speakers	Presentation Title
1	10.00-10.20	Dr. Shiv Prasad Principal Scientist, IARI, PUSA, New Delhi	Innovations in Agricultural Biotechnology for Sustainable Food Security and Climate Resilience
2	10.20-10.40	Dr Vikas Chandra Gupta Head-Plant Quality Operations, PG IPL, HP	Quality, Sustainability and Innovation in Bioprocessing: Industry Perspectives for a Future-Ready Biotechnology Sector

3	10.40-11.00	Dr R. Sankararamakrishnan Professor, Department of Biological Sciences and Bioengineering, Mehta Family Centre for Engineering and Medicine, IIT Kanpur, Kanpur	Computational and Structural Bioengineering Approaches for Understanding Biomolecular Systems
Oral /Poster Presentations			
Tea Break 12.00 pm			
Day-02 (Saturday) Date: 22.08.2026 (12.30 pm-02.00 pm)			
Technical Track – 04 [Advancements in Nanobiotechnology]			
Invited Speakers Presentations			
Chairperson: Dr Santosh Kumar Mishra, Associate Professor, Sharda University, Noida, Uttar Pradesh, India. Co-chairperson: Dr Divya Chaudhary, Associate Professor, MIET, Meerut Rapporteur: Dr Vartika Dhyani, Assistant Professor, MIET, Meerut			
Lead Paper Presentation by Invited Speakers			
S.N.	Time (pm) (12.30-2.00 pm)	Keynote Lecture/Invited Speakers	Presentation Title
1	12.30-12.50	Dr Shailendra S. Gaurav, Professor Department of Seed Science & Technology Chaudhary Charan Singh University, Meerut	Innovations in Seed Science and Biotechnology for Sustainable Agriculture and Food Security
2	12.50-1.10	Dr Sachin Kumar Centre for Biomedical Engineering Indian Institute of Technology Delhi	Engineering Nanomaterials for Dual- Pathogen Capture, Separation, and Detection in Food Samples
3	1:10-1:30	Dr Vinod Kumar Yata Associate Professor Department of Biotechnology School of Allied Healthcare Sciences Malla Reddy University, Hyderabad	AI-Enabled Data-Driven Discovery of Novel Therapeutic Peptides
4	1:30-1:50	Prof. Mega Novita Associate Professor Informatics Department at Universitas PGRI Semarang (UPGRIS) in Indonesia	From Atoms to AI and the Future of Scientific Discovery
Oral / Poster Presentations			
Lunch 02.00 pm			
Day-02 (Saturday) Date: 22.08.2026 (02.30 pm- 05.00 pm)			
Technical Track – 05 [Innovations in Animal and Plant Biotechnology]			
Invited Speakers Presentation			
Chairperson: Dr Narendra Kumar, Professor (Research), NIET, Greater Noida Co-chairperson: Dr Rekha Yadav, Assistant Professor, MIET, Meerut Rapporteur: Dr Deepak Verma, Associate Professor, MIET, Meerut			
Lead Paper Presentation			
S.N.	Time (pm) (2.30-5.00)	Keynote Lecture/Invited Speakers	Presentation Title
1	2.30-2.50	Dr Neelesh Kapoor, Department of Fingerprinting, College of Biotechnology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut	Advances in DNA Fingerprinting and Molecular Biotechnology for Sustainable Agriculture and Forensic Applications
2	2.50-3.10	Dr. Shiv Poojan Advisor, BioTech Park, Lucknow; Independent Director, Biotox Solution; Cosmetic Toxicologist, Lucknow, Uttar Pradesh, India	Cosmetic Toxicology and Safety Assessment: Emerging Approaches for Sustainable Biotechnology and Consumer Health

3	3:10-3:30	Prof. Raghavendra Singh, Thomas Jefferson University-MitoCare Centre Philadelphia, USA	Role of mitochondrial Ca2+ gatekeeping by MICU1 in synaptic transmission
Oral/Poster Presentation			
Evening Tea (5.00 pm)			
Day-03 (Sunday) Date: 23.08.2026 (9.30 am-11.30 am)			
Technical Track - 06[Translational Research and Bioeconomy, BioPharma Innovations and AI			
Invited Speakers Presentations			
Chairperson: Dr Sushant Singh, Professor, Life Science, Sharda University, Noida, Uttar Pradesh, India. Co- chairperson: Dr Rekha Jakhar, Assistant Professor, MIET, Meerut Rapporteur: Dr Shweta Chand Thakuri, Assistant Professor, MIET, Meerut			
Lead Paper Presentation			
S.N.	Time (9.30-12.00)	Keynote Lecture/Invited Speakers	Presentation Title
1	10.30-10.50	Dr Manoj Singh Rohilla Scientist F Department of Biotechnology (DBT) Ministry of Science & Technology, New Delhi	Biotechnology Innovations for Sustainable Development: Emerging Opportunities and Future Directions
2	10.50-11.10	Dr Priyanka Srivastava Associate Professor, School of Biosciences, Institute of Management Studies, Ghaziabad	Nanotoxicity, neurodegenerative diseases, and cancer therapeutics
Oral/Poster Presentation			
Valedictory Session (12.00 pm)			
12.00 pm	Welcome Dignitaries on the Dais	Conference Organising Committee	
12.10 pm	Address by the Dignitaries on the Dais	Hon’ble Chief Guest Hon’ble Chairman, MIET, Meerut Hon’ble Vice-Chairman, MIET, Meerut Director, MIET, Meerut Dean Academics, MIET, Meerut	
12.20 pm	Awards and Prize distribution	Participants of Oral/Poster presentation	
12.30 pm	Summary of the Conference	Dr Gourav Mishra, Organising Secretary	
12.35 pm	Vote of thanks	Dr Avinash Singh, Organising Convener	
12.40 pm	National Anthem	By Volunteers	
Hi-Tea Break 12.42 PM			



Editorial

It gives me immense pleasure to extend my warm greetings to all the delegates, keynote speakers, researchers, academicians, industry experts, and students participating in the **International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)**.

On behalf of **Green Petals Trust (GPT), Meerut**, it is indeed a matter of great honour to associate with this prestigious international conference as the **Academic Partner**. The twenty-first century has witnessed extraordinary advances in both **Biotechnology** and **Artificial Intelligence**. Today, these two transformative domains are converging to address some of humanity's most pressing challenges, including sustainable agriculture, healthcare, environmental conservation, bio-resource management, climate resilience, precision medicine, and industrial biotechnology.

The theme of BAISBE-2026 reflects this emerging global vision by providing an excellent platform for interdisciplinary dialogue, knowledge exchange, scientific collaboration, and innovation.

This **Souvenir and Book of Abstracts**, comprising **151 research contributions**, represents the collective intellectual efforts of researchers from diverse institutions and disciplines. Each abstract reflects scientific curiosity, rigorous investigation, and a commitment to developing sustainable solutions for the benefit of society.

I sincerely appreciate the dedicated efforts of the Organising Committee, Scientific Committee, reviewers, session chairs, keynote speakers, and all contributing authors whose valuable work has made this publication possible.

As the **Academic Partner**, Green Petals Trust is privileged to contribute to the dissemination and preservation of this valuable scientific knowledge. We firmly believe that research achieves its true significance when it is effectively communicated, shared, and translated into practical solutions that improve lives and contribute to sustainable development.

I am confident that the deliberations during BAISBE-2026 will inspire new ideas, foster interdisciplinary collaborations, strengthen academic partnerships, and generate innovative research directions for addressing global challenges.

I congratulate MIET, Meerut, for organising this significant international conference and extend my best wishes for its grand success. May the knowledge shared through this conference continue to inspire researchers, educators, innovators, and policymakers in building a healthier, greener, and more sustainable future.

With warm regards and best wishes,

Satya Prakash Verma

Academic Partner & Editor

International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment (BAISBE-2026)

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Guest of Honour Lecture (Abstract)

Novel Therapeutic Strategies for Pancreatic Cancer

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Background: Pancreatic cancer (PanCa) is projected to become the second leading cause of cancer-related mortality by 2030 and remains one of the most therapeutically challenging malignancies. Current treatment options, including gemcitabine- and nab-paclitaxel-based regimens, provide only modest survival benefits, highlighting the need for novel targeted therapeutic strategies. MUC13, a transmembrane mucin aberrantly overexpressed in pancreatic tumours, represents a promising target for tumour-specific drug delivery.

Methods: We developed a novel nanotherapeutic platform comprising MUC13 antibody-conjugated, curcumin-loaded superparamagnetic iron oxide nanoparticles (MUC13-CUR-SPIONs) to achieve targeted drug delivery and modulation of the pancreatic tumour microenvironment. In vitro studies were performed using MUC13-positive pancreatic cancer cell lines to evaluate nanoparticle uptake, cell proliferation, migration, and invasion. Therapeutic efficacy was further assessed in an orthotopic pancreatic cancer mouse model. Tumour tissues were analysed for proliferative markers, Sonic Hedgehog (SHH) signalling components, immune cell infiltration, and responsiveness to immune checkpoint blockade.

Results: MUC13-CUR-SPIONs demonstrated significantly enhanced uptake in MUC13-positive pancreatic cancer cells, resulting in sustained curcumin delivery and marked inhibition of cellular proliferation, migration, and invasion. In orthotopic pancreatic tumour-bearing mice, targeted nanoparticles selectively accumulated within pancreatic tumours and significantly suppressed tumour growth. Mechanistic analyses revealed substantial modulation of the tumour microenvironment following treatment. MUC13-CUR-SPION therapy reduced the expression of proliferating cell nuclear antigen (PCNA) and downregulated key mediators of the SHH pathway, including SHH, Gli-1, Gli-2, Patched-1, and Smoothened (SMO). Additionally, treatment enhanced intratumoral T-cell infiltration while significantly reducing immunosuppressive populations, including regulatory T cells (Tregs) and monocytic myeloid-derived suppressor cells (M-MDSCs). These immunomodulatory effects improved responsiveness to immune checkpoint inhibitors targeting the PD-1/PD-L1 and CTLA-4 pathways and mitigated mechanisms associated with therapeutic resistance.

Conclusions: MUC13-targeted CUR-SPIONs represent a promising precision nanomedicine approach for pancreatic cancer therapy. This novel platform enables tumour-specific drug delivery, inhibits oncogenic signalling pathways, remodels the immunosuppressive tumour microenvironment, and enhances immunotherapy efficacy. These findings support the translational potential of MUC13-CUR-SPIONs as a strategy to improve therapeutic outcomes and overcome treatment resistance in pancreatic cancer.

Keywords: Pancreatic cancer, MUC13, Nanomedicine, Superparamagnetic iron oxide nanoparticles, Curcumin, Immunotherapy, Tumour microenvironment, Sonic Hedgehog pathway, Immune checkpoint blockade, Precision oncology.

Artificial Intelligence-Driven Industrial Bioprocessing for Sustainable Bioeconomy: Machine Learning Techniques and Applications

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Abstract

The transition toward a sustainable bioeconomy requires the development of intelligent, resource-efficient, and environmentally responsible bioprocessing technologies capable of meeting increasing global demands for food, biofuels, biochemicals, pharmaceuticals, and biomaterials. Artificial intelligence (AI), particularly machine learning (ML), has emerged as a transformative technology that enhances industrial bioprocessing through data-driven decision-making, predictive modelling, and autonomous process optimisation. In this presentation, the application of machine learning techniques for process development of industrially important metabolite production using microbial and microalgal processes will be discussed. The production of industrially important exopolysaccharide (EPS) from extremophiles will be discussed under a multi-objective optimisation framework, response surface methodology (RSM), and a genetic algorithm (GA)-optimised artificial neural network (ANN). Based on multi-objective optimisation, the GA-ANN model predicted an increase in the EPS to biomass ratio with increasing EPS and associated biomass production. Similarly, another microalgae bioprocess employed for landfill leachate treatment and CO₂ biofixation in a parallel three-bubble column photobioreactor (BCPBR) of 35 L capacity will be discussed in view of machine learning-based process optimisation. Machine learning-based hyperparameter (HP)-optimised artificial neural network (ANN) and random forest (RF) models were developed for specific COD utilisation rates and for mapping specific COD utilisation rates to biomass, pH, COD, and incubation time in BCPBRs. It provided an excellent fit, demonstrating that ANNs can be used effectively to predict BCPBR performance. By integrating advanced computational algorithms with real-time sensor data and process analytics, ML enables accurate prediction of microbial growth, metabolite production, substrate utilisation, product quality, and process deviations, thereby improving operational efficiency and reducing production costs.

Keywords: Machine Learning; Artificial Neural Network; COD removal; EPS Production; CO₂ emission; Resource recovery.

Engineering Nanomaterials for Dual-Pathogen Capture, Separation, and Detection in Food Samples

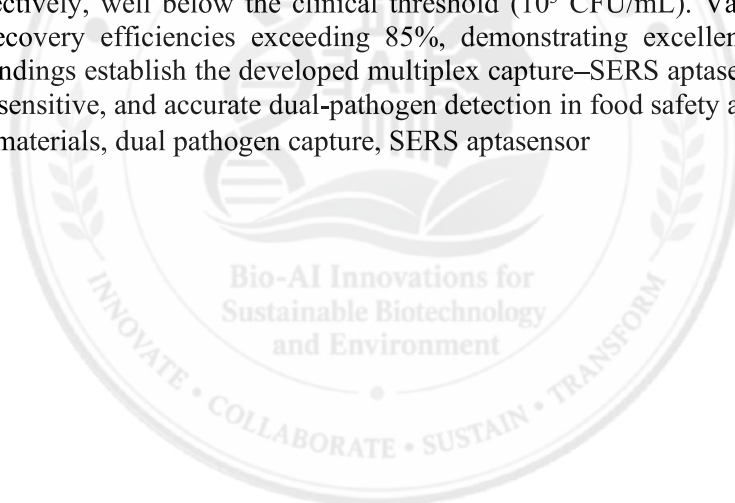
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Abstract

Next-generation nanomaterials have emerged as promising platforms for biomedical applications owing to their unique physicochemical properties and tunable surface functionalities. Our research exploits these attributes for biosensing and tissue engineering applications, with a particular focus on developing highly sensitive pathogen detection systems and nanomaterial-based microcarriers for controlled therapeutic ion delivery for wound healing. In this presentation, I will highlight the application of nanomaterials for rapid multiplex food pathogen detection. We developed a one-pot sensing platform by integrating (i) multi-aptamer-functionalized polymeric magnetic nanospheres for simultaneous pathogen capture and separation, (ii) gold nanoparticle-based SERS nanotags functionalized with pathogen-specific aptamers and Raman reporters (MPY and DTNB), and (iii) a three-dimensional (3D) SERS substrate for enhanced signal amplification. Binding of *Staphylococcus aureus* and *Salmonella typhimurium* generated sandwich complexes that produced distinct Raman signatures, enabling rapid and simultaneous pathogen identification. The developed aptasensor achieved detection limits of 12 and 9 cells/mL for *S. aureus* and *S. typhimurium*, respectively, well below the clinical threshold (10^5 CFU/mL). Validation in food samples yielded recovery efficiencies exceeding 85%, demonstrating excellent accuracy and reliability. These findings establish the developed multiplex capture-SERS aptasensor as a robust platform for rapid, sensitive, and accurate dual-pathogen detection in food safety applications.

Keywords: Nanomaterials, dual pathogen capture, SERS aptasensor



Role of Mitochondrial Ca^{2+} Gatekeeping by MICU1 in Synaptic Transmission

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Abstract

Mitochondrial clearance of intracellular calcium and ATP production during neuronal stimulation play a crucial role in neuronal health and in modulating Ca^{2+} -dependent synaptic function. Ca^{2+} enters the mitochondrial matrix via the mitochondrial Ca^{2+} uniporter complex, the pore-forming unit of which is MCU. Ca^{2+} sensitivity to MCU is conferred by MICU1, a mitochondrial intermembrane space protein that helps to keep MCU closed at low $[\text{Ca}^{2+}]$ and supports MCU's cooperative activation as $[\text{Ca}^{2+}]$ rises. Human loss-of-function mutations in MICU1 correlate with learning difficulties, skeletal muscle weakness, and motoric impairment. In mouse models, neuronal MICU1 deficiency is linked to motoric and learning disabilities, myopathy, motor neuron loss, and a reduction in dendritic spine density in the motor cortex. These findings raise a role for MICU1 in synaptic transmission. In the present study, using neuron-specific MICU1 KO mice and culturing full-body MICU1 KO E15.5 primary cortical neurons, it was demonstrated that MICU1 regulation of mitochondrial calcium entry influences local synaptic intracellular calcium buffering and neurotransmitter-vesicle fusion during synaptic activity. It was found that WT and KO neurons had similar global cytoplasmic $[\text{Ca}^{2+}]$ responses during electrical stimulation (ES). In KO neurons, a mitochondrial matrix $[\text{Ca}^{2+}]$ ($[\text{Ca}^{2+}]_m$) rise ensued even at a 50 nM increase in $[\text{Ca}^{2+}]_c$ upon low-pulse (10-30) field stimulation (20V, 10Hz), and it was tightly coupled to the $[\text{Ca}^{2+}]_c$ increase. In WT neurons, high-pulse (150) field stimulation (40V, 20Hz) was required for a $[\text{Ca}^{2+}]_m$ rise, and it lagged behind the $[\text{Ca}^{2+}]_c$ rise. Furthermore, at the sub-optimal field stimulation, the presynaptic local $[\text{Ca}^{2+}]_c$ rise was attenuated by the presence of mitochondria in KO neurons but not in WT. Also, the cytoplasmic ATP: ADP ratio showed a tendency for lower resting ATP/ADP and a larger decrease during ES in KO neurons. Moreover, synaptic (SV) fusion was suppressed in KO neurons at all the ES parameters used; particularly, the secretory response evoked by repetitive suboptimal ES seemed to be greatly inhibited in KO neurons. Notably, the ES-evoked SV fusion at the boutons lacking mitochondria was not different between WT and KO, while mitochondrial presence suppressed SV fusion immensely in KO. In addition, blocking reacidification of alkaline trapped vesicles by bafilomycin-A1 led to a larger maximal ES-evoked secretory response in WT than KO, suggesting that exocytosis per se is affected in MICU1 KO neurons. Our results shed light on the specific role of MICU1-gated mitochondria in regulating Ca^{2+} -dependent neurotransmitter vesicle exocytosis, unravelling an intricate connection between mitochondrial Ca^{2+} control and synaptic transmission.

Keywords: Intracellular calcium, MICU1, ATP: ADP ratio, synaptic transmission

From Atoms to AI and the Future of Scientific Discovery

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Abstract

Artificial intelligence (AI) is transforming scientific discovery by enabling researchers to explore complex chemical and materials spaces, identify hidden relationships, and accelerate the search for new knowledge and sustainable solutions. However, high predictive performance alone does not guarantee meaningful or trustworthy science. The scientific value of AI depends on how physical and molecular systems are represented, how rigorously models are validated, and whether their predictions can be translated into interpretable scientific insight.

This work explores these principles through four case studies spanning materials science, chemistry, and molecular informatics. First, prediction of the excited-state energy of Mn⁴⁺-doped red phosphors demonstrates how physics-informed descriptors can connect machine learning predictions with luminescent behaviour. Second, a study of Li-ion battery cathode materials shows how apparently excellent predictive performance can decline substantially under rigorous, duplicate-aware evaluation, highlighting the importance of independent validation. Third, prediction of the electronic dielectric constant of oxide materials demonstrates how explainable AI can reveal physically meaningful relationships between material descriptors and electronic response. Finally, cross-domain classification of peptides, plastics, and oligonucleotides illustrates how a standardised molecular representation can provide a common numerical language across chemically diverse systems. Together, these studies highlight three foundations for trustworthy AI-enabled discovery: meaningful representation, rigorous validation, and scientific interpretation. Rather than replacing scientific reasoning, AI can strengthen it by connecting data, prediction, explanation, and domain knowledge. This integration offers a pathway toward faster, more reliable, and more sustainable scientific discovery across materials, molecular science, biotechnology, and related fields.

Keywords: Artificial Intelligence, Scientific Discovery, Molecular Representation, Explainable AI, Sustainable Materials.

AI-Based Predictive Analytics for In Vitro Fertilisation (IVF) Outcomes

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Abstract

Infertility is a growing global health concern affecting males as well as females. To combat this, *In Vitro* Fertilisation (IVF) has become one of the most widely adopted assisted reproductive technologies. Despite continuous research in clinical protocols, IVF success rates remain low due to the complexity of demographic, biological, clinical, and lifestyle-related factors. Accurate prediction of IVF outcomes before treatment can improve patient counselling, optimise clinical decision-making, and reduce the emotional and financial burden associated with repeated treatment cycles. This study proposes an Artificial Intelligence (AI)-based predictive analytics framework to identify the key determinants of successful IVF procedures and to develop an interpretable prediction model using the available routine patient data. The study will utilise clinical datasets obtained from publicly available repositories and published literature. Variables including female and male age, body mass index (BMI), menstrual regularity, polyendocrine metabolic ovarian syndrome (PMOS), stress level, smoking, alcohol intake, sperm count, sperm motility, duration of infertility, treatment type, and pregnancy outcome will be analysed. Data preprocessing will involve cleaning, handling missing values, encoding categorical variables, and feature selection. In addition, the study explores the integration of Small Language Models (SLMs) as lightweight, domain-specific AI assistants to complement predictive analytics. Unlike large language models, SLMs can be fine-tuned on reproductive medicine datasets to summarise patient records, assist in feature extraction from clinical notes, explain prediction outcomes in clinically understandable language, and support personalised patient counselling while maintaining computational efficiency and enhanced data privacy. The proposed framework of SLM-based clinical decision support aims to improve model interpretability, accessibility, and application in fertility clinics. The findings are expected to identify significant predictors of IVF success, demonstrate the potential of AI-driven decision support in reproductive medicine, and provide a scalable foundation for future intelligent, patient-centred fertility management systems.

Keywords: *In-Vitro* Fertilisation (IVF), Polyendocrine Metabolic Ovarian Syndrome, predictive analytics, small language models (SLMs).

Genome-wide Analysis and Functional Validation of the Rice Isopentenyl Transferase (IPT) Gene Family Reveal the Role of *OsIPT9* in Enhancing Abiotic Stress Tolerance

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Abstract

Cytokinins are key phytohormones regulating plant growth, development, photosynthesis, senescence, and responses to abiotic stresses. Stress-induced reduction in cytokinin levels adversely affects crop productivity, necessitating strategies to sustain cytokinin biosynthesis under adverse conditions. In this study, a comprehensive genome-wide analysis of the Isopentenyl Transferase (*IPT*) gene family, encoding the rate-limiting enzymes in cytokinin biosynthesis, was performed in rice (*Oryza sativa* L.). Ten *OsIPT* genes were identified and characterised through phylogenetic relationships, chromosomal distribution, gene structure, conserved motifs, protein domains, cis-regulatory elements, and synteny analyses. Expression profiling revealed distinct tissue-specific and stress-responsive expression patterns, with *OsIPT9* showing predominant shoot expression and strong regulation under abiotic stress, identifying it as a promising candidate for functional validation. Accordingly, the endogenous *OsIPT9* gene was cloned from the drought-tolerant cultivar *Nagina 22* and expressed in rice cultivar *MTU1010* under the stress-inducible *AtRD29A* promoter via *Agrobacterium*-mediated transformation. Transgenic plants were confirmed by PCR, Southern blot, and qRT-PCR analyses. Under drought and salinity stress, *OsIPT9* overexpressing lines exhibited enhanced water retention, chlorophyll preservation, membrane stability, delayed senescence, and improved root architecture, resulting in sustained photosynthetic performance through protection of *RuBisCO* and Photosystem II complexes, stable V_{max} , J_{max} , and F_v/F_m , reduced stomatal density, and increased leaf thickness. These physiological and anatomical adaptations significantly improved spikelet fertility and grain yield under stress compared with wild-type plants. This integrated study provides comprehensive insights into the evolution and expression of the rice *IPT* gene family and demonstrates that *OsIPT9* is a promising genetic target for developing climate-resilient, high-yielding rice cultivars.

Keywords: Phylogenetic relationship, conserved motifs, Cytokinin Overexpression, Drought and Salinity Tolerance, Grain yield, Photosynthesis.

Nano-Enabled Sustainable Agriculture: Transforming Crop Production for a Climate-Resilient Future

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Abstract

Agriculture is facing increasing challenges from climate change, water scarcity, soil degradation, declining nutrient-use efficiency, and the growing demand for food from a rapidly expanding population. In this context, nanotechnology has emerged as a promising approach for developing sustainable and climate-resilient agricultural systems. Green nanotechnology, particularly the synthesis and application of plant-derived nanoparticles and nanobioconjugates, offers environmentally friendly alternatives to conventional agrochemicals and fertilisers. Nanomaterials can enhance nutrient-use efficiency, improve seed germination and plant growth, regulate physiological and biochemical responses, and increase crop tolerance to abiotic stresses such as drought, salinity, and temperature extremes. Nano-enabled fertilisers and biostimulants can facilitate controlled and targeted delivery of essential nutrients, thereby reducing nutrient losses and minimising environmental contamination. Similarly, nano-based pesticides and disease-management approaches can improve efficacy while potentially reducing chemical inputs. Integration of nanotechnology with precision agriculture, smart sensing, and controlled-release systems can further optimise the application of water, nutrients, and crop-protection agents. However, the long-term environmental fate, nanoparticle–plant interactions, soil microbiome effects, toxicity, and economic feasibility require careful assessment before large-scale adoption. Therefore, responsible development and application of green nanotechnology can contribute significantly to sustainable intensification of agriculture, improved resource-use efficiency, enhanced climate resilience, and global food security. Future research should focus on eco-friendly synthesis, field-scale validation, biosafety assessment, and the development of multifunctional nanomaterials tailored to specific crops and environmental stresses.

Keywords: Green nanotechnology, sustainable agriculture, nanofertilizers, nanobioconjugates, climate resilience, nutrient-use efficiency, abiotic stress, precision agriculture, food security.

Antibacterial Potential of Treated and Untreated Pomegranate Peel with Apple Cider Vinegar

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Abstract

Pomegranate (*Punica granatum*) cultivation has increased significantly due to its well-recognised medicinal properties and health-promoting benefits. In addition to the edible fruit and juice, pomegranate peel, a major byproduct of the food processing industry, is rich in bioactive compounds, including phenolic compounds, tannins and flavonoids. These phytochemicals possess strong antioxidant and broad-spectrum antibacterial activities. The present study aimed to evaluate the antibacterial potential of pomegranate peel extracts against urinary tract infection (UTI) pathogens. Antibacterial activity was assessed using the agar disc diffusion method, comparing untreated peel extracts with treated peel extracts with apple cider vinegar. Furthermore, different extraction methods for phytochemicals were employed to determine their impact on antibacterial efficacy. The findings from this research will provide valuable insights for the food processing and pharmaceutical industries, highlighting the potential utilisation of pomegranate peel as a natural antimicrobial agent with practical applications in both industry and daily life.

Keywords: Antimicrobial activity, Phytochemicals, Tannins, Flavonoids, Apple cider vinegar

NeuroFlow AI: Revolutionising Neural Data Interpretation and Research Workflow Automation

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Abstract

Rapid development of neural recording technology has produced massive volumes of brain signal data, leading to an increasing need for accessible and effective computational analysis tools. But current brain data analysis methods often depend on several software platforms, laborious preparation, and specialised skills, restricting their accessibility for researchers, physicians, and students. We present NeuroFlow AI, an explainable AI-based online platform that facilitates interpretation of brain data using a unified research process. The platform allows users to organise research projects, upload neural datasets securely, visualise brain signals via interactive dashboards and get AI-assisted advice during the process of analysis. A key feature of NeuroFlow AI is its Multi-Agent AI architecture, in which specialised AI agents collaboratively perform data quality assessment, preprocessing recommendations, analysis guidance, result interpretation, and automated report generation to provide context-aware and explainable assistance throughout the research workflow. A conversational AI assistant explains signal properties, visualisation findings, and workflow choices in a human-readable manner, boosting transparency and usability. This AI also suggests preprocessing pipelines depending on the features of the dataset and automatically provides structured reports that summarise signal quality, analysis techniques, visualisation outputs and AI-generated interpretations. Its workflow memory architecture utilises previously effective analytical methodologies to provide context-aware and explainable suggestions, contributing to reproducibility and consistency in neuroscience research. Instead of presenting a novel neural decoding technique, NeuroFlow AI shows how explainable AI may improve research efficiency, interpretability, and decision-making in computational neuroscience.

Keywords: Computational Neuroscience, Multi-Agent AI, Explainable Artificial Intelligence, Brain Signal Analysis.

Micropropagation of *Malus domestica* L.: An Efficient Protocol for In Vitro Regeneration via Nodal Explants

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Abstract

Micropropagation is an essential technique for the rapid multiplication of genetically uniform and disease-free planting material. This study aimed to establish an efficient in vitro regeneration protocol for green apple (*Malus domestica* L.) using nodal explants cultured on Murashige and Skoog (MS) medium. Surface-sterilised nodal segments were inoculated onto MS medium supplemented with varying concentrations of plant growth regulators (PGRs) and maintained at 28°C under controlled conditions. Results revealed that the combination of naphthalene acetic acid (NAA) and kinetin significantly enhanced callus induction and shoot proliferation compared to other treatments. Bud initiation was successfully observed within three weeks, and plantlet development progressed efficiently to the four-leaf stage. These findings demonstrate that nodal culture provides a reliable method for large-scale production of *Malus domestica*, supporting germplasm conservation and facilitating future improvements in apple cultivation.

Keywords: *Malus domestica*, Micropropagation, Plant Tissue Culture, Nodal Explants, MS Medium, In Vitro Culture, Callus Induction, Plant Growth Regulators

AI-Enabled Data-Driven Discovery of Novel Therapeutic Peptides

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Abstract

The rapid advancement of artificial intelligence (AI) is transforming therapeutic discovery by enabling data-driven approaches to identify, design, and optimise novel peptide-based therapeutics. Therapeutic peptides offer significant advantages, including high specificity, potency, and biological activity, but their discovery remains challenging due to the vast sequence space and complex relationships between peptide sequence, structure, stability, and function. AI and machine learning approaches can analyse large-scale biological and chemical datasets to uncover hidden patterns, predict important peptide properties, and prioritise promising candidates for further investigation. Deep learning and generative AI can further facilitate the de novo design of novel peptide sequences with desired functional and physicochemical characteristics. Integration of AI with bioinformatics, structural prediction, molecular docking, molecular dynamics simulations, and computational chemistry provides a powerful framework for evaluating peptide candidates and reducing the time and resources required for experimental screening. This talk will highlight the emerging role of AI-enabled data-driven strategies in peptide discovery, covering key aspects of data curation, feature representation, predictive modelling, generative design, structural evaluation, and candidate prioritisation. It will also discuss major challenges, including data quality, model interpretability, biological validation, generalizability, and the translation of computational predictions into experimentally validated therapeutics. The convergence of AI, computational biology, structural bioinformatics, and emerging computational technologies has the potential to accelerate the discovery of next-generation therapeutic peptides and contribute to more efficient, precise, and personalised approaches to modern drug discovery.

Keywords: Therapeutic Peptides; Machine Learning; Deep Learning; Generative AI; Data-Driven Drug Discovery; Peptide Design.

Beyond Trial and Error: AI-Driven Enzyme Engineering as the Future of Industrial Biotechnology

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Abstract

Microbial enzymes are enzymes that are produced by microorganisms like bacteria, fungi, and yeast. There are different types of microbial enzymes, which are essential for the production of various industrial products. These enzymes help to speed up various biological and chemical processes, which in turn are beneficial for us to get rapid and environmentally safer production of products, but with this come some problems. A gap this industry faces due to traditional processes is Trial and Error. But as every problem has its solution, this one can also be solved and improved with the help of Artificial Intelligence (AI). It is the ability of a computer or a machine to perform tasks that require human intelligence. With this revolutionary concept, more efficient, stable and functional enzymes can be obtained. As with traditional processes, we tend to rely on iterative experimental approaches, which require human intelligence and are time-consuming. AI, particularly machine learning and deep learning models are used, which enables researchers to predict enzyme structure, function and substrate specificity by analysing large-scale biological datasets. AI-driven approaches are widely applied in drug development, industrial biocatalysis and environmental sustainability. However, there are a few challenges that still remain, such as limited data quality. Enzyme engineering with AI represents a transformative approach enabling the development of efficient, sustainable and high-performance biocatalysts.

Keywords: AI-powered Enzyme Engineering, Sustainable Biotechnology, Industrial Biocatalysis

Machine Learning and Artificial Intelligence for Next-Generation Nanocatalyst Designing

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Abstract

Global challenges in sustainable chemical manufacturing, energy conversion to clean energy, environmental remediation, and pharmaceutical synthesis are all key areas where materials containing high-performance nanocatalysts can help solve these problems. The traditional catalyst development process is, however, still very labour-intensive, time-consuming, and dependent on trial-and-error experiments. With revolutionary advances in machine learning (ML) and artificial intelligence (AI), nanocatalyst research is now transforming to predict, rationally design and optimise catalytic materials with unprecedented accuracy and efficiency. This review aims to comprehensively summarise advancements in the use of AI and ML for next-generation nanocatalyst design, covering the entire catalyst development cycle from materials discovery to catalytic performance prediction and the interpretation of catalytic mechanisms. The uses of supervised, unsupervised, reinforcement and deep learning algorithms and their related models, such as graph neural networks, generative models and explainable AI, for predicting catalyst composition, morphology, electronic structure, active sites, and stability and reaction selectivity are critically discussed.

Keywords: Machine learning; Artificial intelligence; Nanocatalysts; Catalyst design

Democratizing Bio-AI for Indian Agriculture: A Phygital Framework for Empowering Digitally Excluded Smallholders and Livestock Farmers

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Abstract

Despite the rapid advancement of Artificial Intelligence (AI) in global agriculture, a deep "farm-tech divide" persists in developing nations like India, where over 80% of farming relies on small and marginal landholders. Cutting-edge AI-Biotech solutions exist for precision crop and livestock health monitoring. They remain virtually inaccessible to the 99% of remote, small-scale farmers who lack basic digital literacy and financial capital. In this study, we have proposed a highly realistic, "phygital" (physical + digital) framework to bridge this last-mile gap. Rather than pushing complex, individual-user mobile applications, we advocate for a community-shared infrastructure model. Under this framework, technology acquisition is centralised through local Farmer Producer Organisations (FPOs) and Krishi Vigyan Kendras (KVKs), who serve as trusted physical intermediaries. Furthermore, we outline the deployment of voice-first, multilingual Generative AI advisory tools leveraging indigenous regional languages to convert complex computational data into simple, actionable farming practices. By integrating low-cost, shared wearable sensors for livestock with simplified visual crop-stress AI diagnostics, this model demonstrates how rural communities can achieve true sustainability. Ultimately, this research argues that the success of the next agricultural revolution depends not on the complexity of the AI model, but on its democratic accessibility to the marginal farmer.

Keywords: Artificial Intelligence (AI), AI in Agriculture and Farming

Sustainable Bio-Based Food Wrapping from Sugarcane Bagasse

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Abstract

In the current era of rapid living, the pursuit of healthy eating frequently clashes with the need for convenience. Ready-made meals and easy-to-carry lunchboxes have become commonplace, yet the materials used for food packaging are seldom scrutinised. Traditional options such as plastic wraps and aluminium foil come with hidden drawbacks. Plastic remains in the environment for hundreds of years, while producing aluminium requires significant energy and releases greenhouse gases. Although foil can technically be recycled, contamination in households often prevents its reuse, contributing to landfill accumulation. To tackle these issues, this research presents an environmentally friendly food wrapping paper made from sugarcane bagasse. Bagasse, a fibrous byproduct of the sugar industry, is abundant, economical, and renewable. Converting this agricultural residue helps reduce industrial waste while supporting the principles of Zero-Waste and the Circular Economy. Unlike conventional packaging materials, the newly developed bio-paper integrates multiple protective and regenerative properties. It is fortified with natural antibacterial extracts to ensure food safety and includes a moisture indicator that changes colour to track freshness. In addition to its practical use, the material is designed for a sustainable end-of-life: chia seeds are embedded within its structure. When disposed of in soil, the biodegradable paper breaks down into compost, allowing the seeds to sprout and transforming consumer waste into new plant life. This innovative, plantable packaging showcases eco-friendly design by integrating safety, sustainability, and practicality. It provides an effective answer to contemporary packaging issues, minimising environmental damage while encouraging better food storage methods.

Keywords: Sugarcane Bagasse, Biodegradable Wrapping, Antibacterial Packaging, Freshness Indicator, Plantable Paper, Sustainable Innovation

Eco-Friendly Chromium Bioremediation of Tannery Effluent Using Indigenous Microbial Isolates

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Abstract

In India, about 3,000 tanneries process 700,000 tons/year of hides and skins, polluting rivers with chromium, exceeding the permissible concentration of 0.05 mg/L in drinking water, posing a major threat to the ecosystem. A yellow-colored Gram-positive bacterial strain APG-4, isolated from Jajmau (Kanpur) tannery effluent, was identified as *Staphylococcus saccharolyticus* strain APG-4, capable of remediating 81.6% of Cr(VI) in 44 hours at 37 °C from LB media having Cr Concentration 400 mg/L at pH 7 with specific growth rate 0.4213 hr⁻¹, Doubling Time 1.6449 hour, removal efficiency 81.469%, volumetric rate 145.26 mg/L cells Conc.⁻¹ and removal capacity 7.282 mg/L/hour. Its MIC is 3500 mg/L for Cr, and during bioremediation, its pH is reduced from 7.6 to 7.3. It involves Cytochrome Oxidase, confirmed by NaN₃. It may involve Chromate reductase of 47 kDa in the cytoplasm and 43 kDa in the cell membrane, and SEM shows cells are unconstrained in their shape and size, but not ruptured. Altogether, our results indicate that APG-4 had the potential to reduce chromium from very high concentrations to safe levels in the contaminated environment; thus, it can be effectively used for bioremediation.

Keywords: Bioremediation; Chromium; Chromate Reductase; Tannery.

Bacterial-Mediated Selenium Nanoparticles for Biodegradation of Environmental Plastics

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Abstract:

Future research will involve the use of SeNPs synthesised by bacteria as a new biotechnology approach to the biodegradation of plastic waste in the environment. The selected bacterial strains will transform inorganic forms of selenium into stable nanoscale particles, and these biogenic SeNPs will be exploited to improve microbial activity with recalcitrant polymeric substrates. The study assessed the ability of SeNPs to control enzymatic activity, surface adhesion and oxidative responses of bacteria, which will help to break down persistently bound polyethylene, polypropylene and other polymers. Mechanistic insight is gained by spectroscopic, microscopic and molecular analysis, providing information on how the SeNP–bacteria systems will break polymer chains and generate biodegradable intermediates. The eco-friendly synthesis of SeNPs will reduce toxic by-products, and their biocompatibility will provide a safety perspective for their use in environmental settings. The results showed that the synergistic effect of SeNP–bacteria led to the degradation of plastic faster than the conventional microbial method, which provided a sustainable solution to tackle plastic pollution. The results of this research provided a basis to incorporate nanotechnology and microbial biotechnology in environmental remediation approaches, and promoted bacterial-mediated SeNPs as a potential remediation agent for plastic waste management and ecological restoration.

Keywords: Selenium Nanoparticles, Bacterial Synthesis, Plastic Biodegradation, Environmental Bioremediation.

AI in Biotechnology: Innovation and Application

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Abstract

Artificial Intelligence (AI) has become an important technology in the field of biotechnology. It is changing the way scientists collect, study, and use biological information. AI helps researchers analyse large amounts of data in less time, making research faster, more accurate, and more efficient. Today, AI is being used in many areas of biotechnology, including healthcare, agriculture, genetics, pharmaceutical research, and environmental science. One of the most valuable applications of AI is in drug discovery, where it helps identify new medicines and reduces the time needed for research. In healthcare, AI supports doctors by helping in the early detection of diseases and suggesting suitable treatment options based on patient data. In agriculture, AI is used to monitor crop health, detect plant diseases, improve crop production, and support sustainable farming. It also plays a role in protecting the environment by helping scientists study pollution, climate change, and biodiversity. The combination of AI and biotechnology is creating new opportunities for scientific research and innovation. As both fields continue to grow, AI is expected to improve healthcare, agriculture, and environmental protection even further. This paper provides an overview of the major innovations, applications, benefits, challenges, and future possibilities of AI in biotechnology and highlights its growing importance in solving real-world problems.

Keywords: Sustainable Farming, Healthcare, Drug discovery, AI, Biodiversity

Early-Stage Parkinson's Disease Detection Using Speech-Based Voice Biomarkers: A Threshold-Based Computational Approach

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Abstract

Parkinson's disease is a chronic neurological disorder that primarily influences motor control. It can also affect speech production due to impairment of neuromuscular coordination. Acoustic features extracted from speech can act as detectable markers of motor impairments. These features can help to identify the early stages of the disease. Because clinical diagnosis is usually based on observable motor symptoms that develop during later stages of the disease, it becomes challenging to identify Parkinson's disease at an early stage. Early detection is important, as it helps in managing the symptoms before they worsen. As a result, speech analysis has been considered a promising non-invasive biomarker for early motor impairment. Changes in speech characteristics may indicate early motor dysfunction associated with Parkinson's disease. These minor shifts in speech are often missed by traditional clinical examination, but recent computational techniques have made it possible to analyse these speech changes more effectively. In this study, acoustic features obtained from publicly available datasets were analysed using a threshold-based approach to identify patterns associated with Parkinson's disease. Speech-based features like PPE (Pitch Period Entropy), DFA (Detrended Fluctuation Analysis) and RPDE (Recurrence Period Density Entropy) were used. Analysis of publicly available datasets suggests that voice biomarkers can serve as a non-invasive tool for detecting early-stage Parkinson's disease. The results indicate that this threshold-based approach could provide a simple, low-cost and non-invasive method for the early detection of Parkinson's disease.

Keywords: Parkinson's Disease, Voice Biomarkers, Early Detection, PPE, DFA, RPDE, Threshold-based Approach, Speech-based features.

Potential of Agro Waste Mixture Towards the Bio-Remediation of Cr⁶⁺

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Abstract

Hexavalent Chromium (Cr⁶⁺) is a dangerous pollutant that mainly comes from industries like leather processing, electroplating & dye manufacturing. When it enters water or soil, it can cause serious environmental danger & health issues. Because of this, generating an effective & affordable way for remediation of Cr⁶⁺ is very important. In this study, a simple solution is proposed by finding the potential of agricultural waste materials such as "Rice husk, Wheat husk & Coconut husk". These materials are easily available, low-cost, & naturally contain substances that can bind & remediate harmful metals from contaminated water. Instead of using them separately, the agricultural wastes were combined to see if the mixture would work better. The experiments showed promising results. The agro-waste mixture removed chromium more effectively than individual materials, especially under slightly acidic conditions. Overall, this approach offers a practical and eco-friendly way to clean chromium-contaminated water. It not only helps reduce pollution but also gives a useful purpose to agricultural waste, making it a sustainable solution for environmental protection.

Keywords: Hexavalent Chromium (Cr⁶⁺), Cr⁶⁺-Remediation, Agricultural Waste, Rice husk, Wheat husk, Coconut husk

Effect of Moisture Stress on Morpho-physio and Biochemical Traits in Early Stage of Wheat (*Triticum aestivum* L.)

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Abstract

Wheat (*Triticum aestivum* L.) is a cornerstone of global food and nutritional security, yet its productivity is highly vulnerable to abiotic stresses, particularly waterlogging, which restricts oxygen availability in the root zone and disrupts plant growth, physiology, and yield. In this study, 36 wheat genotypes were evaluated under control and waterlogging conditions during the early growth stage. Key morpho-physiological traits like germination percentage, seedling length, vigour index, root and shoot growth, chlorophyll content, and relative water content were assessed. Additionally, biochemical traits including proline, protein, catalase activity, and malondialdehyde (MDA) were measured to understand adaptive responses. Expression analysis of stress-responsive genes was also performed in contrasting genotypes. Results indicated that waterlogging stress reduced germination, seedling growth, vigour index, chlorophyll, and water content, while proline accumulation and antioxidant enzyme activity increased, reflecting activation of protective mechanisms. Significant genetic variability was observed, with genotypes such as DWR303, DBW39, DBW327, DBW222, DBW370, HD3090, and DBW14 showing superior tolerance, whereas HD2609, HD3385, and DBW187 were more susceptible. The integration of morphological, physiological, biochemical, and molecular traits proved effective in identifying waterlogging-tolerant genotypes. These tolerant lines represent valuable genetic resources for breeding climate-resilient wheat cultivars capable of sustaining productivity under excess moisture conditions.

Keywords: *Triticum aestivum*, Waterlogging, Morpho-physiological traits, Biochemical traits, Waterlogging tolerance

AI-Driven BioBricks for Sustainable Biotechnology

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Abstract

AI-Driven BioBricks represent an emerging approach in synthetic biology that combines artificial intelligence (AI) with standardised genetic parts (BioBricks) to develop efficient, sustainable, and environmentally friendly biological systems. BioBricks are reusable DNA sequences that can be assembled to engineer microorganisms for applications such as biofuel production, bioremediation, carbon capture, bioplastics, and sustainable agriculture. AI accelerates the design-build-test-learn (DBTL) cycle by predicting gene functions, optimising metabolic pathways, selecting suitable genetic components, and reducing experimental time and cost. This integration improves the accuracy and efficiency of engineered biological systems while minimising resource consumption and waste. AI also enables real-time analysis of biological data, helping researchers develop high-performing microbial strains for industrial biotechnology. These innovations support circular bioeconomy principles by replacing fossil-based processes with renewable biological alternatives. Despite challenges such as data quality, biosafety, ethical concerns, and regulatory requirements, AI-driven BioBricks have the potential to transform sustainable biotechnology. As AI and synthetic biology continue to advance, their integration will play a crucial role in addressing global challenges related to energy, climate change, pollution, and sustainable manufacturing.

Keywords: Artificial Intelligence; Deoxyribonucleic Acid; Design–Build–Test–Learn BioBricks

Artificial Intelligence in Sustainable Biotechnology: Emerging Trends, Opportunities, and Future Challenges

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Abstract

Artificial Intelligence (AI) has revolutionised sustainable biotechnology, shifting the domain from empirical experimentation to predictive engineering. This review paper synthesises the paradigm shift facilitated by machine learning (ML), deep learning (DL), and generative AI architectures between 2000 and 2026. We examine how computational workflows expedite metabolic pathway engineering, protein folding, ecological remediation, and precision agricultural frameworks. By systematically mapping biological data landscapes, AI minimises structural resource waste, accelerates the commercial feasibility of the circular bioeconomy, and mitigates climate change stressors. However, data interoperability gaps, model uninterpretability ("black-box" systems), and dual-use biosecurity risks present systemic bottlenecks. This paper details these foundational shifts, compiles multi-domain breakthroughs, and proposes structural directions for future physics-informed, open-source biological intelligence frameworks.

Keywords: Artificial Intelligence, Sustainable Biotechnology, Generative Molecular Design, Circular Bioeconomy, Metabolic Engineering, Precision Agriculture, Digital Twins, Biosecurity.

Pretreatment Technology: A Versatile Strategy for Effective Utilisation of Lignocellulosic Biomass

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Abstract

Lignocellulosic materials represent one of the largest potential biomass resources for future energy, feeds, and chemical production. Lignocellulosic biomass is a heterogeneous complex of carbohydrate polymers and lignin (a complex polymer of phenylpropanoid units). The crystalline structure and lignin presence in lignocellulosic materials prevent attack by microorganisms. In order to develop an economically viable technical process, these difficulties must be overcome by a suitable mechanical and chemical pretreatment. An efficient pretreatment must free the highly crystalline structure of cellulose and extend the amorphous areas. The goal of any pretreatment process technology is to alter or remove structural and compositional impediments to hydrolysis in order to improve the rate of enzyme hydrolysis and increase the yields of fermentable sugars from cellulose or hemicellulose, or break the lignin seal and disrupt the crystalline structure of cellulose. Pretreatment may increase the surface area of cellulose, thereby enhancing its reactivity with the enzymes. Pretreatment is necessary to achieve reasonable rates and yields in the enzymatic hydrolysis of biomass. The ultimate aim of the pretreatment process is to separate the carbohydrates from the lignin matrix while minimising chemical destruction of fermentable sugars required for chemical and fuel production. The various pretreatment methods, such as mechanical reduction, uncatalysed steam explosion, hydrothermolysis, dry and wet ball milling, acid hydrolysis, alkaline hydrolysis and their mode of action are described in this review paper. The objective of this review is to find out which pretreatment method will be most successful and attractive to apply for effective utilisation of lignocellulosic biomass.

Keywords: Physical Pretreatment, Chemical Pretreatment, Lignocellulosic biomass, Lignin

Anuvamsha Vijnana: An AI-Assisted Web Platform for Integrated Prenatal Genomics Analysis and Clinical Decision Support

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Abstract

Prenatal genomic analysis plays a crucial role in the early detection of fetal genetic abnormalities; however, existing bioinformatics workflows often require multiple software tools, command-line expertise, and extensive technical knowledge, limiting their accessibility to many researchers and clinicians. In this work, we present Anuvamsha Vijnana AI, an AI-assisted web platform designed to simplify and integrate prenatal genomics analysis within a unified, user-friendly environment. The proposed platform combines essential bioinformatics workflows, including sequencing data upload, quality assessment, sequence alignment, variant analysis, and result visualisation, with artificial intelligence to generate clinically interpretable summaries and assist in genomic report interpretation. Unlike general genomics platforms, Anuvamsha Vijnana AI incorporates prenatal-specific AI decision support designed to support NIPT, fetal genomics, and prenatal risk interpretation through clinically interpretable explanations and AI-assisted insights. Unlike conventional fragmented workflows, Anuvamsha Vijnana AI provides an interactive dashboard that enables users to monitor analysis progress, visualise results, and obtain AI-supported explanations without requiring advanced bioinformatics expertise. The platform is intended to bridge the gap between complex computational pipelines and practical clinical applications by improving accessibility, workflow efficiency, and interpretability. As a prototype, it demonstrates the feasibility of integrating bioinformatics and AI into a single web-based system that supports prenatal genomic research and future AI-enabled precision healthcare.

Keywords: Prenatal Genomics, Bioinformatics, Artificial Intelligence, Clinical Decision Support.

Artificial Intelligence in Drug Discovery: Transforming Challenges into Opportunities

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Abstract

Artificial Intelligence (AI) is transforming the field of drug discovery by accelerating the identification, design, and development of novel therapeutic molecules. Conventional drug discovery is a lengthy, expensive, and complex process with a high rate of clinical failure. AI technologies, including machine learning, deep learning, and predictive analytics, enable rapid analysis of large biological and chemical datasets, improving target identification, virtual screening, lead optimisation, and prediction of drug efficacy and toxicity. These computational approaches significantly reduce the time and cost involved in drug development while enhancing the accuracy of decision-making. AI has also demonstrated remarkable potential in drug repurposing, precision medicine, and personalised healthcare, contributing to faster therapeutic development and improved patient outcomes. Despite its numerous advantages, challenges such as data quality, model interpretability, ethical concerns, and regulatory acceptance continue to influence its widespread adoption. Continued advancements in AI, coupled with interdisciplinary collaboration between biotechnology, pharmaceutical sciences, and computational research, are expected to overcome these limitations and revolutionise the future of healthcare by enabling the development of safer, more effective, and patient-centred medicines.

Keywords: Artificial Intelligence (AI), Drug Discovery, Machine Learning, Precision Medicine, Drug Repurposing, Healthcare

Artificial Intelligence-Driven Robotic Surgery: Transforming Precision and Decision-Making in Modern Cancer Care

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Abstract

The field of cancer surgery is undergoing revolutionary changes due to the development of robot-assisted surgical instruments and artificial intelligence (AI). Machine learning, deep learning, and computer vision techniques of AI have made improvements in all phases of surgical oncology. Algorithms that are powered by artificial intelligence are able to analyse medical images, determine the boundaries of tumours, evaluate the risks associated with surgical procedures and provide support for personalised treatment planning before surgical procedures. Surgeons can execute more precise tumour resections during robotic treatments while maintaining healthy tissues and lowering surgical complications with the help of AI-assisted navigation, real-time anatomical recognition, motion tracking and enhanced visibility. AI predictive models can be effective for postoperative monitoring, complication prediction and personalised management of patients. Innovations such as autonomous robotic assistance, telesurgery, digital twins and AI-driven surgical skill evaluation have the capacity to enhance surgical efficiency, training, and accessibility to specialised care, but there are still several hurdles that must be cleared, including lack of quality data sets, algorithmic transparency, cybersecurity concerns, ethical/legal issues, regulatory requirements, and the need for comprehensive multicenter clinical validation. AI can be seen as more of a clinical decision support system and not a replacement for the knowledge of surgeons in surgery.

Keywords: Artificial Intelligence, Robotic Surgery, Surgical Oncology, Machine Learning, Precision Oncology.

Artificial Intelligence in Food Safety and Quality Control Facilitation

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Abstract

Food safety is one of the major global concerns these days because of the frequent and increasing episodes of foodborne diseases, microbial contamination, and quality deterioration throughout the food supply chain. In the past few years, artificial intelligence has emerged as innovative equipment that enhances food safety through intelligent surveillance, rapid detection, predictive analysis, and automated decision-making. Certain studies concluded that artificial intelligence, with its highly upgraded monitoring system, significantly improves the surveillance process that includes: (i) timely pathogen detection, (ii) contamination prediction, (iii) food quality inspection, (iv) shelf-life estimation, (v) traceability, and (vi) supply chain monitoring while minimising human error and enhancing the speed and accuracy of decision-making. However, the implementation of artificial intelligence tools is assisted by several demerits that include: (i) limited availability of high-quality datasets, (ii) implementation costs, (iii) data privacy concerns, and (iv) regulatory challenges, which might probably continue to restrict the widespread adoption of these technologies. Therefore, it can be concluded that artificial intelligence has immense potential to transform and revolutionise modern food safety systems by allowing precise, efficient, and real-time monitoring, hence boosting sustainable food production, consumer protection, and improved global food security.

Keywords: Artificial Intelligence, Food Safety, Machine Learning, Food Quality.

AI in Cancer Detection

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Abstract

Globally, cancer is one of the leading causes of death. To guarantee better results and increase the patient's chances of survival, early cancer detection is therefore necessary. Artificial Intelligence (AI) is one of the latest technologies being employed in cancer detection since it enables quick and effective clinical decision-making using data. Massive medical data sets can be processed using AI techniques like machine learning (ML) and deep learning (DL). Artificial intelligence-based diagnostic technologies improve the accuracy of diagnosis by helping medical professionals find any potential anomalies that would be missed by routine testing. These systems are able to identify various cancer types in their early stages, diagnose them, predict how a particular disease will progress, and create suitable treatment regimens. Breast, lung, colorectal, prostate, skin, and cervical cancer are just a few of the cancers that artificial intelligence has been used to diagnose. Additionally, by merging individual data, artificial intelligence contributes to personalised therapy. Despite the numerous advantages, the successful use of AI in oncology necessitates the utilisation of high-quality data sets, sufficient model validation, and appropriate application of AI technology. For AI systems to be used in the profession, issues including data privacy, biases, transparency, and the requirement for regulation must be resolved. In conclusion, through more accurate diagnosis, early therapeutic interventions, and individualised patient care, artificial intelligence is transforming cancer detection. Oncology will benefit much more from additional scientific study and advancements in AI technology.

Keywords: Artificial Intelligence, Cancer Detection, Machine Learning, Deep Learning, Medical Imaging, Early Diagnosis.

Phenobarbital in Alcohol Withdrawal Management: Dual GABA-Glutamate Modulation for Superior Control

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Abstract

Alcohol Withdrawal Syndrome (AWS) is a critical manifestation of central nervous system maladaptation following the cessation of chronic alcohol use, driven by a neurochemical imbalance of reduced GABAergic inhibition and excessive glutamatergic excitation. While benzodiazepines remain the standard treatment, their limitations in severe and refractory cases, including high cumulative dosing requirements and associated respiratory risks, have prompted a re-evaluation of therapeutic strategies. This critically analyses the pathophysiology of AWS and advocates for the integration of phenobarbital into modern management protocols. Unlike benzodiazepines, phenobarbital acts through a dual mechanism: it enhances GABA-A receptor activity and simultaneously inhibits AMPA and kainate glutamate receptors, providing broader neurochemical stabilisation. Additionally, its prolonged half-life (80–120 hours) offers a natural "auto-tapering" effect that prevents rebound withdrawal and minimises dosing frequency. Synthesised clinical evidence demonstrates that phenobarbital-based protocols, particularly when used for front-loading or in refractory cases, significantly improve outcomes compared to benzodiazepine monotherapy. Specific benefits include reduced ICU admission rates, decreased need for mechanical ventilation, and shorter hospital lengths of stay. The review concludes that shifting from empirical sedation to mechanism-based stabilisation using phenobarbital represents a safer, more resource-efficient approach for managing the global burden of severe AWS, provided that structured safety monitoring is maintained.

Keywords: Alcohol Withdrawal Syndrome, Benzodiazepines, Phenobarbital, GABA-A Receptor

Effect of Biopesticide on the Growth and Yield of Tomato (*Solanum lycopersicum*)

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Abstract

This research investigated how bio pesticides influence tomato plant growth and productivity. With growing concerns over the environmental impact of synthetic chemicals, the agricultural sector is shifting toward more sustainable farming practices. This research was conducted to evaluate the potential of bio pesticides as a safer and more sustainable alternative for enhancing tomato crop productivity. During the experiment, tomato plants were treated with varying concentrations of bio pesticide formulations, and their progress was monitored alongside an untreated control group. To provide a detailed analysis, we recorded several key growth parameters, including plant height, leaf count, the time required for flowering, and the final fruit yield. The collected data showed a clear positive impact of bio-pesticides on plant vigour, with treated plants displaying significantly greater foliage density and higher fruit production compared to the control group. Furthermore, there was a substantial reduction in pest activity in the treated sections, demonstrating that these biological agents act effectively as both growth enhancers and natural protectors. Our findings suggest that adopting bio-pesticides in tomato cultivation is a viable and eco-friendly strategy that can improve yields while maintaining long-term soil health.

Keywords: Bio-pesticides, Tomato (*Solanum lycopersicum*), Growth Parameters, Soil Health

Role of AI in drug discovery and precision medicine

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Abstract

By addressing the limitations of conventional approaches, artificial intelligence (AI) is transforming drug development and personalised medicine. Unlike traditional predictive AI, advances in generative AI enable quick chemical development, improvement of drug candidates, and generation of customised treatment programs. The many Generative AI architectures such as GANs, VAEs, Transformer models, and Diffusion models, as well as their uses in drug discovery, including molecular generation, target identification, drug repurposing, and clinical trial optimisation, are examined in this review. It also highlights the use of generative AI in precision medicine, including the identification of biomarkers and the prediction of illness risk. To guarantee the safe application of AI in healthcare, important issues such as data quality, model interpretability, privacy, and clinical validation must be resolved. The review also discusses emerging trends like explainable AI, multimodal learning, federated learning, and human-AI collaboration.

Keywords: Generative AI; Drug discovery; Precision medicine; Explainable AI

Diagnostic Biomarkers of Alzheimer's Disease: Current Status and Future Approaches

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Abstract

Alzheimer's disease (AD) is a progressive neurodegenerative condition and the most common cause of dementia globally, marked by the buildup of amyloid-beta ($A\beta$) plaques, abnormal tau phosphorylation, and loss of synaptic integrity. One of the biggest hurdles in managing AD is achieving an early and reliable diagnosis, since the underlying neuropathology typically begins well before clinical symptoms appear. Conventional diagnostic methods such as cerebrospinal fluid (CSF) testing and positron emission tomography (PET) scanning, while highly specific, remain constrained by their invasive nature, elevated cost, and limited availability in routine clinical settings. As a result, growing attention has turned toward developing minimally invasive biomarker assays using accessible biological fluids, including blood, saliva, tears, and urine. Prominent biomarkers being explored include the $A\beta_{42/40}$ ratio, phosphorylated tau variants (p-tau181 and p-tau217), neurofilament light chain (NfL), and glial fibrillary acidic protein (GFAP), together with enzyme-substrate-driven biosensor technologies that allow fast, affordable, and highly sensitive detection. Rather than relying on a single biomarker, multiplex panels that integrate several analytes are gaining preference for their ability to enhance diagnostic precision and distinguish AD from other neurodegenerative disorders. This review examines the present state of AD biomarker research, discusses emerging point-of-care detection technologies, and evaluates how non-invasive biofluid-based diagnostics could support earlier clinical intervention and more effective disease management.

Keywords: Alzheimer's Disease, Biomarkers, Amyloid-Beta, Tau Protein, Biosensors, Non-Invasive Diagnostics

Protein Corona Engineering in Nanoparticles: Implications for Targeting and Toxicity

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Abstract

Nanoparticles possess distinctive physicochemical properties and thus have been recognised as a widely applicable approach for their applications in diagnosis, therapeutics and site-specific drug delivery. Despite this, when nanoparticles are exposed to systemic circulation, they adsorb biomolecules, primarily proteins, which results in the formation of a protein corona, thereby modifying their biological properties. The dynamics of the protein corona significantly affect the biological distribution of nanoparticles, targeting efficacy, cell internalisation, immunological recognition, and clinical efficiency. The unregulated development of the protein corona may lead to unintended effects, but advancements in the tailoring of the protein corona have turned this biological event into a viable strategy for designing nanomedicines. Surface functionalization strategies have been shown to modify protein adsorption, extend circulation time, reduce immunogenic reactions, and improve site-specificity. This review focuses on the mechanisms underlying the generation of the protein corona, the effect of the protein corona on targeting, factors affecting its composition, and engineering strategies to regulate the properties of the protein corona and nanotoxicity.

Keywords: Protein Corona, Protein Corona Engineering, Nanoparticles, Nanotoxicity, Surface Functionalisation

Microbial Metagenomics for Enzyme Mining

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Abstract

The microbial metagenome represents the complete set of genetic material found in a particular environment, including a variety of microorganisms like bacteria, archaea, fungi, and viruses. Unlike traditional microbiology, which often relies on isolating and culturing individual species, metagenomics utilises cutting-edge next-generation sequencing (NGS) to analyse DNA extracted directly from environmental samples. It plays a crucial role in studying microbial ecology, monitoring antimicrobial resistance genes, discovering novel enzymes, human health and disease diagnosis, understanding host–microbe interactions, industrial biotechnology and bioremediation. In microbial research, it enables researchers to assess microbial diversity and identify rare and unculturable species. Overall, metagenomics has revolutionised microbial research by offering a comprehensive understanding of microbial diversity and function. The major area of application of metagenomics is the exploration of novel enzymes from natural habitats. Microbial enzymes have an essential role in the industrial sector. The use of culture-based methods for isolation of enzyme-producing microbial strains results in diversity data of less than 1% of the total microorganisms in the environment; however, data acquired on microbial diversity by Metagenomics has a 99% success rate. Functional metagenomics involves the direct extraction of environmental DNA coupled with expression and activity screening to unlock the catalytic potential of microbial communities that remain uncultured by conventional microbiological techniques. It is widely explored as a valuable tool for sustainable biocatalyst development. Metagenomics, therefore, has become a new concept in microbiology studies to discover new biochemical metabolites that are available in nature and can be utilised in the biotechnology industry. The discovery of novel as well as extremophilic enzymes has been accelerated with the availability of numerous curated databases and advanced analytical tools.

Keywords: Metagenomics, Enzyme Mining, Biocatalysts

Algae – bacteria consortia: An emerging Solution for Sustainable Plastic Waste Management

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Abstract

Most conventional plastics are non-biodegradable and persist in the environment for hundreds of years, accumulating in landfills and water bodies, posing a serious risk to wildlife and potentially to humans. Addressing plastic pollution requires sustainable and efficient alternatives that do not produce secondary pollutants. Traditional methods, such as algae and bacteria consortia, represent a promising biological approach in which photosynthetic algae and plastic-degrading bacteria function synergistically for polymer breakdown. Algae supply oxygen and organic metabolites, while bacteria use it to produce extracellular enzymes that degrade plastic into simpler compounds. These consortia enhance degradation efficiency and minimise environmental impact. Recent studies indicate that such consortia can contribute to waste management and support a circular bioeconomy. Although challenges related to large-scale implementation remain, continued research may enable practical application that harnesses algae bacterial partnership for a sustainable, cost-effective, and environmentally friendly strategy for mitigating the global plastic pollution crisis.

Keywords: Algae-Bacteria Consortia, Plastic Biodegradation, Extracellular Enzymes, Circular Bioeconomy

Green Synthesis of Silver Nanoparticles Using *Ocimum sanctum* (Tulsi) Leaf Extract and Their Antibacterial Activity Against Multidrug-Resistant Bacteria

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Abstract

The rapid spread of multidrug-resistant (MDR) bacteria has become a major global health problem, reducing the effectiveness of traditional antibiotics and pushing the need for safe and environmentally friendly antimicrobial alternatives. One promising approach is the green synthesis of silver nanoparticles (AgNPs) using extracts from medicinal plants. This method is simple, cost-effective, and eco-friendly. The study focuses on *Ocimum sanctum*, commonly known as Tulsi, a plant rich in flavonoids, phenolics, tannins, and terpenoids, which naturally act as reducing and stabilising agents during nanoparticle formation. An aqueous extract from Tulsi leaves will be used to make AgNPs, which will then be tested for their antibacterial activity against multidrug-resistant bacteria. The goal is to show that AgNPs are more effective than the plant extract alone, highlighting the potential of green nanotechnology in developing sustainable antimicrobial solutions to combat antimicrobial resistance. In this research, the aqueous leaf extract of *Ocimum sanctum* will be used to produce nanoparticles, and their antibacterial properties against MDR bacteria will be evaluated. The size, shape, structure, stability, and crystallinity of the nanoparticles will be analysed, and the agar diffusion method will be used to measure their antibacterial effects. The study is expected to demonstrate that AgNPs have greater antibacterial activity compared to the plant extract alone. It also aims to highlight the potential of green nanotechnology in creating eco-friendly antimicrobial agents that can be used in medicine, environmental biotechnology, and food safety.

Keywords: Green Synthesis, Silver Nanoparticles, *Ocimum sanctum*, Multidrug-Resistant Bacteria.

Effect of NaCl on Some Total Secondary Metabolites of *Emblica officinalis* callus Cultured *in vitro*

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Abstract

E. officinalis cotyledons were used as explants. For obtaining callus under various salt stress levels, MS supplemented with 2.0mg/l 2,4-D was prepared. Callus was then subjected to various NaCl concentrations from 50-200 mM NaCl. Callus formation was allowed to take place for a period of six weeks in the dark. Calli from treatments were then harvested and subjected to growth, total phenolics, total flavonoids and total tannin content determinations. Results of the present study have shown that mild salt stress, which was created by the lower sodium chloride concentration, reduced growth with concomitant increase in total phenolics, total flavonoids and total tannins, while the higher salt concentration significantly decreased growth and secondary metabolite accumulation as well.

Keywords: *E. Officinalis*, Total Phenolics, Total Flavonoids

Preparation of Eco-friendly Bioplastic from Lemon and Orange Peels

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Abstract

Plastic pollution is one of the most important environmental concerns due to the persistence of petroleum-based plastics, which adversely affect soil, water, wildlife, and human health. The development of biodegradable and eco-friendly alternatives is therefore vital. This study focused on the synthesis of bioplastic from lemon and orange peels, which are often wasted as kitchen and agricultural waste. These citrus peels are rich in pectin, a natural polymer that serves as the fundamental raw material for bioplastic production. Pectin was extracted using a simple extraction process and combined with starch, glycerol, and citric acid to make biodegradable plastic. Starch strengthened the mechanical strength of the bioplastic, glycerol acted as a plasticiser to promote flexibility, and citric acid increased structural stability. The resulting bioplastic is renewable, eco-friendly, and biodegradable. It reduces plastic waste in the environment by biodegrading spontaneously, unlike traditional plastics. Additionally, this effort encourages fruit peel waste to be used instead of being disposed of. Citrus peels may be turned into practical bioplastic, which promotes sustainable waste management and resource conservation. In this study, a straightforward extraction procedure was used to extract pectin from orange and lemon peels. A thin, biodegradable plastic sheet is created by heating the mixture, pouring it into moulds, and letting it dry. In heavy-duty applications, the bioplastic made from orange and lemon peels might not be able to fully replace traditional plastic. However, it has a promising future in disposable biodegradable packaging, food wrapping and other short-term applications, and further improvements in formulation and manufacturing techniques can increase its strength. Durability and water resistance for wider commercial use. In conclusion, the study shows that lemon and orange peels can be considered as low-cost, eco-friendly raw materials for the production of bioplastic.

Keywords: Bioplastic, Lemon Peels, Orange Peels, Pectin, Eco-Friendly, Agricultural Waste, Sustainable Material, Plastic Pollution, Biodegradable.

Assessment of heavy metal contamination in Hindon River in the region of Greater Noida

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Abstract

This study aims to determine the sources of heavy metal pollution in the Hindon River, which is a major freshwater resource for rural communities in western Uttar Pradesh, India. The river receives industrial wastewater with potentially hazardous concentrations of heavy metals. Soil, water and crop samples (methi, bathua, palak, mustard and wheat) were taken from 5 different locations and were analysed for concentrations of Pb, Ni, Cd, Cu, Zn and Cr. The Nemerow Pollution Index (NPI) and environmetric techniques like Principal Component Analysis (PCA) were employed to evaluate the overall pollution status. NPI values greater than 3 indicated severe contamination of river water. Also, PCA revealed that Pb and Zn were the major contaminants, which suggests that wastewater from electroplating activities directly enters the river. Heavy metals in water, soil and crop samples indicate the possibility of transfer of contaminants through the food chain. Long-term consumption of contaminated water and crops can lead to bioaccumulation of toxic metals in the human body. It increases the risk of negative health effects like neurological disorders, kidney dysfunction, developmental abnormalities and some types of cancers. To stop further degradation of the Hindon River ecosystem, i.e., the aquatic life and water quality, it is advised that a strategic eco-conservation plan be developed and put into action beforehand.

Keywords: Heavy Metals, Wastewater, Environment, Human Activities, Pollution

Induced Pluripotent Stem Cells for Parkinson's Disease: A Regenerative Paradigm

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Abstract

Parkinson's disease is a progressive neurodegenerative disorder that is characterised by the degeneration of neurons that produce dopamine in the substantia nigra region of the brain and the accumulation of misfolded α -synuclein in affected brain regions. These pathological changes result in the motor signs of this disease. Current therapies improve symptoms by restoring dopaminergic signalling, but they do not stop loss of neurons or modify disease progression. Induced pluripotent stem cells provide a patient-specific model for Parkinson's disease by allowing midbrain dopaminergic neurons to be generated from adult somatic cells, avoiding the use of embryonic or fetal tissue. When differentiated using Floor-plate specification protocols, these neurons reproduce key pathological features, including dysfunction of mitochondria, oxidative stress, and α -synuclein aggregation. This approach enables researchers to study disease mechanisms in patient-derived cells while also assessing the potential of emerging therapeutic strategies. Despite these encouraging findings, several challenges remain before this approach can be adopted in routine clinical practice. These include reducing the risk of tumour formation from residual undifferentiated cells, minimising immune rejection, and developing reliable GMP-compliant manufacturing processes with strong quality control.

Keywords: Parkinson's Disease, Induced Pluripotent Stem Cells, Cell Replacement Therapy, A-Synuclein, Regenerative Medicine

Artificial Intelligence in Food Microbiology: Emerging Applications in Microbial Spoilage Prediction

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Abstract

Microbial spoilage is one of the major causes of food deterioration, leading to reduced shelf life, economic losses, and increased food wastage. Conventional microbiological methods used for detecting spoilage microorganisms are reliable but often require considerable time and laboratory resources. In recent years, Artificial Intelligence (AI) has emerged as a valuable tool in food microbiology by assisting in the prediction of microbial spoilage before visible signs appear. This review aims to highlight the emerging applications of AI in microbial spoilage prediction and its role in improving food safety and quality. A review of recent scientific literature was carried out to understand the use of machine learning and other AI-based approaches in predicting microbial growth and spoilage patterns. The findings indicate that AI models can analyse factors such as temperature, pH, storage conditions, and microbial load to estimate shelf life and identify spoilage at an early stage. In addition, the integration of AI with biosensors and image-based monitoring systems has shown promising potential for real-time food quality assessment. However, challenges such as limited availability of high-quality datasets, implementation costs, and the need for standardised validation still limit its wider application. Overall, AI has the potential to complement conventional microbiological techniques by enabling timely spoilage prediction, reducing food waste, and supporting the development of safer and more sustainable food systems.

Keywords: Artificial Intelligence; Food Microbiology; Microbial Spoilage Prediction; Food Safety

***Drosophila melanogaster* in Translational Drug Discovery and Nanomedicine**

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Abstract

The demand for reliable preclinical models in drug discovery has risen due to the complexity of diseases and the need for safer treatments. *Drosophila melanogaster*, with its short life cycle, advanced genetic tools, low maintenance costs, and conservation of human disease-associated genes, has become a valuable model. It serves not only in target validation and drug screening but also in disease modelling and therapeutic development. Additionally, *Drosophila* enables detailed examination of molecular pathways and interactions at the nano-bio level, beyond macro observations. This study emphasises *Drosophila*'s role in drug development, particularly in drug target identification, high-throughput screening, repurposing, and evaluating treatment efficacy. It explores advancements in nanomedicine, focusing on drug delivery, nanoparticle toxicity, biodistribution, and safety. The integration of nanotechnology with disease models presents a cost-effective platform for therapeutic optimisation. However, challenges such as the need for standardised procedures and pharmacokinetic variations in humans remain. Future directions include genome engineering, multi-omics, AI-assisted screening, and precision medicine, positioning *Drosophila* as a promising model for accelerating drug discovery and developing personalised treatments.

Keywords: *Drosophila melanogaster*, Drug Discovery, Nanomedicine, Translational Research, Nanotoxicology, High-Throughput Screening.

The Role of Artificial Intelligence in Food Packaging: Transforming Food Safety, Quality, and Sustainability

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Abstract

The food packaging sector is increasingly adopting artificial intelligence (AI) to improve food safety, quality, shelf life, and sustainability. AI technologies, including machine learning, deep learning, computer vision, and the Internet of Things (IoT), enable real-time monitoring of food freshness, contamination detection, shelf-life prediction, and optimisation of packaging materials and supply chains. AI also accelerates the development of sustainable packaging by facilitating the design of biodegradable and nanocomposite materials, reducing food and packaging waste, and supporting circular economy practices. Furthermore, AI-powered traceability and predictive analytics enhance transparency, product authentication, and regulatory compliance across the food supply chain. Despite these advancements, widespread implementation is constrained by challenges such as limited high-quality datasets, sensor reliability, high deployment costs, cybersecurity concerns, and the need for standardised regulatory frameworks. This review critically examines recent developments, applications, challenges, and future opportunities of AI in food packaging. Emerging technologies, including explainable AI, edge computing, blockchain integration, and digital twins, are highlighted as promising tools for advancing intelligent packaging systems. AI has the potential to transform food packaging into a smart, data-driven, and sustainable technology that improves food safety, minimises environmental impact, and enhances consumer confidence while supporting resilient and efficient food systems.

Keywords: Artificial Intelligence, Food Packaging, Sustainability, Circular Economy

Artificial Intelligence in Nanomedicine and Targeted Drug Delivery: Emerging Strategies for Precision Therapeutics

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Abstract

In the last two decades, nanomedicine has shown its potential in modern pharmaceutical research, and many nanocarriers have been developed to improve drug solubility, prolonged stability and targeted delivery. Despite many advances in nanomedicine, major challenges like low reproducibility, tedious physicochemical analysis and in vivo toxicity due to unpredictable activity lead to reduced clinical translation of nano-therapeutics. The integration of artificial intelligence (AI) with nanomedicine can overcome these limitations and provide a new dimension in the medical field. This work explores the role of AI-driven approaches to reshape the area of targeted drug delivery. The prediction of nanoparticle behaviour, optimisation of formulation parameters and tailoring of size, surface charge and release kinetics can be accelerated by using machine learning and deep learning algorithms. Already, computational approaches have demonstrated their potential in enhancing precision in cancer therapy, enabling blood-brain barrier crossing in brain-targeted delivery and evolving personalised therapy by monitoring patient history using their physiological and genetic data. Additionally, AI-driven models provide fast screening of drug combinations in nanoformulations to reduce experimental burden and improve prediction accuracy in preclinical evaluation. However, existing challenges in AI-integrated nanomedicine, such as limitations of high-quality databases, lack of interpretation in AI models, and regulatory uncertainties, need to be addressed. This work focuses on a novel amalgamation of AI and nanomedicine for precision-oriented drug delivery systems. Furthermore, discuss the critical analysis of current applications, challenges, and future aspects to facilitate the faster development of safer, highly efficient and personalised nanomedicine.

Keywords: Nanomedicine, Artificial Intelligence, Targeted Drug Delivery, Personalised Therapy

The Role of Green Innovation in Corporate Performance and Environmental Transition

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Abstract

As global challenges such as climate change and resource depletion intensify, green innovation has emerged as a critical driver for balancing economic development with environmental stewardship. This study examines the strategic adoption of green innovations encompassing eco-friendly product designs, sustainable manufacturing processes, and clean technologies and their impact on corporate competitiveness and ecological sustainability. Drawing on a mixed-methods approach, the research evaluates key internal enablers (such as organisational culture and R&D capabilities) and external pressures (including regulatory frameworks and consumer demand) that influence sustainable technology integration.

Keywords: Green Innovation, Competitiveness, Sustainability, Technology Integration

Enhanced Biological Solubilization of Silica from Agroresidues by *Ectopseudomonas mendocina* Isolated from the Rice Rhizosphere

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Abstract

Silicon (Si) is considered a beneficial element for silica-accumulating plants, but the availability of Si in agricultural soils is decreasing due to intensive farming, plant utilisation, etc. Silica-solubilising bacteria (SSB) have a role in the Si-biogeochemical cycle by synthesising an enzyme called silicase that can convert insoluble silicates into bioavailable silicic acid. The current study aimed to isolate, identify, and optimise SSB from the rhizospheric soil of rice. Primary screening was carried out in silicate glucose agar (SGA) medium and yielded a strain with a silica solubilization index value of 3. Molecular identification was done using 16S rRNA gene sequencing, and the strain was identified as *Ectopseudomonas mendocina* (GenBank accession no.: PX285833). Production of silicic acid was confirmed by FTIR-ATR spectroscopy showing the characteristic vibrations of O-H stretch and bending at 3257 and 1636 cm⁻¹, and Si-O-Si stretch between 1192 and 1048 cm⁻¹. In submerged fermentation, the strain produced the highest silicase activity (1.5 ± 0.08 U/mL) in the presence of rice straw as compared to other agro-residues screened. Optimisation of silicase production was performed using a one-factor-at-a-time (OFAT) approach followed by Central Composite Design (CCD) with Response Surface Methodology (RSM). Temperature, pH, nitrogen sources, and incubation time optimisation have influenced high silicase production, resulting in a silicase activity of about 1.7 U/mL in a highly significant predictive model (R² = 0.971). These findings established *Ectopseudomonas mendocina* as a promising SSB for silica bioconversion, agro-residue valorisation, Si-based biofertilizer development, and sustainable agriculture.

Keywords: Silica Bioconversion, Silicase, Biofertilizer, Sustainable Agriculture, Valorisation.

Investigation of the potential Role of CLE26 peptide in Rice Adaptation Under Low-Nitrogen Conditions

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Abstract

Nitrogen is a critical macronutrient essential for plant growth, development, and productivity, limiting its effect on root growth and grain yield in rice (*Oryza sativa*). Enhancing nitrogen-use efficiency is vital for sustainable agriculture. CLAVATA3/EMBRYO SURROUNDING REGION-RELATED (CLE) peptides have emerged as key signalling molecules regulating root architecture and nutrient-responsive pathways. Among these, CLE26 is known to influence root architecture, but its role in rice adaptation to nitrogen deficiency remains unclear. This study proposes to investigate the effect of exogenous CLE26 peptide application on rice in a hydroponic solution under half-strength Yoshida nutrient. This study allows to easily observe undamaged root systems for precise physical measurements. The research uniquely explores CLE26 as a peptide-based regulator of nitrogen deficiency adaptation, offering insights into peptide signaling role in nutrient stress responses. Outcomes may contribute to innovative strategies for improving nitrogen use efficiency and promoting sustainable rice production with reduced fertiliser dependence.

Keywords: CLE26, Hydroponic, Rice, Root Architecture, Yoshida Nutrient, Nitrogen Use Efficiency, Nitrogen Deficiency.

Engineering a Microbial Consortium for Enhanced Bioremediation of Per- and Polyfluoroalkyl Substances (PFAS): A Sustainable Biological Strategy for Persistent Environmental Contaminants

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are extremely persistent environmental contaminants due to the extreme strength of the carbon–fluorine (C–F) bond. Traditional techniques like activated carbon adsorption, ion-exchange resins, membrane filtration, and advanced oxidation procedures frequently transfer contaminants or require high energy; biological remediation provides a sustainable option for true devastation. This study proposes a designed microbial consortium to enhance biodegradation through collaborative, synergistic metabolic interactions. By integrating metabolically complementary bacteria from the genera *Pseudomonas*, *Rhodococcus*, and *Acidimicrobium*, the community aims to achieve sequential defluorination and enhanced tolerance to toxic intermediates. The methodology examines these artificial and manufactured groups within laboratory-scale, biofilm-supported bioreactors treating PFAS-contaminated groundwater and wastewater. Advanced analytical techniques, incorporating LC-MS/MS for PFAS monitoring and ion chromatography or fluoride-selective electrodes to quantify fluoride ion release, verify C-F bond cleavage. Additionally, quantitative PCR (qPCR), 16S rRNA gene sequencing, and transcriptomic profiling will elucidate community dynamics and particular metabolic pathways. The results contain optimised treatment parameters, fundamental mechanistic insights into biological C-F cleavage, and a scalable biological treatment framework. This consortium-based approach pursues to advance sustainable environmental biotechnology, laying the foundation for hybrid remediation systems merging biological deterioration with complementary physical or electrochemical strategies.

Keywords: PFAS, Bioremediation, Engineered Microbial Consortium, Environmental Biofilm, Biotechnology, Biodegradation, LC-MS/ MS, Groundwater Remediation.

A Comprehensive Study on Biodiesel from Algae

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Abstract

The growing international demand for sustainable and renewable power assets has placed algae-derived biodiesel at the forefront of biofuel studies. Classified as a third-generation biofuel, algal biodiesel gives several advantages, along with a fast increase in yield, high lipid content, and minimum opposition with food crops, making it an incredibly promising opportunity to conventional fossil fuels. This overview paper examines the latest technologies and studies trends in biodiesel manufacturing from algae, with specific emphasis on algal species range, cultivation conditions, lipid extraction strategies, and transesterification strategies. Microalgae generally exhibit lipid contents ranging from 20% to 70% of dry biomass, extensively surpassing conventional oilseed vegetation, including soybean, palm, and rapeseed in both yield per hectare and production balance. Although macroalgae normally possess lower lipid content, they still provide valuable feedstock options, thereby expanding the raw material base.

Keywords: Biodiesel, Algae, Microalgae, Macroalgae, Lipid extraction, Transesterification, Biofuel Production, Sustainable Fuel.

Urbanization-Induced Decline of House Sparrow (*Passer domesticus*): Drivers, Bioindicator Significance and Conservation Strategies in Lucknow, India

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Abstract

Due to rapid urban growth, natural habitats have been transformed, and the House Sparrow (*Passer domesticus*) is one of the species that has declined in number and is used as an indicator of environmental health. The present study is designed to discuss ecological factors responsible for the decline of House Sparrow in Lucknow city, India, such as habitat loss, decrease in nesting habitats, alteration of habitat due to change in food availability and increase in pollution and urbanisation. Field observations and secondary information were used to determine the distribution of sparrows in various urban settings and the relationship between urbanisation and population changes. The results indicate that highly urbanised areas have significantly smaller bird populations of sparrows as compared to suburban and semi-urban areas, indicating that man-made activities are affecting biodiversity in urban areas. The study also assesses the bioindicator value of House Sparrow as a tool for assessing environmental quality and ecosystem health. The observed ecological patterns guide the development of practical conservation strategies aimed at sustainable urban biodiversity management, such as habitat restoration, artificial nest-boxes, improvement of urban green space and community participation.

Keywords: House Sparrow (*Passer domesticus*), Urbanisation, Urban Ecology, Bioindicator, Biodiversity Conservation

Endophytic Bacteria for Microplastic Biodegradation

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Abstract

Microbial diversity, soil health, agricultural production, and ecosystem sustainability are all negatively impacted by microplastic contamination, which has grown to be a major worldwide environmental concern. Food security and terrestrial ecosystems are seriously threatened by the buildup of microplastics, which are produced when traditional plastics like polyethylene, polypropylene, and polystyrene break down. The need for ecologically friendly biological alternatives is highlighted by the fact that current physical and chemical restoration techniques are frequently costly, energy-intensive, and unsustainable. Because of their varied enzymatic capabilities and metabolic adaptability, endophytic bacteria, which live in plant tissues without causing illness have become attractive candidates for the biodegradation of microplastics. This study aims to isolate and characterize endophytic bacterial strains from various plant species and evaluate their ability to degrade different types of microplastics. The isolates will be screened for plastic-degrading enzymes, including laccases, peroxidases, cutinases, and hydrolases. Their degradation efficiency will be assessed under different environmental conditions using weight loss analysis, surface morphology, and spectroscopic techniques. Potent bacterial strains will be identified through 16S rRNA gene sequencing to understand their biodegradation potential. The findings are expected to improve knowledge of plant-microbe interactions and support the development of eco-friendly, endophyte-based bioremediation strategies for reducing microplastic pollution in terrestrial and agricultural ecosystems, thereby promoting sustainable environmental conservation and long-term ecological resilience worldwide.

Keywords: Endophytic Bacteria, Microplastics, Biodegradation, Plastic-Degrading Enzymes, Bioremediation, Polyethylene, Polypropylene, Polystyrene

Conversion of Rice Husks into Biofertilizers using Microbial Technology

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Abstract

Rice husks are one of the major agricultural residues generated during rice milling, and their improper disposal often causes environmental pollution and wastage of valuable biomass resources. This study focuses on converting rice husks into biofertilizer using microbial technology as an eco-friendly and sustainable approach to agricultural waste management. Rice husks contain organic matter, silica, and essential nutrients that can be transformed into nutrient-rich biofertilizer through microbial degradation. Beneficial microorganisms, including nitrogen-fixing bacteria, phosphate-solubilising bacteria, and decomposer fungi, are employed to accelerate the decomposition process and enrich the nutrient content of rice husks. These microorganisms enhance the breakdown of lignocellulosic materials, shorten the composting period, and improve the availability of essential plant nutrients. The microbial conversion process not only reduces agricultural waste but also produces a value-added biofertilizer that supports sustainable farming practices. The developed biofertilizer is evaluated for its physicochemical characteristics, microbial population, nutrient composition, and its effectiveness in improving soil fertility and crop productivity. Parameters such as pH, moisture content, organic carbon, nitrogen, phosphorus, potassium, and microbial load are assessed to determine the quality and efficiency of the biofertilizer. The primary objective of this study is to develop a cost-effective, environmentally friendly, and sustainable method for converting rice husks into high-quality biofertilizer. The application of rice husk-based biofertilizer has the potential to enhance soil health, improve nutrient availability, reduce dependence on chemical fertilisers, and increase crop yield. Furthermore, this approach promotes efficient recycling of agricultural residues, minimises environmental pollution, and contributes to sustainable agriculture by supporting eco-friendly waste management and long-term soil productivity.

Keywords: Rice husk; Biofertilizer; Microbial technology; Agricultural waste management; Nitrogen-fixing bacteria; Phosphate-solubilising bacteria; Sustainable agriculture; Soil fertility.

Guard Cell Senescence and Its Potential in Crop Improvement

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Abstract

Plants are constantly experiencing various types of environmental stresses such as drought, salinity, extreme temperatures and pathogen invasion. To endure such conditions, they use several physiological mechanisms that regulate gas exchange, water balance, and photosynthesis. Stomata, one of these, are the majority, as it controls gas exchange between plants and the atmosphere. Guard cells are specialised epidermal cells that regulate the opening and closing of stomata. Because of their crucial role in growth and stress responses, guard cells have received increasing attention from researchers in recent years. Apart from regulating the movement of stomata, guard cells also undergo senescence, which has received very little attention. Over time, this cellular senescence will cause changes in structure, physiology, biochemistry and molecular components of guard cells, which slowly decrease the efficiency of their function. The question of guard cell senescence has recently been recognised as more relevant, especially in the context of climate change and global food security. A better understanding of the molecular and physiological mechanisms mediating these processes has potential applications for improving crop tolerance to stress, water use efficiency, and yield. This review discusses the causes and effects of guard cell ageing, its importance in plant health, and how advances in genetics and biotechnology can be used to delay guard cell senescence for developing high-yielding and climate-resilient crops.

Keywords: Senescence; Guard cells; Stomata; Photosynthesis

Eco-Friendly Soil Nutrient Management through Microbial Bio-Agents

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Abstract

Nowadays, urban settings have modified the natural ecosystems. Though the habitats are prone to quick environmental changes, healthy and nutrient-rich soils are a true sign of the health of an environment. Our surrounding soils are more prone to compaction and contraction. Rigorous and rigid contraction can increase the quantity of chemical fertilisers that will deplete the soil because decreasing the penetration capacity of water into the soil. In India, 57% of people were engaged in agriculture, and 72% of people live in countryside areas. However, neglecting the problem of managing micronutrients in soil causes nutritional imbalances, which affect the quality and yield of crops. Consortia of bio-agents are being introduced into farming as a result of a striving task. In the Present study, test trials were conducted in POT for nutrient management in order to enhance the soil macronutrients (NPK) and prevent insects by application of consortia of microbial bio-agents (*Aspergillus niger*, *Penicillium chrysogenum* and, *Trichoderma viride*). All these three species were cultured on suggested cheap media, and the highest biofertilizer activity showed by *T. viride*, followed by *P. chrysogenum* and *A. niger*. This research revealed how fungal co-culture helps to maintain soil fertility. It is suggested that standardising the dose of consortia of bioagents and improving soil testing promotes the use of microbial consortia for sustainable farming. The Consortia of microbial bio-agents were applied as Seed Treatment, soil application by enriching FYM/Compost at the time of sowing, followed by drenching and foliar application in standing crop, to obtain higher yield by increasing nutrient uptake by plants.

Keywords: Nutrients, Diseases, Macronutrients, Micronutrients, Microbial Bio-agents Consortia

AI-Driven Healthcare and Industrial Bioprocessing: Emerging Applications and Future Perspectives

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Abstract

Artificial Intelligence (AI) has emerged as a transformative technology that is reshaping healthcare and industrial bioprocessing by improving accuracy, efficiency, and decision-making. This review aims to explore the recent advancements and applications of AI in disease diagnosis, drug discovery, precision medicine, and industrial biotechnology. Relevant information was compiled and critically analysed from peer-reviewed research articles, scientific reviews, and authentic databases to evaluate the role of AI in modern biotechnological practices. The analysis revealed that AI-powered tools, including machine learning and deep learning algorithms, significantly enhance disease prediction, medical image interpretation, personalised treatment planning, and rapid identification of potential drug candidates. In industrial bioprocessing, AI facilitates process optimisation, real-time monitoring of fermentation systems, predictive maintenance of bioreactors, quality assurance, and efficient resource utilisation, thereby improving productivity while minimising operational costs. Despite these advancements, challenges such as limited availability of high-quality datasets, data privacy concerns, algorithm interpretability, and regulatory issues continue to hinder the large-scale implementation of AI technologies. Nevertheless, the integration of AI with biotechnology has demonstrated remarkable potential for developing intelligent, sustainable, and cost-effective healthcare and industrial solutions. Continued interdisciplinary research, ethical implementation, and technological innovations are expected to accelerate the adoption of AI-driven systems and the advancement of biotechnology.

Keywords: Artificial Intelligence, Healthcare, Industrial Bioprocessing, Biotechnology.

Synthesis of Carbon Nanodots-based Nanocomposites for Adsorption and Photocatalytic Degradation of Organic Pollutants in Wastewater

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Abstract

Nanotechnology enables efficient wastewater treatment through nanomaterials with high surface area, excellent adsorption capacity, and superior catalytic activity. Carbon dots (CDs) are carbon-based nanoparticles that have emerged as nanomaterials possessing physicochemical, optical and biocompatible properties. Carbon dots are a family of fluorescent nanoscale materials that behave like quantum dots, usually between 1 and 10 nm in diameter. Carbon nanodots (CDs) have gained considerable attention due to their ultrasmall size, high water solubility, low toxicity, chemical stability, and excellent optical and electronic properties. However, pure CDs have limitations including poor adsorption capacity and rapid electron-hole recombination. To overcome these issues, we propose synthesising CD-based nanocomposites by combining CDs with semiconductor photocatalysts, carbon materials, polymers, or metal oxides to improve adsorption and photocatalytic degradation efficiency. This research focused on the most recent developments in CDs-based heterostructures for advanced photocatalytic applications, particularly in the field of environmental remediation, providing a comprehensive overview of emerging strategies, synthesis approaches, and the resulting enhancements in photocatalytic water treatment applications.

Keywords: Abiotic Stress Detection, Artificial Intelligence, Drought Stress Biomarkers, Machine Learning

Calcium Sulfate Microparticle-Driven Vacuolization: A Robust Assay for Screening Phagocytic Modulators

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Abstract

Phagocytosis and phagosome maturation are central to immune defence and cellular homeostasis; their dysregulation contributes to infections, inflammation, cancer, lysosomal diseases, and immune-mediated disorders driven by pathological engulfment of host cells. Because excessive phagocytic activity is clinically important to control, scalable, economical in vitro assays suitable for pharmacological screening are needed. Conventional assays typically depend on fluorescent particles, specialised probes, and costly equipment, limiting accessibility and throughput. Here, we describe a simple, low-cost, and scalable phagocytosis assay based on thermally activated calcium sulfate (ACS)-induced vacuolization and Neutral Red (NR) quantification. ACS microparticles were efficiently internalised by multiple mammalian cell lines (HeLa, RAW 264.7, 3T3-L1, SH-SY5Y), triggering prominent cytoplasmic vacuolation that matured and acidified over time. NR accumulation in acidic compartments provided a direct, quantitative readout of phagocytic activity and phagosome maturation. Responses were concentration- and time-dependent, with maximal vacuolar acidification at 24 hours followed by decline due to vacuolar turnover and restoration of homeostasis. Pharmacological validation using bafilomycin A1, a V-ATPase inhibitor, produced dose- and time-dependent suppression of vacuole formation and acidification, confirming the assay's sensitivity to lysosomal and maturation pathways. When applied to drug screening, ten commercial compounds exhibited distinct profiles of cytotoxicity, vacuole inhibition, and phagocytosis modulation. In summary, ACS-induced vacuolization with NR readout provides a robust, cost-effective, and high-throughput-compatible assay to identify modulators of phagocytic and lysosomal function.

Keywords: Activated Calcium Sulfate (ACS); Phagocytosis Assay; Drug Screening; Cytoplasmic Vacuolization; Lysosomal Acidification.

Advanced Cultivation Techniques for Mining the Uncultured Microorganisms

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Abstract

In recent years, considerable progress has been made in microbial technology, but most of the world's microorganisms remain uncultured. This is due to a better understanding of the natural environment and finding new antimicrobial agents. Recent breakthroughs in cultivation strategies have enhanced the identification of previously inaccessible microorganisms. Modern cultivation methods, like diffusion chambers, iChip technology, microfluidic devices, co-cultivation strategies, and high-throughput approaches, aim to imitate natural habitats and enable the growth of previously unavailable microbes. Methods such as the isolation chip (iChip), culturing chip (cChip), diffusion growth chambers, and microencapsulation have greatly improved the recovery of previously uncultured microorganisms. By providing conditions that resemble their natural surroundings, these techniques enhance microbial growth and make it possible to isolate species that were once considered impossible to culture. These physical and chemical innovations have improved insights into the cultivation mechanism and allowed exploration of the hidden potential of various microbial species. The application of these cultivation-based explorations has led to the identification and production of new antibiotics and enzymes with various medical and industrial benefits. It can lead to the discovery of novel drugs, environmentally friendly agrochemicals, and efficient industrial biocatalysts with a wide range of practical applications. These advancements in the field of microbial research have opened numerous opportunities for exploring the uncharted world of microorganisms, including the mining of natural bioactive compounds.

Keywords: Advanced Cultivation Techniques, Microbial Diversity, iChip, Metagenomics

Waste to Wealth: Unlocking the Potential of Plastic-Eating Enzymes

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Abstract

Plastic waste is a huge problem for our planet today. The main reason is that plastic does not break down easily. A plastic bottle or bag can stay in the soil and water for hundreds of years. This causes a lot of pollution and also harms animals and marine life. To deal with this, scientists are using biotechnology, which means using microorganisms to solve this problem. Some bacteria and fungi make special enzymes. These enzymes can eat plastic and break it into very small pieces. After the plastic is broken down, we can use those small pieces to make new things like new plastic bottles, clothes, and boxes. So instead of throwing plastic away, we can reuse it more sustainably. In 2016, scientists found a bacterium called 'Ideonella sakaiensis' in Japan. It produces two enzymes, 'PETase' and 'MHETase', that can break down PET plastic used in water bottles. Recent studies reported that in 2022, a company called Carbios in France built a plant that uses enzymes to recycle PET plastic in just 10 hours. In 2023, scientists used AI to design new enzymes that work 10 times faster. In 2024, Samsara Eco in Australia partnered with brands like Nike to make clothes from enzyme-recycled plastic. In future, these enzymes can be used in big recycling plants, for cleaning oceans and landfills, and for making new products from waste plastic. This can create a circular economy where waste becomes wealth.

Keywords: Plastic Pollution, Degrading Enzymes, Waste To Wealth, Microorganism.

Sustainable Biotechnology and Environment: An Overview of Novel Approaches Towards Environmental Conservation and Sustainable Development

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Abstract

Growing environmental challenges, including pollution, climate change, and the depletion of natural resources, have increased the demand for sustainable and eco-friendly technologies. This review provides an overview of recent advances in sustainable biotechnology based on published scientific literature. It highlights the role of bioremediation in pollutant degradation, the application of microorganisms in wastewater treatment, the use of biofertilizers and biopesticides for sustainable agriculture, the production of biofuels from renewable biomass, and the development of biodegradable bioplastics as environmentally friendly alternatives to conventional plastics. The review also discusses the contributions of computational biotechnology and bioinformatics in optimising biological processes and supporting environmental conservation. These innovative approaches contribute to resource conservation, pollution reduction, and the promotion of a sustainable bioeconomy. Furthermore, current challenges, including large-scale implementation, economic feasibility, and biosafety concerns, are briefly discussed. Although further experimental validation is required, sustainable biotechnology offers significant potential to protect ecosystems and support long-term environmental sustainability.

Keywords: Sustainable Biotechnology, Environmental Conservation, Bioremediation, Biofertilizers, Biofuels, Bioplastics, Computational Biotechnology, Bioinformatics, Sustainable Development, Review.

Nanobiosensors for Rapid Disease Detection – A Review

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Abstract

Nanobiosensors have emerged as one of the most promising innovations in modern healthcare because they enable rapid, sensitive, and accurate disease detection. By integrating nanotechnology with biological recognition elements such as enzymes, antibodies, nucleic acids, and aptamers, these devices can identify disease-specific biomarkers within a short time. Compared with conventional diagnostic methods, nanobiosensors provide higher sensitivity, faster response, and improved portability, making them highly suitable for point-of-care testing. Recent advances in gold nanoparticles, graphene, quantum dots, and magnetic nanoparticles have significantly enhanced analytical performance and detection accuracy. They are increasingly used for the early diagnosis of infectious diseases, cancer, cardiovascular disorders, diabetes, and neurological conditions. This review summarises recent developments, biomedical applications, advantages, and current challenges of nanobiosensor technology. It also discusses issues related to stability, reproducibility, large-scale manufacturing, regulatory approval, and clinical validation. Overall, nanobiosensors represent a powerful diagnostic platform that can accelerate clinical decision-making, improve patient outcomes, and support the future of precision medicine through rapid, reliable, and cost-effective healthcare solutions.

Keywords: Nanobiosensors, Nanotechnology, Rapid Disease Detection, Point-of-Care Testing, Gold Nanoparticles, Graphene, Quantum Dots, Precision Medicine, Review.

A Multi-Tool AI-driven Approach for Diagnosis of Environmental Carcinogen-Induced Prostate Cancer

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Abstract

Prostate cancer (PCa) is one of the most common cancers affecting men globally. Its pathogenesis is an interplay of genetic and environmental factors, including exposure to a large number of environmental contaminants like Cadmium, pesticides and other endocrine-disrupting chemicals (EDCs). These toxic compounds induce cancer through a variety of mechanisms like Reactive Oxygen Species (ROS) generation, promoter hypermethylation of relevant genes and overexpression of the androgenic pathway through EDCs. The current diagnostic tools, like Prostate-specific antigens, partially fail to detect cancer early and also do not indicate the environmental drivers of carcinogenesis. However, in the current scenario, a combination of modern tools like high-throughput epigenomics, metabolomics and exposomics coupled with modern AI tools may help provide deep insight into tumour characteristics. These modern machine learning tools are expected to provide significantly higher diagnostic performance compared to conventional PSA testing and other diagnostic options available for prostate cancer, eliminating the diagnostic blind spot created by the available tools. Availability of this type of data to clinicians may help them make better therapeutic decisions by helping them accurately discriminate between benign prostatic hyperplasia, non-aggressive prostate cancer and aggressive prostate cancer. This multi-approach integration may improve the survival rate and quality of life amongst prostate cancer patients.

Keywords: Environmental Contaminants, Epigenomic Alterations, Androgenic Pathway, AI Diagnostics

AI-Driven Prediction of Antimicrobial Resistance Using Genome Sequences

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Abstract

Antimicrobial resistance (AMR) is an escalating global health threat, as many bacterial pathogens no longer respond to routinely prescribed antibiotics. Conventional laboratory methods for detecting resistance are accurate but often slow, which can delay the start of appropriate therapy. This research proposes an Artificial Intelligence (AI)-based framework that predicts whether bacteria are resistant to specific antibiotics by analysing their genome sequences. To enhance predictive performance, the system combines genomic features with epigenetic information. It also employs Explainable AI (XAI) techniques so that clinicians can understand why a particular prediction was made, for example by highlighting the genes, mutations, or genomic regions that most influence the model's output. To protect patient confidentiality, the framework uses federated learning, enabling multiple hospitals to train a shared model without exchanging raw patient data. In addition, Graph Neural Networks (GNNs) are used to model the relationships among genes and other biological entities, leading to richer representations and improved prediction accuracy. The model is further designed to identify bacterial strains that are at high risk of developing resistance in the future and to be deployable on portable devices suitable for use in hospitals and resource-limited rural healthcare centres. Overall, this approach aims to provide a faster, more accurate, interpretable, and privacy-preserving solution for AMR prediction. By helping clinicians choose more effective antibiotics at the point of care, it has the potential to improve patient outcomes and contribute to global strategies aimed at limiting the spread of drug-resistant infections.

Keywords: Antimicrobial Resistance (AMR), Artificial Intelligence (AI), Bacterial Genome Sequencing, Bioinformatics

Mapping Ayurveda Research on Lung Cancer: A Bibliometric Analysis of PubMed Literature

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Abstract

Ayurveda is a traditional medical system practised primarily in India and, to a lesser extent, in other parts of the world. Numerous research articles have explored the role of Ayurveda in lung cancer. The present study conducted a bibliometric analysis to map the research landscape of Ayurveda-based studies on lung cancer. Articles were extracted from the PubMed database on April 23, 2026. Science mapping techniques were applied, and visualisations were generated using VOSviewer, while Bibliometrix (Biblioshiny) and Microsoft Excel were employed to analyse author-wise, journal-wise, and year-wise publication frequencies. Of the 69 articles retrieved, 67 were included in the final analysis. The *Journal of Ayurveda and Integrative Medicine* published the highest number of articles (n = 12). Daffodil International University contributed the most publications (n = 17). Among individual authors, Rohit Sharma (Sharma R) had the maximum number of articles (n = 6), while Adiba Sultana (Sultana A) recorded the highest number of first-author publications (n = 2). Between 2006 and 2026, the year 2022 saw the greatest output, with nine publications. Keyword analysis revealed that “humans” (n = 32) and “apoptosis” (n = 19) were the most frequently used terms. This bibliometric study highlights the growing interest in Ayurveda-based approaches to lung cancer research over the past two decades. However, the analysis also revealed a paucity of standard journals, with only two dedicated Ayurveda journals identified. These findings underscore both the potential and the limitations of the current research landscape, pointing to the need for broader dissemination and standardisation in Ayurveda-related oncology studies.

Keywords: Ayurveda, Ayurvedic Medicine, Indian System Of Medicine, Herbal Medicine, Research Trends, Traditional Medicine

AI-Assisted Optimisation of Microbial Bioremediation for Heavy Metal Removal from Industrial Wastewater

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Abstract

Artificial intelligence (AI) is transforming sustainable biotechnology by improving the efficiency of biological processes, which are used to manage resources and protect the environment. The integration of AI with microbial and fungal biotechnology has opened new vistas for the development of eco-friendly solutions for complex environmental problems such as heavy-metal contamination, plastic waste and other persistent pollutants. Heavy metals such as chromium, cadmium, and lead are commonly found in industrial wastewater. These metals remain in the environment for long periods. They can contaminate soil and water, affecting ecosystems and their components. These heavy metals are toxic even at low concentrations and resist natural degradation. AI-based approaches can promote the rapid identification of metal-tolerant microbial strains like *Pseudomonas*, *Bacillus* and a fungal strain, *Aspergillus*, and optimisation of metabolic pathways, prediction of enzyme activity, and improvement of biodegradation performance. It helps in reducing both time and experimental costs compared to traditional methods. A computational framework was constructed that integrates statistical experimental design with machine learning to optimise microbial heavy metal removal. Under this framework, batch biosorption experiments would first be designed using Response Surface Methodology (RSM) to generate a structured dataset across a range of operating conditions. Machine learning models, like Random Forest Regression and Artificial Neural Networks (ANN), would then be trained on this dataset to predict removal efficiency, with their performance compared against RSM's own predictive capability. The best-performing model could subsequently be paired with a Genetic Algorithm to identify optimal combinations of pH, biomass dosage, and contact time for maximum metal removal. This type of integrated approach is expected to reduce the required number of experimental trials, improve prediction accuracy and support more reliable scale-up of bioremediation processes for industrial application. The combination of microbial bioremediation with AI- based predictive modelling assists researchers in addressing the growing need for sustainable, data-driven solutions in environmental, biotechnology and industrial pollution management. The proposed approach also opens avenues for future experimental validation and interdisciplinary collaboration between microbiologists, environmental engineers, and data scientists.

Keywords: Bioremediation, Heavy Metal Removal, Machine Learning, Microbial Biosorption, Wastewater Treatment, Sustainable Biotechnology.

Bioelectromagnetic Effects of a Conductive Electroculture Antenna System on Edaphic Variables and Bio-health: A Bioengineering Investigation with Certified STFR Validation

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Abstract

Sustainable intensification of agriculture demands alternatives to chemical-dependent soil management that simultaneously preserve ecological integrity and enhance plant productivity. Electroculture, the disciplined application of naturally occurring electromagnetic (EM) fields to soil-plant systems, has re-emerged as a scientifically credible paradigm, yet rigorous edaphic characterisation of antenna-based implementations remains sparse. This investigation presents the engineering design, fabrication, and experimental deployment of a multi-module conductive electroculture antenna comprising a Lensky copper ring, a basalt-core telluric collection body, brass ionic exchange modules, and quartz crystal amplifier units. The antenna was deployed over an eight-week observation window encompassing *Magnolia grandiflora* cultivation at two geographically distinct sites in North India (Sultanpur: 26°14'40"N, 82°3'15"E; Nawada: 28°37'23"N, 77°24'6"E). Three soil samples were subjected to full Soil Test Fertility Report (STFR) analysis by the MT Agricultural Laboratory (24 April 2026). The electroculture-treated soil exhibited pH 7.1 (optimal range 6.5–7.5), EC 0.40 dS/m (33% lower than control), organic matter 1.35% (+108% vs control), available N 460 kg/ha (+48%), P 25 kg/ha (+67%), K 230 kg/ha (+44%), and CEC 20 Cmol(+)/kg (+67%). A composite Soil Quality Index (SQI) confirmed the treated sample (SQI = 0.82) significantly outperformed the control (SQI = 0.42). Qualitative plant observations documented accelerated shoot regeneration, enhanced leaf lustre, reduced pest incidence, and cessation of progressive leaf deformation. These results establish a reproducible experimental template for bioelectromagnetic field-assisted edaphic conditioning with translational relevance to biomedical engineering frameworks of bioelectric stimulation and environmentally assisted biological systems.

Keywords: Electroculture, Bioelectromagnetics, Edaphic Variables, Conductive Antenna System, Soil Quality Index, Sustainable Agriculture, Bioelectric Stimulation, Lensky Ring, Cation Exchange Capacity, Soil Fertility Enhancement, Telluric Current, Atmospheric EM Coupling.

A Review of Antimicrobial Resistance Gene Identification Using Bioinformatics and Artificial Intelligence: Proposing a Conceptual Framework for India-Specific Surveillance

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Abstract

Antimicrobial resistance (AMR) is a rapidly growing global public health emergency, with an estimated 1.9 million deaths annually by 2050 if it is not contained. Antimicrobial Resistance Genes (ARGs) are the main biological drivers of this crisis, rapidly spreading in clinical, agricultural and environmental settings through horizontal gene transfer. This review summarises findings from seven recent studies (2023–2026) exploring ARG identification through genomic, environmental, and computational approaches. The literature reviewed here consistently demonstrates that conventional laboratory and alignment-based detection methods are not sufficient for large-scale ARG surveillance. Advanced methods such as whole-genome sequencing, metagenomics and artificial intelligence tools including deep learning, Hidden Markov Models, Random Forest and Gradient Boosted Decision Trees have a significant advantage in terms of accuracy and scalability when compared to traditional techniques. Importantly, a genomic surveillance study across Northern and Western India found that current prediction tools systematically over-predicted resistance in Indian bacterial isolates, reflecting dataset bias from Western-dominated training data. Environmental metagenomic profiling of hospital wastewater from India showed active circulation of dangerous ARGs including blaNDM-1 in urban and rural areas. Based on these findings, the review proposes a three-step framework including retrieval of sequences of Indian origin from NCBI GenBank, training of lightweight machine learning models on local resistance profiles and cross-validation with Indian hospital wastewater metagenomic data. The framework provides a practical and resource-efficient way to enhance AMR surveillance in low- and middle-income settings.

Keywords: Antimicrobial Resistance, ARG Identification, Bioinformatics, Machine Learning

Antibacterial Activity of Plant Extracts such as Guava (*Psidium guajava*), Neem (*Azadirachta indica*), Jamun (*Syzygium cumini*), Lemon (*Citrus × lemon*) and Gulmohar (*Delonix regia*) against *Bacillus subtilis*, *Cellulomonas uda*, *Pseudomonas aeruginosa*, *Sphingomonas paucimobilis* and *Bradyrhizobium japonicum*

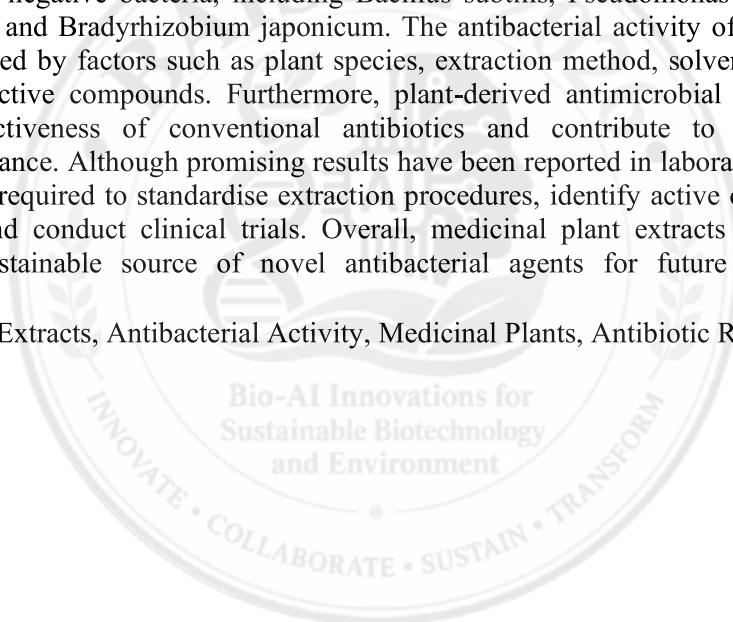
Ifa

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Abstract

Microbial infections remain a significant global health challenge, and the increasing prevalence of antibiotic-resistant bacteria has intensified the need for alternative antimicrobial agents. This review summarises current research on the antibiotic potential of medicinal plant extracts, with particular emphasis on commonly studied species such as *Psidium guajava* (guava), *Azadirachta indica* (neem), *Syzygium cumini* (jamun), *Citrus × limon* (lemon), and *Delonix regia* (gulmohar). Evidence from various studies demonstrates that extracts prepared using solvents such as methanol and ethanol exhibit inhibitory effects against several Gram-positive and Gram-negative bacteria, including *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Cellulomonas uda*, and *Bradyrhizobium japonicum*. The antibacterial activity of these plant extracts is influenced by factors such as plant species, extraction method, solvent used, and concentration of active compounds. Furthermore, plant-derived antimicrobial agents may enhance the effectiveness of conventional antibiotics and contribute to overcoming antimicrobial resistance. Although promising results have been reported in laboratory studies, further research is required to standardise extraction procedures, identify active constituents, evaluate safety, and conduct clinical trials. Overall, medicinal plant extracts represent a promising and sustainable source of novel antibacterial agents for future therapeutic applications.

Keywords: Plant Extracts, Antibacterial Activity, Medicinal Plants, Antibiotic Resistance.



AI-Driven Early Detection and Molecular Prediction of Drought Stress in Crop Plants

Deep and Indu Bhatt

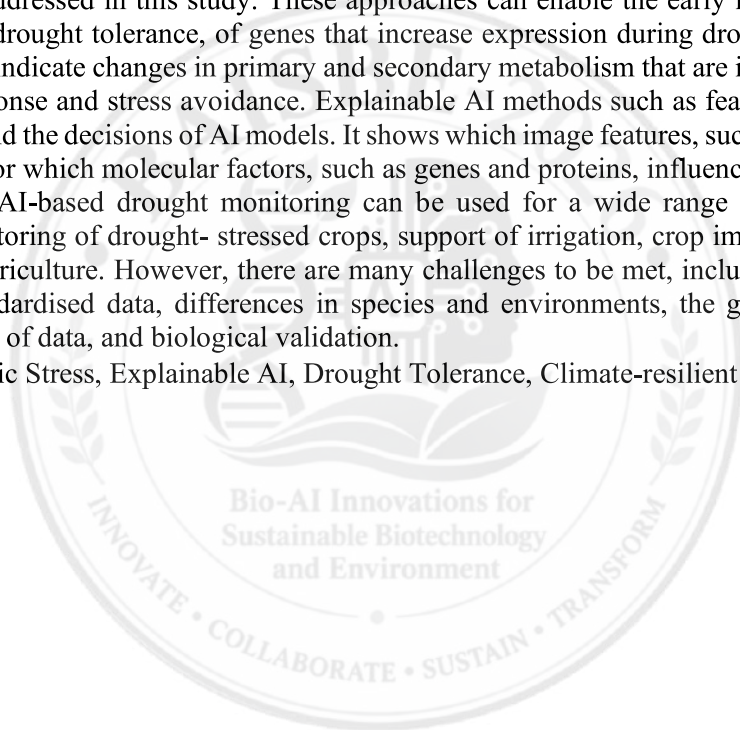
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Abstract

Abiotic stress affects global agriculture and is increasingly influenced by climate change. It poses a huge threat to global food security as it affects crop performance and the ability to adapt to new conditions. The traditional methods of detection of abiotic stresses in agriculture are usually time-consuming, with low accuracy and poor scalability. New methods of detection are required to meet the growing demands for the production of food globally. In the field of artificial intelligence (AI), recent development is to enable, for the first time, highly accurate, image-based, and sustainable solutions for detection of abiotic stresses in crops. In recent years, several studies have applied machine learning, deep learning, and explainable AI to enable early detection of drought stress and to predict the associated physiological and molecular changes in crop plants, which has been extensively addressed in this study. These approaches can enable the early identification of traits that provide drought tolerance, of genes that increase expression during drought stress, and of biomarkers that indicate changes in primary and secondary metabolism that are involved in both drought stress response and stress avoidance. Explainable AI methods such as feature importance help us to understand the decisions of AI models. It shows which image features, such as leaf colour, shape, or damage, or which molecular factors, such as genes and proteins, influence the prediction of drought stress. AI-based drought monitoring can be used for a wide range of applications, including the monitoring of drought-stressed crops, support of irrigation, crop improvement, and climate-resilient agriculture. However, there are many challenges to be met, including the lack of sufficient and standardised data, differences in species and environments, the generalisation of models, integration of data, and biological validation.

Keywords: Abiotic Stress, Explainable AI, Drought Tolerance, Climate-resilient Agriculture



Artificial Intelligence-Integrated Nanobiosensors for Point-of-Care Diagnostics: Advances, Challenges, and Future Directions

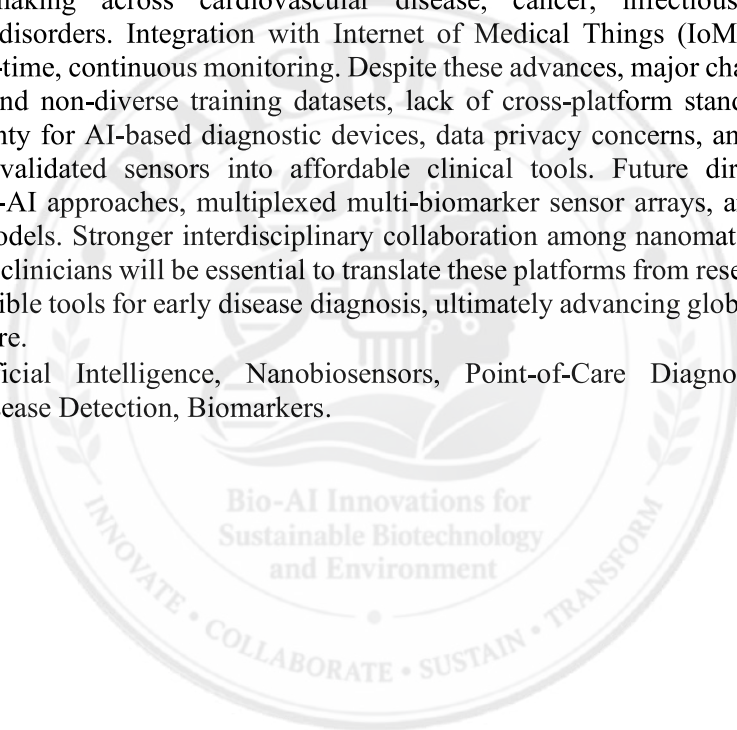
Annu

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Abstract

Point-of-care (POC) diagnosis of human diseases requires rapid, sensitive, and field-deployable detection platforms. Artificial intelligence (AI)-integrated nanobiosensors have emerged as a promising solution to meet these demands. This review examines recent advances, persistent challenges, and future directions in AI-enabled smart nanobiosensors for early POC diagnosis. A literature synthesis was conducted using recent peer-reviewed reviews and primary studies covering electrochemical, optical, and wearable nanobiosensing platforms combined with machine learning and deep learning algorithms. Findings indicate that nanomaterials such as graphene, quantum dots, MXenes, and gold nanoparticles significantly enhance sensitivity and detection limits, while embedded AI algorithms improve signal processing, pattern recognition, and clinical decision-making across cardiovascular disease, cancer, infectious disease, and neurodegenerative disorders. Integration with Internet of Medical Things (IoMT) connectivity further enables real-time, continuous monitoring. Despite these advances, major challenges remain, including limited and non-diverse training datasets, lack of cross-platform standardisation, and regulatory uncertainty for AI-based diagnostic devices, data privacy concerns, and difficulties in scaling laboratory-validated sensors into affordable clinical tools. Future directions include federated and edge-AI approaches, multiplexed multi-biomarker sensor arrays, and digital twin-based predictive models. Stronger interdisciplinary collaboration among nanomaterials scientists, AI researchers, and clinicians will be essential to translate these platforms from research prototypes into reliable, accessible tools for early disease diagnosis, ultimately advancing global precision and preventive healthcare.

Keywords: Artificial Intelligence, Nanobiosensors, Point-of-Care Diagnostics, Machine Learning, Early Disease Detection, Biomarkers.



Artificial Intelligence as a Catalyst for Environmental Education and Sustainable Biotechnology Awareness: Trends, Challenges and Future Directions (2000–2026)

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Abstract

The convergence of Artificial Intelligence (AI), Environmental Education (EE), and Sustainable Biotechnology has emerged as one of the most significant interdisciplinary developments of the twenty-first century. Rapid advances in AI technologies, including machine learning, deep learning, generative AI, intelligent tutoring systems, remote sensing, and predictive analytics, have transformed scientific research, education, environmental monitoring, and biotechnology applications. Simultaneously, increasing concerns regarding climate change, biodiversity loss, environmental degradation, food security, and sustainable resource management have highlighted the urgent need for environmentally responsible citizens equipped with scientific knowledge and sustainability competencies. This review synthesises literature published between 2000 and 2026 to examine the evolving role of AI in strengthening environmental education and promoting awareness of sustainable biotechnology. Drawing upon research from education, environmental science, biotechnology, and AI, the paper discusses major technological developments, educational applications, emerging trends, and current challenges. A conceptual **AI–Environmental Education–Sustainable Biotechnology Awareness (AI–EE–SBA)** framework is proposed to illustrate how AI-enabled personalised learning, intelligent knowledge systems, and experiential digital environments can enhance scientific literacy, promote biotechnology awareness, foster pro-environmental behaviour, and contribute to achieving the Sustainable Development Goals (SDGs). The review concludes that AI should be viewed not merely as an instructional technology but as an intelligent ecosystem capable of connecting education, research, innovation, and sustainability. The paper also identifies research gaps and presents recommendations for educators, policymakers, researchers, and higher education institutions seeking to integrate AI responsibly into environmental and biotechnology education.

Keywords: Artificial Intelligence, Environmental Education, Sustainable Biotechnology, AI in Education, Climate Education, Green Skills, AI Literacy, Sustainable Development Goals.

Molecular Pathogenesis, Precision Therapeutics and Management in ALS (Amyotrophic Lateral Sclerosis)

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Abstract

Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disorder characterised by the degeneration of upper and lower motor neurons, leading to the gradual loss of voluntary muscle function. One of the defining pathological features of ALS is the loss of TDP-43 from the nucleus and its abnormal accumulation in the cytoplasm, which is observed in more than 95% of cases. The disease has a complex genetic basis, with mutations in C9orf72, SOD1, TARDBP, and FUS being the most common genetic contributors. These mutations disrupt normal RNA processing, resulting in the inclusion of cryptic exons and subsequent motor neuron dysfunction and degeneration. ALS is a clinically and genetically heterogeneous disorder that is broadly classified as sporadic or familial based on its inheritance pattern and as bulbar or limb-onset according to the initial site of symptom presentation. The disease has an estimated annual incidence of approximately 2 cases per 100,000 people. Limb-onset ALS is the most common form, whereas bulbar-onset ALS accounts for nearly 30% of cases and is more frequently observed in older women. Although both forms eventually progress to widespread muscle wasting and paralysis, bulbar-onset disease generally advances more rapidly because of the early involvement of muscles responsible for speech, swallowing, and breathing. Current treatment options for ALS are limited, with Riluzole and Edaravone providing only modest benefits by slowing disease progression and reducing neuronal damage. Recent advances in precision medicine have shifted the focus toward mutation-specific therapies, such as Tofersen for patients with SOD1 mutations, offering a more targeted treatment approach. In addition, blood-based biomarkers, particularly neurofilament light chain (NfL), are emerging as valuable tools for monitoring disease progression, stratifying patients, and assessing therapeutic response. Supportive initiatives, including the ACT for ALS Act and the SSDI Waiver, are further facilitating accelerated drug development, improved access to treatment, and timely financial assistance for individuals living with ALS.

Keywords: Amyotrophic Lateral Sclerosis (ALS), TDP-43, C9orf72, SOD1, Neurofilament Light Chain (NfL), Precision Medicine, Tofersen, Biomarkers.

Predictive Bioprospecting of Cyanobacterial Metabolites for Advanced Eco-Shield Skincare: A Computational Review of AI-Driven Photoprotection

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Abstract

Environmental toxicities and endocrine-disrupting risks associated with synthetic chemical UV filters, along with the poor cosmetic appeal of mineral blockers, have intensified the search for sustainable photoprotective alternatives. Marine microalgae and cyanobacteria naturally produce mycosporine-like amino acids (MAAs), secondary metabolites that are highly photostable and exhibit strong UV-absorbing properties. However, conventional bio prospecting approaches are hindered by low extraction yields, high screening costs, and formulation instabilities. This review introduces a computational framework designed to accelerate the discovery and application of algal UV filters. Deep learning neural networks trained on spectral and metabolic datasets are employed to screen uncharacterized microalga genomes, enabling prediction of UV absorption profiles for novel MAA variants. To ensure human and environmental safety before synthesis, candidates undergo high-throughput in silico ADMET profiling to model skin permeation limits and aquatic biodegradation rates. Furthermore, generative chemistry algorithms are applied to design structural modifications on the polar side chains of target MAA scaffolds, optimising lipophilicity for stable incorporation into topical cosmetic emulsions. By replacing slow wet-lab verification with predictive machine learning pipelines, this review outlines a scalable blueprint for industrial biotechnology. Ultimately, this dry-lab approach integrates AI-driven bioinformatics with ecological chemistry, establishing a non-toxic, sustainable development roadmap for modern consumer skincare.

Keywords: Bio-AI, Predictive Bio Prospecting, Mycosporine-Like Amino Acids, Deep Learning, ADMET Profiling, Eco-Compatible Photoprotection, Sustainable Biotechnology.

Heat-Stable Carotenoids from *Geobacillus stearothermophilus* for Eco-Friendly Lip Tint and Blush Formulations

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Abstract

The present study investigate the potential of *Geobacillus stearothermophilus* carotenoids as heat-stable, eco-friendly pigments for cosmetic formulations. Carotenoids derived from thermophilic bacteria are extracted, purified, and characterised to evaluate their structural stability under elevated temperatures. Spectroscopic and chromatographic analyses are employed to confirm pigment integrity and assess antioxidant properties. The pigments are then incorporated into prototype lip tint and blush formulations, where their performance were tested for colour stability, texture compatibility, and safety. Comparative studies with conventional synthetic dyes were conducted to highlight advantages in thermal resistance and environmental sustainability. Consumer-relevant parameters such as shade intensity, spreadability, and skin compatibility will be evaluated through standardised assays. This work demonstrates how microbial carotenoids serve as natural, biodegradable alternatives to synthetic colourants, aligning with the growing demand for sustainable cosmetic innovations. The findings establish *G. stearothermophilus* carotenoids as promising candidates for next-generation lip and cheek products, paving the way for broader applications of thermophilic pigments in the cosmetic industry.

Keywords: Heat-Stable; Eco-Friendly; Lip Tint; Blush Formulation.

A Nanocomposite-Based Approach to Mitigate Terminal Heat Stress in Wheat for Sustainable Crop Production

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Abstract

Wheat (*Triticum aestivum* L.) is one of the world's major staple crops and plays a vital role in global food security. Despite India being the third largest wheat-producing country with an annual production of 117.5 million metric tonnes (MMT) of wheat, its productivity is significantly affected by abiotic stresses, particularly terminal heat stress during the reproductive and grain-filling stages, resulting in impaired physiological functions, poor grain filling, and reduced yield. Conventional application of plant growth regulators and agrochemicals is often limited by low utilisation efficiency, rapid degradation, repeated application, and environmental losses. Nanocomposite-based delivery systems offer a sustainable alternative by enabling controlled and targeted release of bioactive molecules with improved stability and bioavailability. In this study, a functional mesoporous silica-based nanocomposite loaded with stress-alleviating bioactive molecules will be synthesised and characterised using UV–Visible spectroscopy, FTIR, XRD, SEM, TEM, DLS, zeta potential, BET surface area analysis, and TGA. The nanocomposite will be evaluated for its ability to enhance the physiological, biochemical, and molecular responses of wheat under terminal heat stress. The controlled release of bioactive molecules is expected to reduce reactive oxygen species (ROS) accumulation, improve antioxidant defence, maintain cellular homeostasis, enhance osmotic adjustment, and activate heat-responsive signalling pathways, thereby increasing thermotolerance. Overall, this nano-enabled approach offers a promising strategy for improving wheat productivity under elevated temperature conditions and contributes to the development of climate-smart, sustainable agricultural technologies.

Keywords: Terminal Heat Stress, Nanocomposite, Slow Release, Sustainable Agriculture.

Artificial Intelligence and Automation in Sewage Treatment Plants: Challenges, Applications, and Future Prospects

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Abstract

The effective operation of Sewage Treatment Plants (STPs) is critical for protecting public health and preserving environmental sustainability. Traditional STPs primarily rely on manual monitoring, fixed control strategies, and operator experience, which often lead to inconsistent treatment performance, excessive energy consumption, and delayed identification of operational issues. To address these challenges, Artificial Intelligence (AI) has emerged as a powerful tool for automating and optimising wastewater treatment processes. AI technologies, including Artificial Neural Networks (ANNs), fuzzy logic systems, deep learning algorithms, Random Forests, and Support Vector Machines (SVMs), when integrated with Supervisory Control and Data Acquisition (SCADA) systems and Internet of Things (IoT)-based sensor networks, enable real-time monitoring, predictive analytics, and intelligent process control. These advanced systems improve key treatment stages such as screening, aeration, sedimentation, and sludge handling by accurately predicting influent conditions, optimising dissolved oxygen concentrations, automating chemical dosing, and detecting process anomalies at an early stage. Research findings demonstrate that AI models can effectively forecast important effluent quality parameters, including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS). Such predictive capabilities allow plant operators to implement proactive control measures rather than relying on reactive interventions. As a result, treatment efficiency is enhanced, regulatory compliance is improved, and both operational costs and energy consumption are significantly reduced. Additionally, AI-driven automation minimises human error and improves the ability of STPs to adapt to variations in influent flow and pollutant loads. Despite its considerable benefits, the adoption of AI in wastewater treatment is not without challenges. Key obstacles include limited availability of high-quality data, sensor inaccuracies, difficulties in integrating AI solutions with existing treatment infrastructure, and the need for skilled personnel to develop and manage these systems. Overcoming these barriers is essential to fully harness the advantages of intelligent automation in wastewater management. In conclusion, the integration of AI and automation technologies represents a major step toward the development of smart and self-regulating sewage treatment plants. By enhancing operational efficiency, reducing environmental impacts, and improving system adaptability, AI is poised to become a fundamental technology for building sustainable, resilient, and future-ready wastewater treatment infrastructure.

Keywords: Artificial Intelligence, Sewage Treatment Plant, Process Automation, Machine Learning, Predictive Control, Smart Wastewater Management, SCADA Integration.

Synthesis and Computational Screening of Phytoquinone-linked N-Heterocyclic Hybrid Scaffolds as Prospective Multi-targeting Antimicrobial Agents

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Abstract

The sudden increase in antimicrobial resistance is a significant global threat, necessitating the development of novel therapeutic agents with improved efficacy and diverse mechanisms of action. Hybrid pharmacophores have attracted considerable attention for their capacity to integrate multiple bioactive moieties within a single molecular framework. This study reports the rational design and synthesis of novel phytoquinone-linked N-heterocyclic hybrid scaffolds as potential antimicrobial agents. Lawsone (2-hydroxy-1,4-naphthoquinone), a naturally occurring bioactive compound, was strategically functionalized and conjugated with various N-heterocyclic moieties via Mannich base reactions to generate a series of amino-naphthoquinone derivatives. The synthesised compounds were characterised using standard spectroscopic techniques, including FTIR, ¹H NMR, ¹³C NMR, and mass spectrometry, confirming their structural integrity. The antimicrobial activity of these hybrids was evaluated against a panel of Gram-positive and Gram-negative bacterial strains, as well as selected fungal species. Additionally, the compounds were assessed *in silico* for druggability parameters, including Lipinski's rule, Veber's rule, and ADMET properties. Selected compounds demonstrated strong binding affinity to potential microbial targets. Several derivatives exhibited significant antimicrobial activity, with some showing enhanced potency compared to the parent scaffold, suggesting a synergistic effect of the hybrid framework. Overall, these findings indicate that lawsone-based N-heterocyclic hybrids are a promising strategy for developing multi-target, broad-spectrum antimicrobial agents to address drug-resistant pathogens.

Keywords: Hybrid Pharmacophores, Lawsone Derivatives, N-Heterocyclic Scaffolds, Antimicrobial Resistance.

CRISPR-Cas9 in Parkinson's Disease: Revolutionising Gene Editing Therapies and Precision Medicine

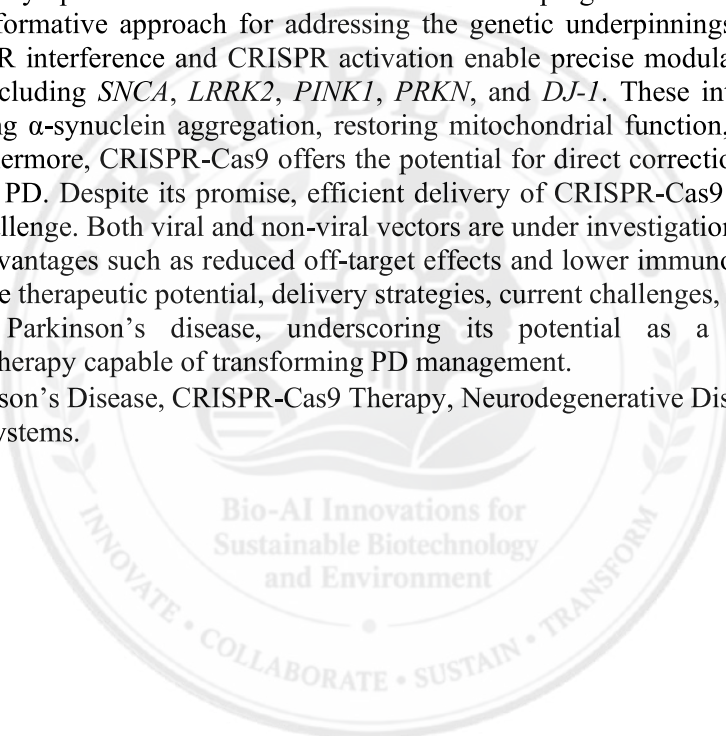
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Abstract

Parkinson's disease (PD) is the second most prevalent neurodegenerative disorder, primarily affecting motor function. It is characterised by the progressive degeneration of dopamine-producing neurons in the substantia nigra and the pathological accumulation of misfolded α -synuclein protein within Lewy bodies. Clinically, PD manifests through hallmark motor symptoms including bradykinesia, resting tremor, muscular rigidity, and postural instability. Current therapeutic strategies such as levodopa, dopamine agonists, monoamine oxidase-B inhibitors, catechol-O-methyltransferase inhibitors, and advanced interventions like deep brain stimulation provide symptomatic relief but fail to halt disease progression. CRISPR-Cas9 has emerged as a transformative approach for addressing the genetic underpinnings of PD. Recent advances in CRISPR interference and CRISPR activation enable precise modulation of disease-associated genes including *SNCA*, *LRRK2*, *PINK1*, *PRKN*, and *DJ-1*. These interventions hold promise for reducing α -synuclein aggregation, restoring mitochondrial function, and preventing neuronal loss. Furthermore, CRISPR-Cas9 offers the potential for direct correction of pathogenic mutations linked to PD. Despite its promise, efficient delivery of CRISPR-Cas9 into target cells remains a major challenge. Both viral and non-viral vectors are under investigation, with non-viral systems offering advantages such as reduced off-target effects and lower immunogenic risk. This review highlights the therapeutic potential, delivery strategies, current challenges, and prospects of CRISPR-Cas9 in Parkinson's disease, underscoring its potential as a next-generation disease-modifying therapy capable of transforming PD management.

Keywords: Parkinson's Disease, CRISPR-Cas9 Therapy, Neurodegenerative Disorders, Genome Editing, Delivery Systems.



Nanoparticle-Integrated Sanitary Pad for Non-Invasive Cervical Cancer Screening: A Prototype for Point-of-Care Diagnostics

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Abstract

Cervical cancer will continue to impose a significant global health burden, especially in low-resource regions where routine screening will remain inadequate. To address this challenge, we will develop a novel sanitary pad integrated with nanomaterial-based biosensors for non-invasive detection of cervical cancer biomarkers. The pad will incorporate gold nanoparticles functionalized with DNA probes and antibodies targeting high-risk HPV DNA, p16INK4a protein, and DNA methylation markers. Vaginal or menstrual fluid absorbed by the pad will interact with the sensing layer, producing a visible colourimetric or fluorescence signal that indicates biomarker presence. A smartphone-based application will enhance sensitivity by quantifying subtle optical variations and recording diagnostic data. The prototype will emphasise biocompatibility, comfort, and affordability, enabling large-scale deployment in rural and underserved populations. Validation will involve comparison with PCR and ELISA assays to determine sensitivity, specificity, and reproducibility. This innovative approach will represent a transformative step toward accessible, point-of-care cervical cancer diagnostics, integrating nanotechnology, wearable biosensors, and mobile health platforms. Ultimately, the proposed system will empower women through early detection, reduce mortality, and advance global health equity by bridging technology and preventive care.

Keywords: Nanoparticle Biosensor; Sanitary Pad Prototype; p16INK4a Biomarker; DNA Methylation Assay.

Artificial Intelligence Integration in Healthcare and Industrial Bioprocessing: Current Advancements and Future Perspectives

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Abstract

The rapid integration of artificial intelligence is fundamentally transforming the healthcare and industrial bioprocessing landscapes, shifting traditional manual operations toward autonomous, data-driven frameworks. Despite these technological strides, the sector faces significant hurdles regarding biological complexity, data standardisation, and the transparency of decision-making models, which currently impede seamless scalability. This research utilises a dual-framework approach, employing deep learning architectures for the complex pattern recognition inherent in clinical records and reinforcement learning for real-time autonomous decision-making within bioprocess sensor streams. The implementation of AI-driven diagnostic frameworks demonstrated a marked enhancement in patient outcome metrics and clinical precision compared to standard traditional diagnostic protocols. This study investigates the integration of multimodal artificial intelligence to harmonise heterogeneous medical data with the optimisation of industrial bioprocessing pipelines. The discussion centres on the critical requirement for interpretability in clinical decision-support systems to foster practitioner trust and ensure the ethical deployment of autonomous diagnostics. Furthermore, the scalability of these AI-driven workflows remains constrained by the necessity to address persistent ethical dilemmas, including algorithmic bias and the complex requirements of regulatory compliance. The research demonstrates that machine learning models, particularly random forest and artificial neural networks, achieve superior accuracy in predicting bioprocess productivities and real-time operational parameters.

Keywords: AI, Healthcare, Biotechnology, Machine Learning.

AI-Driven Automation in Biomanufacturing: Enhancing Efficiency, Quality, and Safety in Industrial Bioprocessing

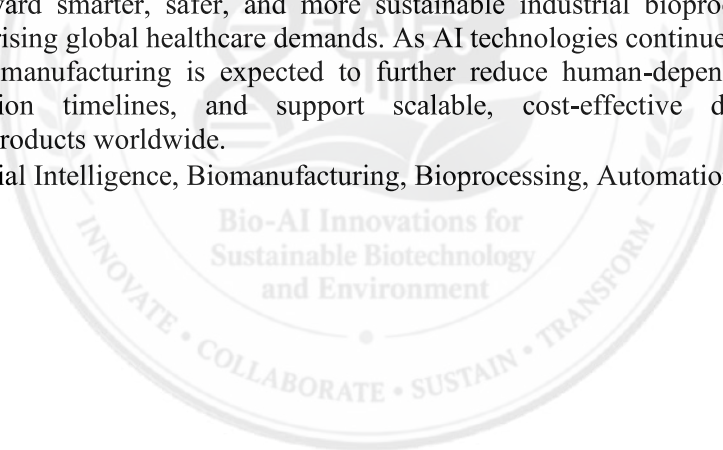
Neelam

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Abstract

The integration of Artificial Intelligence (AI) into industrial bioprocessing has emerged as a transformative approach for improving efficiency, safety, and product quality across biopharmaceutical manufacturing. This work reviews recent advancements in AI-driven biomanufacturing, focusing on how intelligent systems are reshaping traditional production workflows. Conventional bioprocessing methods often depend on manual monitoring and human intervention, which can introduce variability, errors, and inefficiencies during critical stages such as fermentation and cell culture. To address these limitations, AI-based frameworks incorporating machine learning, real-time sensor data analysis, and natural language-controlled laboratory automation were examined as methods for optimising bioprocess parameters. Findings from recent industrial applications show that AI-enabled systems can accurately interpret operational instructions, maintain real-time awareness of laboratory equipment status, and provide safeguards that prevent unsafe or erroneous actions during automated procedures. Furthermore, companies adopting AI-driven optimisation have successfully improved control over critical process variables, including microbial fermentation conditions, resulting in enhanced yield, consistency, and reduced production costs. These outcomes highlight the growing role of AI in improving operational efficiency while strengthening quality assurance and regulatory compliance within biomanufacturing environments. The analysis concludes that AI-driven automation represents a significant step toward smarter, safer, and more sustainable industrial bioprocessing systems capable of meeting rising global healthcare demands. As AI technologies continue to mature, their integration into biomanufacturing is expected to further reduce human-dependent variability, accelerate production timelines, and support scalable, cost-effective development of biopharmaceutical products worldwide.

Keywords: Artificial Intelligence, Biomanufacturing, Bioprocessing, Automation



Artificial Intelligence-Driven Antimicrobial Drug Discovery: Advances, Challenges, and Future Perspectives

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Abstract

One of the most critical threats to global health is antimicrobial resistance (AMR), which threatens the efficacy of current antibiotics and undermines decades of advancements in the treatment of infectious diseases. The continuous rise of multidrug-resistant pathogens, coupled with the declining pace of conventional antibiotic discovery, has created an urgent need for innovative and efficient drug development strategies. Recent advances in AI have transformed antimicrobial research by enabling rapid analysis of complex biological and chemical data, thereby accelerating multiple stages of the drug discovery pipeline. AI is revolutionising the search for novel therapeutic candidates for antimicrobial drugs by significantly reducing the time and cost associated with traditional drug development. The approaches, including graph neural networks, machine learning, generative AI and deep learning, are key stages of drug development, from target identification and virtual screening to lead optimisation, antimicrobial peptide discovery, and structure-based drug design. Recent landmark achievements, including AI-assisted discovery of novel antibiotic candidates and advances in generative molecular design, are highlighted to demonstrate the growing impact of AI on combating antimicrobial resistance. This review offers a thorough perspective on the developing role of AI in next-generation antimicrobial drug discovery and highlights its potential for the development of effective therapeutics against drug-resistant pathogens.

Keywords: Artificial Intelligence, Antimicrobial Resistance, Machine Learning, Generative AI, Drug Discovery, Antimicrobial Peptides



Innovative Development of Eco-Friendly Plant Tissue Culture Media from Agricultural Residues

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Abstract

Plant tissue culture is a widely used technique for rapid micropropagation of endangered plant species, medicinal plants and genetic improvement of economically important plants. However, plant tissue culture is constrained by the high cost of plant tissue culture medium, which includes expensive micro and macronutrients, plant growth regulators, vitamins and nutrients. At the same time, agricultural residues, which are generated from food processing and crop production, are discarded, which leads to environmental pollution. Among these residues, including coconut water, banana peels, sugarcane bagasse and cereal by-products, are rich naturally in minerals, vitamins, carbohydrates, and other nutrients, which could be a great source of alternative media components. The present study deals with the novel development of an eco-friendly plant tissue culture medium by partially or fully replacing the conventional media ingredients with processed agricultural residues. Selected residues will be chemically characterised for their nutritional composition and will be incorporated in Murashige and Skoog (MS) medium in different formulations. Standard tissue culture protocols will be used to assess the effects on explant establishment, shoot multiplication, callus induction, root formation, biomass accumulation and plantlet acclimatisation. Statistical optimisation tools like Response Surface Methodology (RSM) or Design of Experiments (DoE) will be used to find the best combinations of residue-derived components to achieve the highest regeneration efficiency. The approach proposed aims to reduce the cost of production, increase valorisation of waste and promote circular bioeconomy principles, while maintaining or improving tissue culture performance. The formulation of residue-based culture media may serve as a sustainable and low-cost alternative for commercial micropropagation, conservation of endangered plant species and large-scale propagation of horticultural, medicinal and forestry crops. This innovation combines sustainable biotechnology and agricultural waste management and has the potential to improve the economic and environmental sustainability of plant tissue culture systems.

Keywords: Plant Tissue Culture, Agricultural Waste, Eco-Friendly, Sustainable Biotechnology

Artificial Intelligence in Nanobiotechnology: Accelerating Nanomedicine Development

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Abstract

Artificial Intelligence (AI) is revolutionising the world of Nanobiotechnology, enabling the development of Nanomedicines in a rapid, reliable, and resource-efficient manner. Nanobiotechnology involves the use of engineered nanoparticles for drug delivery, diagnostics, and treatment, which offers significant advantages over conventional therapeutics. However, the design and development of Nanomedicines remain a challenging and time-consuming process due to the complexity of the involved biological systems and the need for extensive preclinical and clinical evaluations. AI-driven approaches have the potential to address these limitations by providing valuable insights into the underlying biological mechanisms, identifying optimal nanoparticle designs through pattern recognition, and accelerating the development process through computational modelling and simulation. Machine learning and deep learning algorithms are playing an increasingly important role in nanobiotechnology by enabling the identification of structure-property-function relationships of nanoparticles with enhanced precision and efficiency. AI can be utilised for predictive modelling of various critical parameters such as the size, shape, surface chemistry, physicochemical properties, stability, drug-loading capacity, toxicity, and targeting efficiency of nanomaterials. Moreover, AI can facilitate the design of patient-specific Nanomedicines by taking into account the inter-individual variability in patient physiology and pathology. Finally, the application of AI to nanobiotechnology is expected to play a vital role in advancing our understanding of nanomaterials and their interactions with biological systems while also promoting the timely translation of Nanomedicines into the clinic for the treatment of a wide range of diseases, including cancer, infectious diseases, and neurodegenerative disorders. While there are still several challenges to be addressed, including data quality and interpretability, model generalizability, and ethical concerns, the overall impact of AI on the field of Nanobiotechnology is poised to have a profound and lasting impact on healthcare.

Keywords: Artificial Intelligence (AI), Nanobiotechnology, Nanomedicine, Machine Learning, Deep Learning, Nanoparticles, Drug Delivery, Personalised Medicine, Predictive Modelling.

Advances in SCLC Treatment: From Chemotherapy to Immunotherapy Combinations

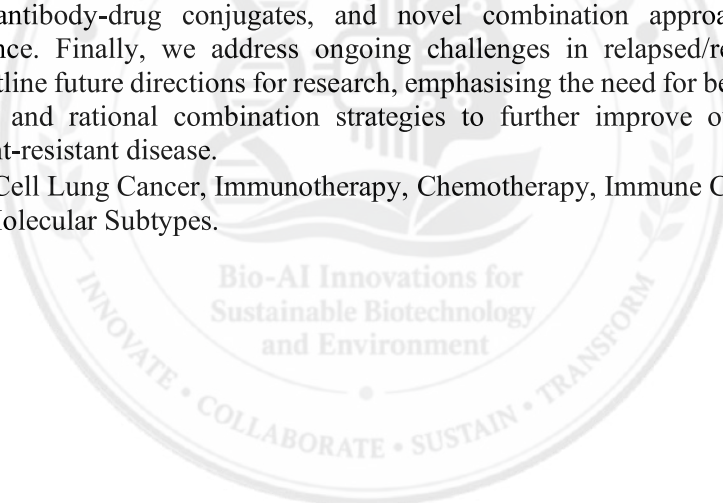
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Abstract

Small cell lung cancer (SCLC) remains one of the most aggressive and lethal malignancies, accounting for approximately 13–15% of all lung cancers and characterised by rapid proliferation, early metastatic spread, and a strong association with cigarette smoking. For over three decades, treatment for SCLC changed little, with platinum-based chemotherapy (typically etoposide plus cisplatin or carboplatin) remaining the cornerstone of first-line therapy despite high initial response rates followed by near-universal relapse and chemoresistance. This review traces the evolution of SCLC treatment from conventional cytotoxic chemotherapy to the recent integration of immune checkpoint inhibitors, marking the first meaningful survival improvements in this disease in decades. We examine the pivotal clinical trials that established the addition of PD-L1 inhibitors (atezolizumab and durvalumab, respectively) to platinum-etoposide chemotherapy as the new standard of care for extensive-stage SCLC, and discuss the modest but clinically meaningful gains in overall and progression-free survival achieved with these combinations. The review will explore the persistent challenge of identifying reliable predictive biomarkers in SCLC, given the limited utility of PD-L1 expression and tumour mutational burden in this tumour type. Additionally, we highlight emerging therapeutic strategies, including DLL3-targeted agents (such as tarlatamab), PARP inhibitors, antibody-drug conjugates, and novel combination approaches aimed at overcoming resistance. Finally, we address ongoing challenges in relapsed/refractory SCLC management and outline future directions for research, emphasising the need for better biomarkers, novel drug targets, and rational combination strategies to further improve outcomes in this historically treatment-resistant disease.

Keywords: Small Cell Lung Cancer, Immunotherapy, Chemotherapy, Immune Checkpoint Inhibitors, DLL3, Molecular Subtypes.



Bio-Hybrid Smart Aerosol Nanocarriers: A Futuristic Platform for Targeted Lung Cancer Drug Delivery

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Abstract

Lung cancer therapy will evolve through the creation of bio-hybrid smart aerosol nanocarriers, a next-generation system designed for precise pulmonary drug delivery. These nanocarriers will be cloaked with lung epithelial cell membranes, enabling immune evasion and natural homing to lung tissue. Their core will be fabricated using dual-responsive polymers that react to acidic pH and elevated reactive oxygen species (ROS) within the tumour microenvironment, ensuring controlled and site-specific drug release. The delivery system will simultaneously transport chemotherapeutic drugs, siRNA/miRNA constructs, and immunomodulatory peptides, thereby addressing multidrug resistance while activating robust antitumor immune mechanisms. Aerosolised administration will facilitate direct deposition into alveolar regions, bypassing systemic circulation and minimising off-target toxicity. Integrated fluorescent and MRI tracers will enable real-time visualisation of biodistribution and therapeutic progress. This futuristic nanomedicine approach will merge targeted delivery, multimodal therapy, and stimuli-responsive release, establishing a transformative paradigm for lung cancer management. By combining biological membrane camouflage with aerosolised nanotechnology, the proposed system will redefine pulmonary oncology, offering enhanced efficacy, reduced side effects, and improved patient outcomes through intelligent, localised, and trackable drug delivery.

Keywords: Bio-Hybrid Nanocarriers; Aerosol Delivery; pH & ROS Responsive; Targeted Lung Cancer Therapy

Sustainable Biotechnology and Environment

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Abstract

Sustainable biotechnology is an interdisciplinary field that applies biological systems, organisms, and biomolecular processes to develop environmentally responsible solutions for global challenges such as climate change, pollution, resource depletion, and food insecurity. By integrating scientific innovation with sustainable practices, biotechnology contributes to environmental conservation while supporting economic growth and social well-being. This presentation provides an overview of the principles and significance of sustainable biotechnology, highlighting its role in environmental protection through applications such as bioremediation, wastewater treatment, sustainable agriculture, bioenergy production, biodegradable materials, and the circular bioeconomy. It also discusses recent technological advancements, including synthetic biology, CRISPR-based innovations, microbial fuel cells, and algae-based carbon capture, that are driving the transition toward a more sustainable future. In addition, the presentation examines the challenges associated with implementing sustainable biotechnological solutions, including economic, regulatory, and ethical considerations. To demonstrate the practical impact of sustainable biotechnology, the presentation concludes with a case study on the bioremediation of the Deepwater Horizon oil spill, illustrating how naturally occurring oil-degrading microorganisms accelerated environmental recovery and highlighted the potential of biotechnology in addressing large-scale ecological disasters. The presentation emphasises that sustainable biotechnology is a powerful tool for achieving environmental sustainability and supporting the United Nations Sustainable Development Goals (SDGs).

Keywords: Sustainable biotechnology, SDGs

AI-Assisted Optimisation of Plant Tissue Culture Media

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Abstract

Plant tissue culture is a basic technique in plant biotechnology for rapid propagation, conservation of germplasm, production of disease-free plants and genetic improvement. Nevertheless, the optimisation of culture media is still a major challenge due to the complex interactions between plant growth regulators, macro- and micronutrients, vitamins, carbon sources and genotype-specific responses. Conventional optimisation methods rely on trial-and-error experimentation that is labour-intensive, time-consuming, and expensive. Artificial Intelligence (AI), and in particular machine learning (ML), offers a revolutionary way to overcome these limitations by detecting complicated patterns in experimental data sets and predicting optimal media compositions with higher accuracy. This research proposes to develop an AI-assisted framework for optimisation of plant tissue culture media using supervised machine learning algorithms. Experimental data such as media composition, environmental conditions, type of explant and culture responses (e.g., shoot regeneration, root induction, callus formation, biomass accumulation) will be used to develop predictive models. The optimised formulations from the AI model will be validated experimentally and compared with the traditional media optimisation approaches. The proposed system aims to reduce experimental iterations, resource consumption and regeneration efficiency, and to allow the recommendation of media adapted to genotypes. The potential of AI in plant tissue culture is to transform micropropagation through the acceleration of protocol development, improvement in reproducibility and the facilitation of precision plant biotechnology. The framework is also adaptable to biodiversity conservation and commercial plant production. This work is an interdisciplinary effort to develop intelligent decision support systems for next-generation plant tissue culture research.

Keywords: Plant Tissue Culture, Artificial Intelligence, Micropropagation, Sustainable Agriculture.

Recent Advances in Sustainable Nanomaterial-Enhanced Biodiesel for Compression Ignition Engine Applications

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Abstract

The increasing depletion of fossil fuel reserves and growing environmental concerns have accelerated the development of sustainable alternative fuels for compression ignition (CI) engines. Biodiesel has emerged as one of the most promising renewable fuels owing to its biodegradability, carbon neutrality, and compatibility with existing diesel engines. However, limitations such as higher viscosity, lower calorific value, poor atomization, and relatively higher nitrogen oxide emissions restrict its widespread commercial utilisation. In recent years, the incorporation of nanomaterials into biodiesel has attracted considerable attention as an effective strategy to overcome these limitations. Nanomaterial-enhanced biodiesel improves fuel atomization, increases thermal conductivity, enhances catalytic oxidation, and promotes more complete combustion, leading to improved engine efficiency and reduced exhaust emissions. Various metallic, metal oxide, carbon-based, and boron-based nanomaterials have demonstrated significant improvements in brake thermal efficiency while simultaneously lowering carbon monoxide, hydrocarbon, smoke opacity, and particulate emissions. The present paper summarises recent developments in sustainable nanomaterial-enhanced biodiesel for compression ignition engine applications by discussing biodiesel feedstocks, nanomaterial characteristics, combustion behaviour, engine performance, emission reduction potential, and future research opportunities. Particular emphasis is placed on environmentally friendly nanomaterials that offer enhanced combustion characteristics without compromising engine durability or fuel stability. The study highlights the potential of nanomaterial-enhanced biodiesel as a sustainable alternative capable of improving engine performance while supporting global efforts toward cleaner transportation and reduced environmental pollution.

Keywords: Sustainable Biodiesel; Nanomaterials; Compression Ignition Engine; Combustion Characteristics; Engine Performance; Exhaust Emissions; Renewable Energy.

The Rise of Plant Molecular Farming: A Systematic Review of Vaccine Production in *Nicotiana Benthamiana*

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Abstract

The COVID-19 pandemic exposed critical vulnerabilities in traditional vaccine production platforms, including high costs, prolonged timelines, limited scalability, and contamination risks, necessitating the exploration of agile and resilient alternatives. Plant molecular farming has emerged as a transformative solution, with *Nicotiana benthamiana*, a wild Australian relative of tobacco, becoming the preferred host for recombinant vaccine production due to its rapid growth cycle of 4 to 5 weeks, high biomass yield, amenability to transient expression using viral vectors, and inherent safety as a non-food crop. This systematic review synthesises the current state of Plant-based Vaccine development, examining the technological evolution from stable transgenesis to advanced transient expression systems that enable protein yields of up to 2.5 mg per gram of fresh leaf weight. The platform offers compelling advantages: speed from gene to Vaccine candidate in weeks, 50-80 % lower capital investment than mammalian cell facilities, Agricultural scalability, freedom from human or animal pathogens, and eukaryotic post-translational modifications essential for protein function. Recent regulatory milestones, notably the conditional approval of COVIFENZ – the first plant-derived COVID-19 vaccine for human use- have validated the clinical Potential of this approach. Success extends to veterinary applications, including vaccines against Bluetongue disease, Viral Nervous Necrosis, Porcine Reproductive and Respiratory Syndrome, and Newcastle Disease. Despite challenges in downstream processing, glycoengineering and regulatory navigation, emerging technologies such as CRISPR-Cas9 genome editing and nanoparticle delivery systems promise further optimisation. This review concludes that Plant Molecular Farming in *N. benthamiana* represents a paradigm shift in biopharmaceutical production, offering rapid, scalable and cost-effective access and enhancing global pandemic preparedness.

Keywords: Plant Molecular Farming, *Nicotiana Benthamiana*, Plant-Based Vaccines, Pandemic Preparedness, Biopharmaceuticals, Veterinary Vaccines.

Waste to Worth: A Circular Biotechnology Framework for Coconut Shell Valorisation and Household Kitchen Greywater Reuse

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Abstract

Rapid urbanisation, the rising demand for freshwater, and poor household waste management have increased environmental challenges, especially in developing countries like India. Indian households generate a significant amount of biodegradable waste and kitchen grey water every day. Unfortunately, these are often treated as separate waste streams. Coconut shells, which have a high carbon content and potential for reuse, are often discarded without being recovered. Kitchen grey water, containing food scraps, oils, detergents, and organic matter, is usually dumped directly into drainage systems. Current waste management practices mainly focus on disposal rather than recovering resources. This shows a clear need for decentralised and sustainable solutions that use circular biotechnology. This study proposes a framework for circular biotechnology at the household level. It combines coconut shell reuse with kitchen greywater treatment to encourage resource recovery and water reuse. The plan uses discarded coconut shells as a renewable source for making biochar through controlled thermal processes. The biochar then serves as the main filtration medium in a household greywater treatment unit. It acts as an adsorbent with a large surface area, effectively removing suspended impurities, colour, odour, detergent residues, and dissolved organic pollutants. The treated greywater can be used for non-potable purposes like gardening, toilet flushing, and cleaning. This approach reduces freshwater use and promotes local water conservation. Unlike traditional methods that manage solid waste and wastewater separately, the proposed framework creates a closed-loop system. Here, coconut shell waste is turned into a useful biomaterial that aids household water recycling. By combining waste reuse, sustainable water management, and circular economy principles in one household model, this framework shows a way to lessen landfill use, conserve water, and improve environmental sustainability. Additionally, the study lays the groundwork for future improvements using biologically active filtration, smart water quality monitoring, and modular designs suitable for widespread use in middle-income households

Keywords: Waste-to-Wealth, Biotechnology, Resource Recovery, Circular Economy.

Beyond Biological Bounds: A Python-Based Computational Auditor to Mitigate Sequencing Biases, Data Imbalance, and Regulatory Vacuum in CRISPR-Cas9 Germline Editing

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Abstract

While contemporary discourses on CRISPR-Cas9 remain heavily fixated on common therapeutic targets like HIV, cancer, and pest eradication, the transition of gene editing into secure, real-world execution is severely bottlenecked by systematic flaws in current predictive software. The core limitation lies in traditional short-read sequencing techniques, which frequently fail to map large structural variations, creating dangerous computational biases where measured simulations conflict with real lab scenarios. Furthermore, existing predictive tools suffer from severe genomic data imbalance, trained predominantly on specific populations, which introduces geographic and demographic biases. This predictive failure introduces profound technical and bio-ethical hazards; as underscored by previous human embryo controversies (e.g., the He Jiankui case), undetected off-target mutations can permanently corrupt the human germline, transferring irreversible genomic damage to future generations. To bridge this critical gap within a landscape of sluggish and overlapping international regulations, this paper proposes an automated, open-source Python framework designed to act as an independent "Virtual Checkpoint." Operating upon the philosophical blueprint of the historical Office of Technology Assessment (OTA), this framework functions as a non-commercial, unbiased technical gatekeeper that democratizes access for underfunded research institutions. By deploying advanced sequence-alignment algorithms combined with Explainable AI (XAI) principles, the software not only corrects short-read and demographic diagnostic biases but also provides transparent reasoning for predicted risks before physical laboratory deployment. This computational intervention eliminates the immense financial overhead of failed wet-lab experiments, balancing cost-effectiveness with extreme precision. Ultimately, this framework presents a scalable model for institutional self-regulation, ensuring high-risk biotechnology aligns with bio-safety ethics even in the absence of formalised global legislation.

Keywords: CRISPR-Cas9, Computational Bias, Short-Read Sequencing, Virtual Checkpoint, Technology Assessment (OTA), Explainable AI, Data Imbalance.

Drug Repurposing in Vector-Borne Diseases: Current Strategies and Future Directions

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Abstract

Vector-borne diseases (VBDs), including malaria, dengue, chikungunya, leishmaniasis, and filariasis, continue to impose a substantial global health burden, particularly in tropical and subtropical regions with limited healthcare infrastructure. Despite ongoing efforts, the development of novel therapeutics for these diseases remains slow, hampered by high costs, lengthy clinical trial timelines, and limited commercial incentive given their concentration in low- and middle-income countries. Drug repurposing the identification of new therapeutic applications for existing, approved, or investigational drugs has emerged as a promising strategy to accelerate the availability of effective treatments while circumventing the time and expense associated with de novo drug development. This review examines the current landscape of drug repurposing efforts across major vector-borne diseases, highlighting successful examples such as the antiparasitic and antiviral potential of ivermectin, the repositioning of antimalarials like chloroquine and artemisinin derivatives for adjunct use in other infections, and the exploration of statins, antihistamines, and antidepressants for their unexpected activity against vector-borne pathogens. We discuss the computational and experimental approaches driving repurposing efforts, including high-throughput screening, molecular docking, network pharmacology, and artificial intelligence-based drug-target prediction, which have enabled systematic identification of candidate compounds from existing pharmacopoeias. The review also addresses the underlying mechanistic rationale for repurposing, such as shared host-pathogen pathways, immune modulation, and vector control applications, alongside challenges including inadequate pharmacokinetic profiles for new indications, regulatory hurdles, and the need for robust clinical validation. Additionally, we explore the role of repurposed drugs in combination therapy strategies to combat emerging drug resistance in vector-borne pathogens. Finally, we outline future directions for integrating repurposing pipelines with global VBD control programs, emphasising the potential of this approach to deliver cost-effective, rapidly deployable therapeutic options in resource-limited settings and during outbreak scenarios.

Keywords: Drug Repurposing, Vector-Borne Diseases, Malaria, Dengue, Antiviral Therapy, Computational Drug Discovery.

Understanding the Role of the mitochondrial transcription termination factor family in response to abiotic stress in wheat

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Abstract

Wheat (*Triticum aestivum*) is a globally critical staple crop cultivated commercially for its superior nutritional profile and palatability. It primarily supports human consumption, with approximately 65% of total production utilised in manufacturing essential food items such as bread, pasta, noodles, and diverse baked goods. Wheat production and productivity face severe challenges from compounding biotic and abiotic stresses, which are increasingly exacerbated by shifting global climate scenarios. In India, the world's second-largest wheat producer after China, this crop forms a cornerstone of the agricultural economy. However, climate-driven production disruptions pose severe threats to national food security and rural livelihoods. Genetic improvement to enhance stress resistance is the most effective method for sustainable wheat production and relies crucially on identifying novel genetic resources and resistance genes. Identifying and integrating these alleles into modern breeding programs expands the narrow genetic base of wheat and can be used for mitigating current and future climate-driven production challenges. The plant mitochondrial transcription termination factor (mTERF) family regulates organellar gene expression (OGE), playing a significant role in growth and stress responses across diverse, functionally characterised species. In our study, we identified the wheat mTERF gene family (TamTERF) and conducted a comprehensive genome-wide analysis, characterising their chromosomal distributions, phylogenetic relationships, conserved protein motifs, gene structures, and tissue-specific expression profiles under both abiotic and biotic stresses. Notably, specific TamTERF genes exhibited differential expression patterns under heat and drought conditions, suggesting their critical regulatory roles in mediating abiotic stress responses. Collectively, these findings offer a foundational framework for engineering next-generation, stress-resilient wheat cultivars via the precise genetic manipulation of target TamTERF candidates.

Keywords: Wheat, Abiotic stress, mTERF, Wheat Improvement, Wheat Genomics.

Identification and Validation of Potential Biomarkers in Type 2 Diabetes Mellitus Using Integrated Transcriptomic Meta-Analysis, Network Biology and Machine Learning Approaches

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Abstract

Type 2 diabetes mellitus (T2DM) is a complex, multifactorial metabolic disorder for which reliable and reproducible molecular biomarkers remain limited. This study presents an integrated computational framework for prioritising candidate biomarkers associated with T2DM by combining transcriptomic meta-analysis of cross-platform datasets, functional enrichment analysis, gene co-expression network biology, and supervised machine learning. Two independent pancreatic islet microarray datasets, GSE25724 (Affymetrix; 7 controls and 6 diabetic samples) and GSE29221 (Illumina; 12 controls and 12 diabetic samples), were harmonised into a common dataset comprising 10,943 genes. A consensus-scoring meta-analysis was performed to identify genes that were consistently dysregulated across both platforms, resulting in the identification of 954 and 146 significant genes. Based on integrated prioritisation, the candidate biomarker panel was refined to ten genes: DNASE2, MYOD1, NR2F2, PGM5, DERA, OAT, ABCD1, CHPF, STARD5, and GTF2B. A Random Forest classifier achieved a leave-one-out cross-validation accuracy of 92.3%, with an internal ROC–AUC of 1.00. Direct transfer of the model across platforms initially resulted in lower apparent performance, with an accuracy of 20.8% and an AUC of 0.014. However, applying a single polarity correction substantially improved cross-platform performance, increasing the apparent accuracy to 79.2% and the AUC to 0.986. Overall, this study presents a reproducible, multi-layered biomarker discovery pipeline for T2DM and suggests that the observed cross-platform performance differences are likely attributable to recoverable directional inversion rather than the absence of a biological signal.

Keywords: Type 2 Diabetes Mellitus, Biomarker Discovery, Transcriptomic Meta-Analysis, Machine Learning

Drug repurposing for Parkinson's Disease (PD): A Novel Approach

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Abstract

Parkinson's disease (PD) is a progressive, multifactorial neurodegenerative disorder characterised by the selective loss of dopaminergic neurons, α -synuclein aggregation, mitochondrial dysfunction, oxidative stress, and chronic neuroinflammation. Despite extensive research, current therapeutic strategies, particularly levodopa-based treatments, remain largely symptomatic and fail to halt or reverse disease progression, highlighting the urgent need for effective disease-modifying interventions. Accordingly, repurposed drugs that can modulate multiple pathological pathways offer substantial therapeutic potential and have emerged as a promising and cost-effective strategy to accelerate therapeutic discovery by leveraging existing drugs with well-established safety and pharmacokinetic profiles. Furthermore, advances in computational drug discovery and systems biology have facilitated the identification of novel repurposing candidates. Although promising results have been observed in preclinical and early clinical studies, challenges related to translational efficacy and long-term clinical outcomes remain. This review highlights the therapeutic potential of FDA-approved agents and current evidence on the repurposing of diverse pharmacological classes, including antidiabetic agents (such as GLP-1 receptor agonists, DPP-4 inhibitors, and SGLT2 inhibitors), antibiotics, anticancer agents, antivirals, and immunomodulators. These compounds demonstrate neuroprotective effects through mechanisms such as enhancement of mitochondrial function, reduction of oxidative stress, inhibition of α -synuclein aggregation, and attenuation of neuroinflammatory responses. Collectively, these findings underscore that drug repurposing represents a compelling and strategic approach for the development of disease-modifying therapies in PD, providing a foundation for future translational research.

Keywords: Neurodegenerative Disease, Parkinson's Disease, Drug Repurposing, Antidiabetic Agents, FDA-approved Drugs, Therapeutic Strategies.

AI-Driven Healthcare and Industrial Bioprocessing: Transforming Biotechnology for a Smarter Future

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Abstract

Artificial Intelligence (AI) has emerged as a transformative technology that is reshaping healthcare and industrial bioprocessing by enabling data-driven decision-making, automation, and process optimisation. In healthcare, AI technologies, including machine learning, deep learning, natural language processing, and computer vision, are enhancing disease diagnosis, medical imaging, drug discovery, precision medicine, and patient monitoring. AI algorithms can analyse large volumes of clinical and genomic data to identify disease patterns, predict health risks, and recommend personalised treatment plans. These innovations improve diagnostic accuracy, reduce human error, lower healthcare costs, and support healthcare professionals in delivering timely and effective patient care. AI-powered virtual assistants, wearable health devices, and telemedicine platforms further improve accessibility to healthcare services, particularly in remote and underserved regions. In industrial bioprocessing, AI is transforming biological manufacturing processes used in the production of pharmaceuticals, enzymes, vaccines, biofuels, food ingredients, and speciality chemicals. Advanced AI models combined with Internet of Things (IoT) devices, biosensors, robotics, and automation systems enable real-time monitoring and control of fermentation, cell culture, and downstream processing. Predictive analytics helps optimise process parameters such as temperature, pH, nutrient concentration, and oxygen levels, resulting in improved productivity, higher product quality, reduced operational costs, and minimised resource consumption. The integration of AI with biotechnology is accelerating innovation by facilitating digital biomanufacturing, intelligent laboratory automation, and rapid development of sustainable lifestyles. However, widespread implementation of AI faces several challenges, including data privacy concerns, cybersecurity risks, ethical considerations, regulatory compliance, algorithm transparency, and the need for high-quality datasets and skilled professionals. In conclusion, Artificial Intelligence (AI) is bringing positive changes to both healthcare and industrial bioprocessing. It helps doctors diagnose diseases more accurately, supports the development of new medicines, and improves patient care. In industries, AI makes production processes more efficient, reduces waste, improves product quality, and saves time.

Keywords: Artificial Intelligence, Healthcare, Industrial Bioprocessing, Sustainability

Development and Assessment of a Moisturising Cream Using Kefir

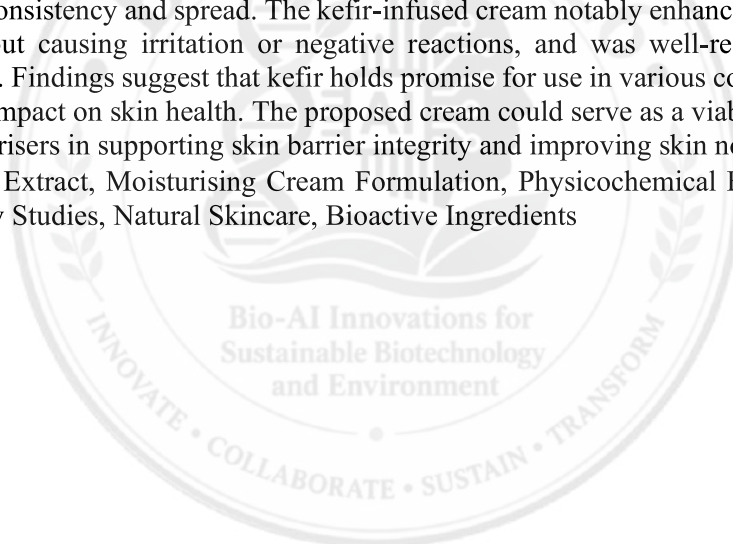
Vishakha Tyagi and Rekha Yadav

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Abstract

Growing consumer interest in natural and multi-benefit cosmetic ingredients has led to increased exploration of bioactive compounds derived from kefir. As a probiotic drink containing a mix of beneficial bacteria, yeast, and enzymes, kefir provides a rich source of nutrients, proteins, vitamins, amino acids, organic acids, and peptide components known to support skin hydration and renewal. This research focused on formulating and assessing a moisturising cream incorporating kefir extract as the primary active component. The resulting cream demonstrated effectiveness in enhancing skin hydration and protective capacity, while maintaining favourable texture, spreadability, and sensory qualities. The formulation process involved combining filtered kefir with almond oil, stearic acid, beeswax, glycerine, and an emulsifying agent to achieve a stable product. Multiple versions of the cream were prepared using varying concentrations of kefir extract to identify the optimal composition. Key physicochemical characteristics, including pH, uniformity, spreadability, and viscosity, were evaluated, along with microbial testing to ensure safety. Additionally, the study examined the cream's rehydrating performance and user acceptability based on sensory attributes such as appearance, texture, scent, absorption rate, and overall preference. Results indicated that the final formulation exhibited strong physical stability, a skin-compatible pH, and adequate consistency and spread. The kefir-infused cream notably enhanced skin moisture and softness without causing irritation or negative reactions, and was well-received by users throughout the trial. Findings suggest that kefir holds promise for use in various cosmetic products due to its positive impact on skin health. The proposed cream could serve as a viable alternative to commercial moisturisers in supporting skin barrier integrity and improving skin nourishment.

Keywords: Kefir Extract, Moisturising Cream Formulation, Physicochemical Evaluation, Skin Hydration, Stability Studies, Natural Skincare, Bioactive Ingredients



Development of a Biodegradable Portable Water Disinfection Tablet Using Natural Biopolymers and Probiotic-Derived Antimicrobial Metabolites for Drinking Water Treatment

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Abstract

Access to safe drinking water remains a significant and essential and notable worldwide difficulty, particularly in rural groups, disaster-affected regions, and resource-limited settings where centralised water treatment systems are inaccessible. Although customary chlorine-based water purification tablets effectively reduce microbial contamination, they may alter the taste and odour of water and can generate undesirable disinfection by-products. This study proposes the development of a biodegradable, water-soluble, transportable water disinfection tablet implementing food-grade natural biopolymers and probiotic-derived antimicrobial metabolites as a sustainable choice for point-of-use drinking water treatment. The tablet is designed to dissolve quickly in plain and clear water, releasing naturally derived antimicrobial compounds that target waterborne microorganisms while minimising environmental impact through biodegradable, non-toxic ingredients. The proposed formulation will integrate biodegradable biopolymers such as pullulan, sodium alginate, pectin, and maltodextrin to provide tablet integrity, swift and prompt dissolution, and compatibility with drinking water applications. Probiotic-derived antimicrobial metabolites, including bacteriocins and selected organic acids, will be examined as natural antimicrobial agents for minimising standard and extensive and prevalent signal bacteria such as *Escherichia coli* and *Staphylococcus aureus*. The formulation will be characterised for tablet hardness, dissolution time, moisture stability, and shelf life. Water quality assessment will include microbial reduction, pH, turbidity, total dissolved solids (TDS), and sensorial attributes to evaluate treatment performance and user acceptability. In addition, first and preparatory cytocompatibility and residue analyses are proposed to evaluate the safety of the formulation for potential drinking water applications. This inquiry aims to develop an eco-friendly, movable, transportable, and biodegradable water disinfection technology that combines natural biomaterials with probiotic-derived antimicrobial compounds to improve microbiological water safety.

Keywords: Portable Water Disinfection Tablet, Biodegradable Biopolymers, Probiotic-derived Antimicrobial Metabolites, Point-of-Use Water Treatment, Sustainable Water Purification, Bacteriocins, Drinking Water Safety.

Formulation and Development of a Novel Low-Sugar Carbonated Functional Beverage with Nanoencapsulated Probiotics for Enhanced Shelf Life and Gut Health

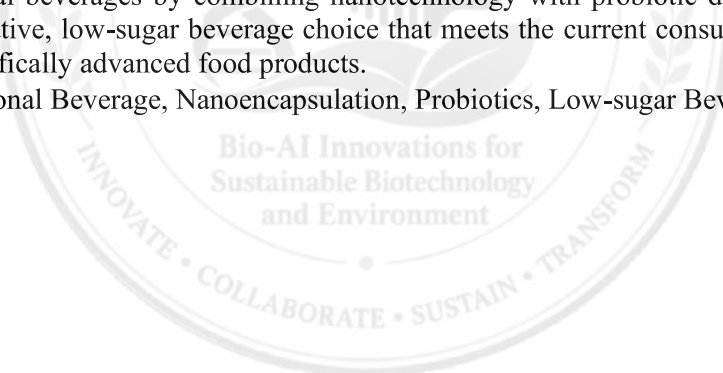
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Abstract

The increasing consumer interest in healthier drink options has spurred the advancement of functional foods that offer nutritional advantages beyond basic sustenance. Low-sugar carbonated drinks fortified with probiotics present a viable alternative to traditional soft drinks; nonetheless, ensuring the survival of probiotics in acidic and carbonated settings poses a considerable challenge. An innovative low-sugar carbonated functional beverage has been developed that incorporates nanoencapsulated probiotic cultures to enhance microbial stability, prolong shelf life, and support digestive health. The beverage will be crafted using low-calorie sweeteners and carefully chosen food-grade components, followed by the addition of nanoencapsulated probiotic strains produced through an appropriate encapsulation method. Various physicochemical characteristics, such as pH, total soluble solids, titratable acidity, carbonation level, and colour, were analysed. The survival rate of probiotics during refrigerated storage was periodically checked, and the microbiological quality, antioxidant activity, and sensory acceptability were evaluated using established analytical techniques. Nanoencapsulation is expected to significantly enhance the survival of probiotics in acidic environments and during storage, while preserving the sensory attributes of the beverage. The newly developed formulation has shown enhanced shelf life, maintains high probiotic viability, and offers potential health advantages through the modulation of gut microbiota. This research aided in creating next-generation functional beverages by combining nanotechnology with probiotic delivery systems, providing an innovative, low-sugar beverage choice that meets the current consumer demand for healthier and scientifically advanced food products.

Keywords: Functional Beverage, Nanoencapsulation, Probiotics, Low-sugar Beverage, Shelf Life, Gut health.



Development of a Self-Activating Enzyme-Embedded Bioplastic Packaging with Moisture-Responsive Biodegradation for Sustainable Plastic Waste Management

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Abstract

The growing collection of plastic packaging waste has emerged as an important and significant environmental difficulty due to the persistence of standard petroleum-based plastics in ecosystems. Biodegradable plastics provide an auspicious and favourable choice. This study proposes the development of a next-generation self-activating smart bioplastic packaging designed to maintain structural stability during storage and product application while promoting improved biodegradation after disposal. The proposed packaging will be fabricated employing renewable biopolymers such as starch, chitosan, cellulose nanofibers, and polylactic acid (PLA). The important and significant innovation includes the incorporation of microencapsulated biodegradable enzymes within the polymer matrix. Unlike free enzymes, microencapsulated enzymes are intended to remain shielded during normal packaging conditions and become available after disposal in response to environmental triggers such as moisture, increased humidity, soil microorganisms, or composting conditions. Controlled enzyme release is expected to accelerate polymer breakdown and facilitate biodegradation under proper environmental conditions. Natural biofillers and plant-derived antioxidants may further improve mechanical attributes, stability, and sustainability. The developed packaging will be assessed for tensile strength, thermal stability, water and oxygen barrier characteristics, shelf-life performance, biodegradation rate, compostability, and ecotoxicity. Comparative soil and compost decline studies will be conducted against traditional biodegradable packaging materials. Furthermore, life-cycle assessment will be used to evaluate potential decreases in plastic persistence, resource consumption, and carbon footprint. This innovative approach aims to integrate smart material design with environmentally reactive biodegradation, offering a hopeful and encouraging pathway toward sustainable packaging. The technology could have future applications in food, pharmaceutical, agricultural, and consumer-product packaging while supporting circular bioeconomy principles and contributing to the reduction of persistent plastic rubbish.

Keywords: Self-Activating Biodegradation, Moisture-Responsive Materials, Microencapsulated Enzymes, Controlled Enzyme Release, Sustainable Packaging, Circular Bioeconomy, Green Biotechnology, Biopolymer Composites.

Development of Smart Biofertilizer Tablets from Household Food Waste Enriched with Beneficial Microorganisms and Biochar for Sustainable Agriculture

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Abstract

The increasing generation of household food waste and the excessive use of chemical fertilisers have become major environmental and agricultural concerns worldwide. Conventional disposal of food waste contributes to greenhouse gas emissions and loss of valuable nutrients, while prolonged dependence on synthetic fertilisers deteriorates soil fertility and microbial diversity. This study proposes the development of an innovative smart biofertilizer tablet produced from household food waste through controlled aerobic composting, followed by enrichment with beneficial plant growth-promoting microorganisms and agricultural waste-derived biochar. The tablet formulation is designed to provide a biodegradable, easy-to-handle, and slow-release nutrient source that improves soil quality and supports sustainable crop production. The prepared compost will be blended with biochar to enhance nutrient retention, moisture-holding capacity, and carbon sequestration. Beneficial microorganisms, including nitrogen-fixing and phosphate-solubilising bacteria, will be incorporated to improve nutrient availability and stimulate plant growth. Natural biodegradable binders such as starch or sodium alginate will be used to compress the mixture into tablets that gradually disintegrate after soil application, ensuring sustained nutrient release while minimising nutrient leaching. This research presents an eco-friendly and cost-effective strategy integrating waste valorisation, microbial biotechnology, and sustainable agriculture. The proposed smart biofertilizer tablet has the potential to provide an innovative solution for organic farming, waste management, and climate-resilient agricultural practices, contributing to the achievement of sustainable development goals related to responsible consumption, environmental protection, and food security.

Keywords: Food Waste Valorisation, Smart Biofertilizer Tablets, Sustainable Agriculture, Biochar, Plant Growth-Promoting Microorganisms, Slow-Release Fertiliser, Circular Bioeconomy, Organic Farming.

Medicinal Plant-Specific Endophytes as Bio-Intelligent Regulators for Simultaneous Microplastic Detoxification and Adaptive Phytochemical Reprogramming

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Abstract

Microplastic build-up in agricultural soils is increasingly acknowledged as a hidden environmental stressor that can impact plant physiology, though its effect on the phytochemistry of medicinal plants remains largely unexamined. This research introduces an innovative bio-intelligent approach where endophytic bacteria specific to medicinal plants serve two roles: actively breaking down microplastic pollutants and adaptively regulating the biosynthesis of secondary metabolites in the host. Unlike traditional bioremediation methods that concentrate solely on removing pollutants, this framework explores whether the perception of stress signals from microplastics by endophytes can initiate selective metabolic changes in the host plant. This could potentially boost the production of valuable phytochemicals without affecting the plant's overall growth, physiological health, or reproductive success. This study focuses on the development of a Smart Endophytic Biobarrier, which is a self-regulating microbial network associated with plants. It is hypothesised that this network can detoxify microplastic residues in both the rhizosphere and endosphere while maintaining phytochemical homeostasis under varying environmental stress conditions. The system is proposed to function through coordinated enzymatic degradation pathways, including laccases, peroxidases, and hydrolases, as well as microbial signalling mechanisms that modulate host secondary metabolic pathways in real time. The research will involve isolating potential endophytes from stress-tolerant medicinal plant species, screening them for dual functionality, and characterising the molecular interactions that underlie stress perception and phytochemical modulation. If successful, this dual-functional microbial system could establish a new paradigm in environmental microbiology by integrating soil restoration, enhancing the resilience of medicinal plants, and enabling the sustainable production of pharmaceutically relevant metabolites within a single biological framework. By bridging bioremediation science with phytochemical engineering, this forward-looking approach holds significant potential to inform climate-smart agricultural practices and next-generation microbial biotechnology aimed at safeguarding both environmental and human health.

Keywords: Endophytic Bacteria; Smart Endophytic Biobarrier; Microplastic Detoxification; Adaptive Phytochemical Reprogramming; Medicinal Plants; Sustainable Microbial Biotechnology.

AI-Enhanced Supercritical Fluid Extraction (SFE): A Green Technology for Sustainable Herbal Drug Discovery

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Abstract

The expanding worldwide interest in herbal medicines has created a pressing need for methods that are sustainable, efficient, and environmentally conscious for extracting bioactive compounds from medicinal plants. Traditional extraction techniques, including Soxhlet extraction and solvent maceration, often require substantial amounts of organic solvents, extended processing times, and high energy inputs. These practices can lead to residual solvents, deterioration of temperature-sensitive compounds, and environmental harm. These challenges highlight the importance of developing green extraction methods that align with the goals of sustainable biotechnology and environmental protection. Supercritical Fluid Extraction (SFE), especially utilising supercritical carbon dioxide (SC-CO₂), has become a prominent green extraction method due to its non-toxic properties, low critical temperature, recyclability, and excellent mass transfer capabilities. The distinct physicochemical attributes of SC-CO₂ allow for the selective extraction of a wide range of phytochemicals while maintaining their biological efficacy. The application of Artificial Intelligence (AI) further advances SFE by facilitating the intelligent optimisation of key extraction parameters, including pressure, temperature, extraction duration, CO₂ flow rate, particle size, and co-solvent concentration. Machine learning techniques can forecast optimal extraction settings, enhance phytochemical yield and specificity, minimise the number of experimental trials, and improve process consistency, thereby supporting faster progress in sustainable herbal drug development. This study emphasises the combination of Artificial Intelligence (AI) with Supercritical Fluid Extraction (SFE), detailing the core principles, operational parameters, and recent developments in AI-driven optimisation of extraction processes. It explores the potential of AI-enhanced SFE for extracting bioactive compounds from medicinal plants such as *Withania somnifera* (Ashwagandha), *Curcuma longa* (Turmeric), *Ocimum tenuiflorum* (Tulsi), and *Azadirachta indica* (Neem). Additionally, the study discusses the challenges and future opportunities associated with integrating intelligent technologies into sustainable extraction methods. Combining Artificial Intelligence with Supercritical Fluid Extraction offers a promising approach for the future of herbal drug discovery by merging environmentally friendly extraction techniques with data-driven process optimisation. This integrated method has the potential to enhance extraction efficiency, minimise environmental footprint, and facilitate the production of high-quality plant-based therapeutics, while promoting the principles of sustainable biotechnology and innovation in Bio-AI.

Keywords: Herbal Medicines, Sustainable Extraction, Bioactive Compounds, Supercritical Fluid Extraction (SFE), Supercritical Carbon Dioxide (SC-CO₂), Artificial Intelligence (AI), Machine Learning, Process Optimisation, Phytochemical Yield, Sustainable Biotechnology, Herbal Drug Development.

Effect of Entomopathogenic Bacteria on Mealybug-Infested Plants

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Abstract

The present investigation was carried out to evaluate the efficacy of entomopathogenic bacteria in controlling mealybug infestation in the laboratory. Mealybug-infested Hibiscus (*Hibiscus rosa-sinensis*) plants along with rhizospheric soil samples were collected from ornamental garden sites. Bacterial isolates were obtained from the rhizospheric soil using serial dilution and spread plate techniques on Nutrient Agar and King's B Medium. The isolates were purified by repeated streaking and characterised based on colony morphology, Gram stain, catalase test, and oxidase test. According to these characteristics, the isolates were identified as *Bacillus thuringiensis* and *Pseudomonas fluorescens*. Antagonistic activity of isolated bacterial cultures against mealybugs was tested by laboratory bioassays using infected hibiscus leaves and twigs in sterile Petri dishes. The experimental setup was regularly monitored for behavioural changes, reduced movement, discolouration and mortality of mealybugs after bacterial treatment. Comparative observations were noted for bacterial-treated and untreated control samples. Results showed that both *Bacillus thuringiensis* and *Pseudomonas fluorescens* exhibited significant biocontrol activity against mealybugs. The treated samples, after about two weeks of treatment, showed a decrease in mealybug population, decreased mobility, drying of the body surface and increased mortality. *Bacillus thuringiensis* exhibited relatively better insecticidal activity, while *Pseudomonas fluorescens* showed moderate suppression of infestation. The treated leaves also showed reduced honeydew deposition and improvement in leaf appearance in comparison to the untreated samples. The results of the present study demonstrated the great potential of rhizospheric bacteria as environmentally friendly biocontrol agents against mealybug infestation. The use of microbial biocontrol agents can contribute to the reduction of chemical pesticides and promote sustainable agriculture and horticulture.

Keywords: Mealybugs, *Bacillus Thuringiensis*, *Pseudomonas Fluorescens*, Bio-Control, Rhizospheric Bacteria, Bioassay, Biological Control, King's B Medium.

Integrated Meta-Analysis of Public Microarray Datasets to Identify Novel Biomarkers and Therapeutic Targets in Cholangiocarcinoma

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Abstract

Cholangiocarcinoma (CCA) is rare due to its late identification, rapid progression, and limited available therapies. This extremely aggressive cancer that develops in the epithelial layer of the bile ducts continues to be one of the main causes of cancer-related death. There is a critical need for credible biomarkers that can aid in early detection and enhance treatment approaches because the molecular pathways behind cholangiocarcinoma are complicated and yet poorly understood. Despite the fact that several transcriptome studies have investigated changes in gene expression in cholangiocarcinoma, the results frequently differ due to variations in sample size, experimental platforms, and analytical techniques. Such constraints can be solved through merging several freely accessible datasets via meta-analysis, which boosts statistical power and finds genes that are consistently expressed in different studies. In order to find new biomarkers and possible treatment targets linked to cholangiocarcinoma, the proposed study intends to conduct an integrated meta-analysis of publicly accessible microarray datasets. Based on predetermined inclusion criteria, pertinent gene expression datasets will be obtained from the Gene Expression Omnibus (GEO) database of the National Centre for Biotechnology Information (NCBI). Differentially expressed genes (DEGs) will be found using an integrated analytical method after data preprocessing and quality evaluation. Gene Ontology (GO) and Kyoto Encyclopaedia of Genes and Genomes (KEGG) pathway enrichment studies will be used for functional annotation of the discovered genes in order to examine their biological importance and related molecular pathways. Additionally, using the STRING database, a protein–protein interaction (PPI) network will be built, and network analysis in Cytoscape will be carried out to find important hub genes that might be crucial to the onset and course of the disease. It is anticipated that the results of this investigation will offer a thorough comprehension of the molecular landscape of cholangiocarcinoma and reveal reliable biomarkers with potential therapeutic and diagnostic value. This bioinformatics-based method may aid in the creation of precision medicine techniques for the efficient treatment of cholangiocarcinoma as well as future experimental validation research.

Keywords: Cholangiocarcinoma, Meta-analysis, Bioinformatics, Microarray, Differentially Expressed Genes, Biomarkers, Protein–Protein Interaction.

Biodegradable Pesticide Carriers: A Green Approach to Sustainable Crop Production

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Abstract

The extensive use of conventional pesticide formulations has significantly contributed to soil pesticide resistance, reduced crop yield efficiency and water contamination. These challenges have accelerated the search for sustainable and biodegradable alternatives that improve pesticide efficiency while minimising ecological impact. Green synthesis of biodegradable pesticide carriers has emerged as a promising approach by utilising renewable biomaterials such as chitosan, alginate, cellulose, starch, lignin, and protein- or peptide-based biopolymers to develop environmentally friendly delivery systems. These biodegradable carriers enable controlled and targeted release of pesticides, enhance stability against environmental degradation, reduce chemical losses through leaching and volatilisation, and improve crop protection with lower pesticide dosages. Recent advances in nanobiotechnology have further enabled the development of biodegradable nano-carriers synthesised through green methods that eliminate the need for hazardous chemicals and energy-intensive processes. Moreover, the integration of Artificial Intelligence (AI) into sustainable agriculture offers new opportunities to optimise carrier design, predict release kinetics, screen suitable biomaterials, and develop precision pesticide delivery systems based on crop and environmental conditions. AI-driven material modelling and data analysis can significantly accelerate the development of efficient, cost-effective, and environmentally safe pesticide formulations. This presentation highlights the principles, materials, synthesis strategies, applications, advantages, and current challenges associated with green biodegradable pesticide carriers while emphasising the emerging role of AI in designing next-generation smart agrochemical delivery systems. The convergence of green chemistry, biodegradable biomaterials, nanotechnology, and AI has the potential to transform sustainable crop protection by improving agricultural productivity while reducing environmental risks, thereby supporting global goals for sustainable biotechnology and environmental conservation.

Keywords: Green synthesis, Biodegradable pesticide carriers, Sustainable agriculture, Biopolymers, Nanotechnology, Artificial Intelligence, Controlled release, Environmental biotechnology.

Artificial Intelligence-Assisted Development of an Eco-Friendly Algae–Bacteria Consortium for Sustainable Wastewater Treatment and Resource Recovery

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Abstract

The increasing generation of wastewater due to rapid industrialisation and urbanisation has created significant environmental and public health challenges. Conventional wastewater treatment methods are often energy-intensive, expensive, and generate secondary pollutants. This study proposes an Artificial Intelligence (AI)-assisted approach for the development of an eco-friendly algae–bacteria consortium to improve wastewater treatment efficiency while promoting sustainable resource recovery. AI techniques, including machine learning algorithms, can be utilised to optimise the selection of compatible algal and bacterial species, predict their interactions, and determine optimal operational conditions for maximum pollutant removal. The algae–bacteria consortium works synergistically by removing nutrients, degrading organic pollutants, capturing carbon dioxide, and producing valuable biomass that can be converted into biofertilizers or bioenergy. The integration of AI with microbial biotechnology enhances treatment performance, reduces operational costs, and supports real-time process monitoring and decision-making. Furthermore, this sustainable biological system contributes to the principles of the circular economy by transforming wastewater into a valuable resource. The proposed research highlights the potential of AI-driven microbial consortia as an innovative, environmentally friendly, and cost-effective solution for future wastewater management. This approach aligns with global Sustainable Development Goals (SDGs), particularly those related to clean water, sustainable cities, climate action, and responsible resource utilisation. The findings are expected to provide a foundation for the development of next-generation smart wastewater treatment systems with improved environmental and economic benefits.

Keywords: Artificial Intelligence, Algae–Bacteria Consortium, Wastewater Treatment, Resource Recovery, Machine Learning, Sustainable Biotechnology, Circular Economy, Bioenergy.

Microplastics and Their Impact on Microbial Communities and Human Health

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Abstract

Microplastics, defined as plastic particles smaller than 5 mm, have become a major environmental and public health concern due to their widespread presence in water, soil, air, and food. These tiny plastic particles originate from the breakdown of larger plastic materials and from products such as cosmetics, synthetic textiles, and industrial waste. Their persistence in the environment allows them to interact with diverse microbial communities, leading to significant ecological and health-related consequences. This review explores the impact of microplastics on microbial communities and human health. Microplastics provide surfaces for microbial attachment, resulting in the formation of biofilms known as the plastisphere. These biofilms can harbour pathogenic microorganisms and facilitate the spread of antimicrobial resistance genes, posing potential risks to both environmental and human health. In addition, microplastics can alter the composition and diversity of beneficial microbial communities in aquatic and terrestrial ecosystems, thereby affecting nutrient cycling and ecosystem stability. Recent studies also suggest that humans are exposed to microplastics through food, drinking water, and inhalation. Once inside the body, microplastics may disturb the gut microbiota, trigger inflammation, induce oxidative stress, and transport harmful chemicals or pathogens. Although research is still evolving, these findings highlight the need to better understand the long-term effects of microplastic exposure on human health. In conclusion, microplastics represent an emerging challenge that links environmental pollution with microbiology and public health. Further research is required to understand their interactions with microorganisms and their effects on the human body. Effective plastic waste management, public awareness, and sustainable environmental practices are essential to reduce microplastic pollution and protect both ecosystem health and human well-being.

Keywords: Microplastics, Microbial Communities, Human Health, Plastisphere, Gut Microbiota, Antimicrobial Resistance.

Cytotoxicity Assessment of Nanoparticles in Animal Cell Lines Assay

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Abstract

Nanoparticles are now utilised for countless biomedical activities ranging from drug target delivery and biosensing to tissue building and cancer medicines. Still, due to the greater application of nanoparticles in medicine, some issues regarding their side effects in organisms arise, for which the cytotoxicity investigation of NPs in vivo and in vitro is a prerequisite. In this article, a review has been conducted in which cytotoxicity screening of nanoparticles in several animal cells was performed, and the variables that should be taken into account during biological investigation of the NPs are analysed. The included literature-based studies incorporated several cell types, most of which included L929, Vero, NIH/3T3, CHO, and RAW 264.7 cells, in order to estimate the nanoparticles' ability to cause cell mortality. As noticed through all examined studies, the main source of induced cell death were physic-chemistry attributes of the particles, like the particles' size, form, surface area load, concentration or exposure period; these contributed to induced cell toxicity by causing such cell biological changes as oxidative burden, decline in mitochondrial features, barrier disruption or a provoke of inflammatory or immunological responses or programmed death. Many in vitro assessments, such as the MTT assay, LDH assay, Neutral Red assay, the annexin V/PI kit, DCHF-DA (DCFH-DA assay), as well as flow Cytometry assay, were employed to measure the cell death induced by nanoparticles. There was evidence from recently researched articles that a coating procedure can reduce the NPstotoxicity. Green synthesis is regarded as a safe approach to apply nanoparticles in biomedical applications. Yet some controversy between the collected data and observations because a few experimental analyses differ considerably in terms of setting. Thus, a specific and consistent manner of studying the cytotoxicity of nanoparticles is important for properly understanding the mechanisms involved and sustainable NPs utilisation.

Keywords: Nanoparticles, Cytotoxicity, In Vitro Assays, Green Synthesis.

Microbial Restoration of Degraded Agricultural Soils: A Sustainable Biotechnological Approach for Enhancing Soil Health and Crop Productivity

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Abstract

Soil degradation, which poses a significant threat to global food security and environmental sustainability, has been greatly exacerbated by intensive farming, excessive use of chemical fertilisers, erosion, salinity, and climate change. A sustainable and eco-friendly alternative to conventional soil management is the rehabilitation of degraded agricultural soils using microbial biotechnology. Key microorganisms, including plant growth-promoting rhizobacteria (PGPR), arbuscular mycorrhizal fungi (AMF), nitrogen-fixing bacteria, phosphate-solubilising microbes, and decomposer organisms, play a crucial role in improving soil fertility, nutrient cycling, organic matter decomposition, and soil structure. These microbial groups enhance plant growth by increasing nutrient availability, producing phytohormones, inhibiting soil-borne pathogens, and bolstering plant resistance to abiotic stresses such as drought, salinity, and heavy metal contamination. Recent progress in environmental biotechnology, such as microbial consortia, biofertilizers, metagenomics, and microbiome engineering, has facilitated the creation of precise methods for reviving soil microbial diversity and ecosystem functions. By combining microbial inoculants with sustainable farming techniques, reliance on chemical fertilisers can be minimised, crop yields can be enhanced, and soil resilience can be bolstered over the long term. Nonetheless, significant challenges persist, including field variability, microbial survival, host specificity, and the commercialisation of these technologies on a large scale. Future studies should aim to develop microbial formulations tailored to specific regions, explore plant–microbe interactions using multi-omics techniques, and assess long-term field performance across various agroecological settings. This review underscores the importance of microbial restoration as a novel environmental biotechnology approach for rehabilitating degraded soils, supporting sustainable agriculture, improving ecosystem services, and contributing to global food and environmental security.

Keywords: Soil Degradation, Environmental Biotechnology, Biofertilizers, Plant Growth-promoting Rhizobacteria (PGPR), Arbuscular Mycorrhizal Fungi (AMF), Soil Microbiome, Sustainable Agriculture, Metagenomics.

Exploring Lignocellulolytic Microorganisms and Microbial Consortia for Sustainable Lignocellulosic Biomass Degradation: Isolation from Partially Degraded Sugarcane Leaves

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Abstract

The biological degradation of lignocellulosic biomass has emerged as a cornerstone of sustainable biotechnology, providing an eco-friendly approach for converting agricultural residues into renewable biofuels, bio-based chemicals, and other value-added products. Owing to the complex and highly recalcitrant architecture of lignocellulose, efficient biodegradation largely depends on the metabolic diversity and enzymatic capabilities of lignocellulolytic microorganisms. This study highlights the diversity of lignocellulolytic bacteria, fungi, and microbial consortia and their pivotal role in the decomposition of lignocellulosic biomass through the coordinated action of cellulases, hemicellulases, lignin-modifying enzymes, and carbohydrate-active enzymes (CAZymes). To investigate their degradative potential, partially degraded sugarcane leaves were collected as a natural source of lignocellulolytic microorganisms. Bacterial and fungal isolates were obtained using serial dilution and spread plate techniques on selective cellulose-containing media, followed by purification and preliminary screening based on cellulolytic activity. The development and evaluation of compatible microbial consortia, together with the individual isolates, are intended to be carried out to assess their lignocellulose degradation potential under controlled laboratory conditions. Despite significant progress, challenges related to biomass recalcitrance, enzyme efficiency, process scalability, and economic feasibility continue to limit large-scale applications. The ongoing isolation, characterisation, and consortium development of lignocellulolytic microorganisms are expected to provide valuable insights into their enzymatic degradation potential, thereby contributing to the development of efficient, sustainable, and economically viable lignocellulosic bioconversion strategies for future biorefinery applications.

Keywords: Lignocellulosic Biomass Degradation, Microbial Consortia, Lignocellulolytic Microorganisms, Carbohydrate-Active Enzymes.

Development of an Eco-Friendly Seed Coating Using Fruit Waste and Plant Growth-Promoting Microorganisms

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Abstract

The extensive use of synthetic seed-coating materials has raised environmental concerns due to their non-biodegradable nature and their potential adverse effects on soil health. This study aims to develop an eco-friendly, biodegradable seed coating using fruit waste-derived pectin as a natural polymer combined with plant growth-promoting microorganisms (PGPM). Pectin extracted from fruit waste will serve as the coating matrix because of its biodegradable, non-toxic, and film-forming properties. Beneficial microorganisms, including *Bacillus subtilis*, *Azotobacter spp.*, and *Rhizobium spp.*, will be incorporated into the coating to enhance seed germination, improve nutrient availability, promote nitrogen fixation, and support early seedling growth. Neem extract will also be included as a natural antifungal agent to protect seeds against soil-borne pathogens while maintaining an environmentally safe formulation. The coating will be prepared using optimised concentrations of pectin, microbial cultures, and neem extract and will be applied to selected crop seeds. The coated seeds will be evaluated for coating quality, microbial viability, germination percentage, seedling vigour, and early plant growth under laboratory conditions. The developed formulation is expected to provide an environmentally friendly alternative to conventional synthetic seed coatings while promoting sustainable agriculture and the utilisation of fruit waste as a valuable bioresource. This research supports the principles of a circular bioeconomy by converting agricultural waste into a value-added product with potential applications in sustainable crop production.

Keywords: Seed Coating, Fruit Waste Pectin, *Bacillus Subtilis*, *Azotobacter*, *Rhizobium*, Neem Extract, Sustainable Agriculture, Circular Bioeconomy.

Engineered Probiotic Bacteria for Smart Infection Control in AI-Enabled Living Wound Dressing

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Abstract

Wound infections are a common healthcare issue, as they delay healing and often lead to over-prescription of antibiotics. With antibiotic resistance increasing, better ways to deal with wound infections are needed. One potential solution to this idea is the coupling of microbiology with Artificial Intelligence (AI). The proposed concept is a living wound dressing with engineered probiotic bacteria, which may assist in targeted control of harmful microbes. In this proposed model, engineered probiotic bacteria are incorporated in a wound dressing. AI would be able to analyse information collected from wound sensors, such as changes in temperature, pH and moisture, to detect early signs of infection. Based on this analysis, the probiotic bacteria may release antimicrobial substances that help reduce the growth of harmful bacteria and maintain the normal skin microbiota. The model will be useful in cutting down unnecessary use of antibiotics, speeding up wound healing and helping to manage infection better. The model requires further laboratory research and clinical evaluation; it highlights how AI and microbiology can be combined to create innovative healthcare solutions. In conclusion, the integration of AI with engineered probiotic bacteria offers an interesting direction for future wound care research. This approach may provide a smarter and more targeted method for infection control while helping to address the growing challenge of antimicrobial resistance.

Keywords: Artificial Intelligence, Probiotic Bacteria, Smart Wound Dressing, Infection Control, Antimicrobial Resistance, Biopharmaceuticals.

Autonomous Laboratories: Integrating Digital Twins and Organoids for Next-generation Biotechnology Research

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Abstract

In the healthcare industry, we require different types of personnel for each patient. But recent developments in technology have introduced AI, leading to Autonomous AI Laboratories. These are self-driven labs that unite artificial intelligence, robotics, automated machinery, and technology to perform scientific experiments on their own. These labs work by relying on multimodal AI for the distribution of work. But when it comes to prescribing medicines, neither an AI nor a human can be accurate. Every disease can show new symptoms in a patient besides the common symptoms because every human has gone through different circumstances in their lives, which have shaped their mental and physical state of well-being, and therefore a patient can lack one symptom which the other patient may be having. To overcome this problem, merging the technologies of digital twins and organoids can help us give an accurate analysis of a person's disease. By analysing Internet-based sources (IBSs), health reports and clinical data like patient-specific imaging data, which involves biophysical processes forming the framework of anatomical twinning and computational paradigms for physiological functioning data. Behavioural data, emotional, cognitive and psychological insights, with the patient's lifestyle and medical history. Predictive analysis and machine learning algorithms can help in predicting disease progression and treatment outcomes. And for drug testing, a cell-derived organoid can be a very helpful aid since it would be a replica of the patient's organ created from its stem cells by preserving the genetics and epigenetics and allowing us to develop a healthy or affected organ and recommend preventive measures by testing the drugs. By reducing the number of humans in the labs, avoiding the major outbreak of infectious and fatal diseases is possible. When the whole lab becomes self-driven and humans only exist for the verification of claims, then fewer carriers will be present. Personalised medicine for every patient can become achievable in the near future.

Keywords: Autonomous, Artificial Intelligence, Public Health Care, Digital Twins, Organoids.

Engineered Bioluminescent Plants: Biosynthesis of Light Using Mushroom Genes

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Abstract

Bioluminescent plants are unique plants that have the ability to glow naturally in the dark. In nature, there are no glowing plants on land. Natural bioluminescence is only found in the deep oceans (glowing jellyfish) or in dark forests (glowing mushrooms). However, using modern plant science, researchers have created artificial glowing plants in laboratories by adding mushroom genes into regular plants. The main purpose of this study is to explain where these plants come from, how they produce light on their own, and how they can help us in our daily lives. For years, scientists have dreamed of creating plants that glow in the dark. Maybe this would be a cool, natural way to light up our rooms or streets at night. Before this, scientists used genes from fireflies, but the plants were very dim and needed extra chemicals to stay lit. Instead, we're now using genes from glowing mushrooms. The genes enable the plant to synthesise light from its own natural food and energy. This study aimed to insert these mushroom genes into a normal plant to make it glow bright and continuously all by itself. Four genes from a glowing mushroom were taken and inserted into a plant using a safe genetic transformation method. As the plants grew, it was found that the new genes were functioning properly within the plant's system. Then, the plants were moved into a totally dark room and used sensitive cameras to measure exactly how much light the plants emitted and where the light came from. Quantitative analysis showed successful general expression and steady light production. The plants glowed a pretty steady green-white. The plants didn't need any special chemicals or extra care; they just glowed naturally, alive and growing. The brightest parts of the plant were also the youngest, such as the new leaves and the opening flower buds. This shows that it is easy to make glowing plants out of nature's own chemistry. It is possible to grow living, glowing plants for our homes and gardens in the future.

Keywords: Glowing Plants, Mushroom Genes, Changing Plant DNA, Living Lights, Simple Science.

Exploring Artificial Intelligence in Early Cancer Diagnosis: Current Scenario and Future Perspectives

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Abstract

Early diagnosis plays a crucial role in improving cancer survival and reducing disease-related mortality. Conventional diagnostic approaches such as medical imaging, histopathology, and biomarker-based tests have significantly improved cancer detection; however, delayed diagnosis, increasing clinical workload, and variability in interpretation continue to affect patient outcomes. Artificial Intelligence (AI), particularly Machine Learning (ML) and Deep Learning (DL), has emerged as a promising approach for analysing complex biomedical data and supporting clinicians in detecting cancer at an early stage. This review highlights recent advances in AI-assisted diagnosis through medical imaging, digital pathology, genomic profiling, and biomarker analysis while emphasising the integration of AI with biotechnology for improving diagnostic accuracy and enabling precision medicine. It also discusses key challenges, including algorithm bias, limited annotated datasets, lack of explainability, data privacy concerns, and barriers to clinical implementation. Addressing these limitations through explainable AI, standardised datasets, and interdisciplinary collaboration will be essential for ensuring reliable and ethical adoption in healthcare. Overall, AI has the potential to complement healthcare professionals by enabling faster, more accurate, and efficient early cancer diagnosis, ultimately improving patient outcomes and supporting future advancements in precision oncology.

Keywords: Artificial Intelligence, Early Cancer Diagnosis, Precision Oncology.

Conversion of Plastic Waste into Petrol by Pyrolysis

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Abstract

Plastic waste has become one of the most serious environmental problems due to its non-biodegradable nature and increasing accumulation in landfills and water bodies. Converting plastic waste into fuel is an effective waste management solution that helps reduce pollution while recovering valuable energy. Among different types of plastics, Low-Density Polyethylene (LDPE), High-Density Polyethylene (HDPE), and Polypropylene (PP) are the most suitable for this process because they produce a high yield of fuel with fewer harmful by-products. This project focuses on converting plastic waste into petrol-like fuel using the pyrolysis process, which is an eco-friendly waste-to-energy technology. In the pyrolysis process, suitable plastic waste is heated at 350–500°C in the absence of oxygen inside a reactor. The plastic breaks down into hydrocarbon gases and vapours, which are then cooled in a condenser to produce liquid pyrolysis oil. After purification and fractional distillation, the oil can be converted into petrol-like fuel. The non-condensable gases produced during the process can also be reused as a fuel source for heating the reactor, improving the overall energy efficiency of the system. This technology helps reduce plastic pollution, decreases landfill waste, and lowers dependence on fossil fuels by producing an alternative source of energy. It also supports sustainable waste management by converting waste into useful products while minimising environmental damage. Although pyrolysis is mainly used on an industrial scale, it has significant potential for future applications due to its environmental and economic benefits. Overall, this project demonstrates that pyrolysis is a promising and sustainable method for managing plastic waste and producing valuable fuel when proper safety measures and suitable plastic materials are used.

Keywords: Plastic Waste, Pyrolysis, Fuel Production, Waste-to-Energy, Sustainable Waste

Management.

AlphaFold3 Modelling Supports Mutually Exclusive ARK1-INCENP-A and ARK1-INCENP-B Complexes over a Stable Chromosomal Passenger Trimer in Plasmodium

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Abstract

The Chromosomal Passenger Complex (CPC) drives cell division during Plasmodium schizogony and gametogony, but how its kinase unit (ARK1) coordinates with two distinct inner centromere protein paralogues-INCENP-A and INCENP-B-has remained an open question. Using AlphaFold3 across five Plasmodium species (*P. falciparum*, *P. berghei*, *P. chabaudi*, *P. gallinaceum*, *P. vivax*) and *Toxoplasma gondii*, we evaluated whether ARK1 forms a single heterotrimer or two mutually exclusive binary complexes. All binary models yielded high-confidence docking interfaces with zero predicted clashes (iptm up to 0.90, interface PAE as low as 1.3 Å). Ternary assemblies, however, failed to form stable complexes in any species tested, breaking down along clear evolutionary lines. Trimeric models in Plasmodium species generated severe steric clashes and low confidence scores (iptm 0.33–0.39, ranking scores < -99). In *T. gondii*, the trimer avoided physical clashes entirely but resolved asymmetrically: ARK1 bound one INCENP paralogue firmly while pushing the second to the periphery (interface PAE > 11 Å). Direct contact between INCENP-A and INCENP-B was absent across all species (interface PAE 16–21 Å). These structural patterns show that ARK1 uses a single, overlapping binding surface for both paralogues, though the mechanical outcome of this competition differs between Haemosporida (clash-driven) and Coccidia (displacement-driven). Control validation with human Aurora B–INCENP and residue-level mapping are underway to confirm this competitive binding model and evaluate the interface for parasite-specific drug design.

Keywords: Chromosome Passenger Complex, Aurora-related kinase 1 (ARK1), INCENP paralogues, Structural Modelling, AlphaFold3, Competitive Binding, Antiparasitic Drug Targets

Beyond Antibiotics: Computational Host-Range Prediction of Bacteriophages against Ganga River AMR Bacteria

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Abstract

Bacteria are outrunning our antibiotics. Strains once controlled by common drugs no longer respond to them, and the Ganga, which is the water source for hundreds of millions of people, has quietly become one of India's largest reservoirs of antimicrobial-resistant (AMR) bacteria, fed continuously by pharmaceutical effluent, hospital waste and agricultural runoff from the cities along its course. When resistance reaches people through this water, there is often nothing left in the medicine cabinet that works. Bacteriophages offer a rare way out: viruses that kill bacteria with a precision no antibiotic has, targeting only their specific host while leaving the rest of the microbial community untouched. The real bottleneck is not whether phages can kill resistant bacteria; it is how fast the right match can be found between the two. Traditionally, this means testing candidates one pair at a time in a lab, a pace no match for how quickly resistance is spreading across an entire river basin. This study uses an AI-based host-range prediction model to close that gap computationally, a pipeline that ranks which known and candidate phages are most likely to infect which Ganga-associated resistant bacterial strains using genomic features including sequence similarity, receptor-binding protein structure, and CRISPR-spacer evidence, drawn from already-published isolate data. This approach may be the first such computational model applied specifically to the Ganga AMR reservoir. Because phages are host-specific, this approach also spares non-target bacteria the collateral damage broad-spectrum antibiotics cause, and provides a faster and sustainable path to treatment. The model's ranked candidates are proposed as a first-pass filter to guide future wet-lab validation.

Keywords: Antimicrobial Resistance, Bacteriophage Therapy, Host-Range Prediction Model, Machine Learning, Ganga River Microbiome.

A Data-Driven Consensus Map of Age-Associated Sperm Methylation Within Epigenetic Escape Regions

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Abstract

Advancing paternal age is associated with progressive alterations in sperm DNA methylation, some of which have been linked to increased offspring risk for neurodevelopmental disorders. While most methylation marks are erased during post-fertilisation epigenetic reprogramming, certain genomic regions, including imprinted loci and other reported regions, are known to resist this erasure. Age-associated sperm methylation changes preferentially localise within these escapee regions, offering a plausible molecular route through which paternal ageing effects could persist into the embryo rather than being erased. The integration of publicly available sperm methylome datasets from independent ageing studies was done to build a high-confidence, cross-study consensus set of age-associated CpGs, alongside a curated reference catalogue of known escapee regions. Genomic overlap and enrichment analyses (hypergeometric testing) assessed that the age-associated CpGs were disproportionately enriched within escapee regions relative to matched genomic controls. In parallel, CpG density was compared between escapee and control regions to characterise sequence-level features potentially associated with reprogramming resistance. This study does not establish causality or confirm transmission to offspring, but to generate a testable, data-driven hypothesis about which paternal age-related epigenetic marks are structurally positioned to survive embryonic reprogramming. By identifying candidate regions where age-related methylation and reprogramming-escape potential converge, this work lays foundational groundwork for understanding a possible mechanism underlying intergenerational epigenetic inheritance with direct relevance to reproductive biology, offspring health risk assessment, and how parental life history shapes descendant epigenomes.

Keywords: Sperm DNA Methylation, Paternal Age, Epigenetic Reprogramming, Escapee Regions, Genomic Imprinting, Intergenerational Epigenetic Inheritance.

Network Pharmacology-Based Approach to Explore Therapeutic Potential of *Aerva lanata* Against Rheumatoid Arthritis

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Abstract

Background: Rheumatoid arthritis is a chronic autoimmune disorder characterised by persistent inflammation of joints. Although DMARD's biological, and glucocorticoids are the main treatment approaches for RA, these medication do not effective for every patient or do not provide complete and long-term relief. Therefore, network pharmacology was used to determine the effects of *Aerva lanata* on multiple targets in RA, and suggested molecular docking for future validation. Objective: To investigate the targets and molecular pathways of anti-arthritis activity in RA using network pharmacology. Methodology: Data from PubChem and IMPPAT databases were used to collect compounds from *Aerva lanata*. Then, the target prediction platforms were used to predict the potential targets of each compound. The genes associated with RA were selected from the GeneCards database. Thereafter, the common genes shared by the disease-associated genes and predicted phytoconstituent targets were identified. In order to map these targets, the STRING database was used to create the PPI network with the targets. The generated network was analysed using Cytoscape to find the hub genes. A pathway enrichment analysis was carried out using the DAVID tool. Result: The PPI network analysis identified seven hub genes, including TNF, AKT1, BCL2, CTNNB1, SRC, EGFR, and HSP90AA1. Enrichment analysis shows that *Aerva lanata* might exert its effect on inflammation by means of a number of pathways, including the MAPK, PI3K-AKT, HIF-1, and JAK-STAT pathways. Conclusion: The results indicate that *Aerva lanata* may be acting on multiple molecular targets and pathways involved in the pathogenesis of RA, suggesting its possible use as a phytotherapeutic agent. However, these findings are based on computational analysis and require further validation using molecular docking and experimental studies to establish the interaction of identified compounds with hub targets before use in the treatment of the disease.

Keywords: Rheumatoid Arthritis, *Aerva lanata*, Network Pharmacology, Bioinformatics, Therapeutic Targets.

Nanobiotechnology-based Smart Biosensors for Early Disease Detection

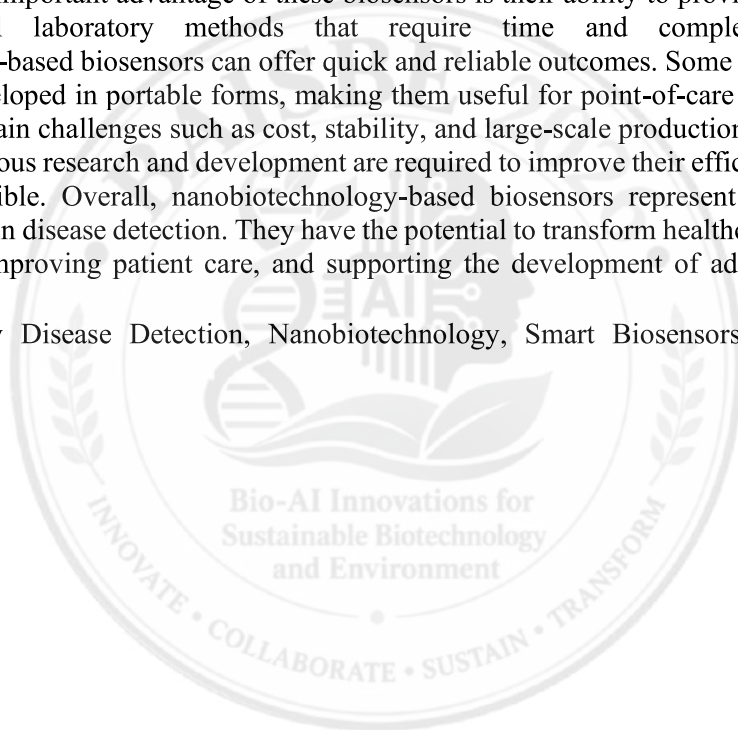
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Abstract

Early detection of diseases plays a crucial role in improving treatment outcomes and reducing health risks. In recent years, nanobiotechnology has opened new possibilities in the field of diagnostics, especially through the development of smart biosensors. These biosensors are designed by combining biological components with nanomaterials to detect specific disease markers with high sensitivity and accuracy. Nanomaterials such as nanoparticles, carbon nanotubes, and quantum dots enhance the performance of biosensors by increasing their surface area and improving signal detection. These features allow the detection of even small changes in biological conditions, making them highly effective for early diagnosis. For example, nanobiosensors can help in identifying diseases like cancer, diabetes, and infections at an early stage, when treatment is more effective. Another important advantage of these biosensors is their ability to provide rapid results. Unlike traditional laboratory methods that require time and complex procedures, nanobiotechnology-based biosensors can offer quick and reliable outcomes. Some of these devices are also being developed in portable forms, making them useful for point-of-care testing. Despite their potential, certain challenges such as cost, stability, and large-scale production still need to be addressed. Continuous research and development are required to improve their efficiency and make them more accessible. Overall, nanobiotechnology-based biosensors represent a modern and practical approach in disease detection. They have the potential to transform healthcare by enabling faster diagnosis, improving patient care, and supporting the development of advanced medical technologies.

Keywords: Early Disease Detection, Nanobiotechnology, Smart Biosensors, Point-of-Care Diagnostics.



Drug Repurposing of Metabolic Regulators for Alzheimer's Disease Treatment

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Abstract

Alzheimer's disease is the most progressive neurodegenerative disorder that affects people globally, making it a major concern and leading cause of dementia. The pathophysiology of AD is described by amyloid-beta ($A\beta$) plaques and neurofibrillary tangles composed of hyperphosphorylated tau. These pathophysiological hallmarks are responsible for synaptic dysfunction, neuronal death, neuroinflammation, and cerebral atrophy, which affect memory, thinking, and daily functioning. Despite decades of extensive research on drug development, currently approved drugs mainly provide symptomatic relief instead of slowing disease progression. Moreover, the drug development pathway is also quite lengthy, costly, and associated with high failure rates. So, to overcome this challenge, drug repurposing has emerged as a promising strategy to accelerate the availability of effective treatments with the help of existing drugs. It has gained attention because it is a cost-effective strategy by utilizing an existing drug with a well-established safety profile for disease (AD) treatment. This approach significantly reduces both the time and financial burden associated with traditional drug discovery while increasing the likelihood of successful clinical translation. Among the most promising repurposed candidates are metabolic regulators, particularly antidiabetic drugs such as metformin, GLP1 receptor agonists, SGLT2 inhibitors, DPP-4 inhibitors, and PPAR- γ agonists that have shown promising therapeutic potential. These agents exhibit neuroprotective effects by targeting multiple pathological processes involved in AD, including amyloid-beta ($A\beta$) accumulation, tau hyperphosphorylation, neuroinflammation, mitochondrial dysfunction, oxidative stress, and impaired insulin signalling. Preclinical and emerging clinical evidence suggests that these drugs may improve cognitive function, protect neurons, improve brain function, and potentially slow disease progression. Furthermore, combining repurposed drugs with existing therapies may provide greater therapeutic benefits by simultaneously targeting multiple disease pathways. Although large-scale clinical trials are still needed to confirm their long-term efficacy and safety, repurposed metabolic regulators represent a promising multi-target approach for developing more effective and accessible treatments for Alzheimer's disease.

Keywords: Alzheimer's Disease, Drug Repurposing, Metabolic Regulators, Neuroprotection.

Utilising Soil Microbes to Suppress Algal Biofilm in AC Drainage System

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Abstract

Nowadays, an air conditioner is a basic need of daily life. The drainage pipe of an AC has a lot of moisture content, which provides favourable conditions for the growth of algal blooms. These algal blooms block the exit for water. When an AC drain blocks, the resulting stagnant water becomes a breeding ground for *Legionella*, various moulds, and volatile organic compounds that are subsequently pulled back into the air we breathe. This is a very common problem but causes serious issues such as health issues, indoor air quality, structural damage and many others. Soil is undoubtedly the most biologically dense medium on the planet, a theatre of constant chemical warfare where bacteria spend ages developing specialised tools to suppress competitors, including algae. The core of this experimental approach lies in analysing the complex dynamics between diverse bacterial isolates and algal strains collected from AC effluents. So, this study involves the isolation of bacteria from soil and the interaction between these bacteria and various algal samples, which are collected from an AC drainage pipe that helps, to help control those algal blooms. The use of soil bacteria is a very clever way to fight biology with biology. This experiment involves the dynamics between different bacteria and different algal samples, and in some cases, it is found that some bacteria inhibit the growth of some algal samples. A novel product has been developed, which can help to get rid of these unwanted algal blooms in drain pipes. The ultimate goal of this study is to transform a natural “predator-prey” relationship into a precision tool for removing algae.

Keywords: Air Conditioners, Bacteria, *Legionella*, predator-prey, precision

Stress-Responsive and Feedback-Controlled Eugenol Production in *Ocimum tenuiflorum*

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Abstract

Tulsi (*Ocimum tenuiflorum*) is a medicinal plant containing several important bioactive compounds, including eugenol. Environmental stress and plant metabolic conditions can affect the production of Eugenol. On the contrary, repetitive activation of the eugenol biosynthesis pathway does not lead to increased eugenol yield due to substrate limitation for enzymatic activity, and plant stress affects metabolic production. This study is a simple stress-responsive and feedback-controlled system for regulating eugenol production in Tulsi. Some external signals, such as a chemical inducer, are used to activate an inducible promoter related to the eugenol biosynthesis pathway. To monitor the production stage, a GFP (Green Fluorescent Protein) reporter is incorporated. Instead of changing the colour of the entire leaf, fluorescence could be designed to appear mainly in selected tissues such as leaf veins or leaf edges to minimise any possible interference with normal photosynthesis. When the desired level of eugenol is reached, the pathway will switch off its activity. Substrate availability, enzyme capacity, stress level and plant growth effects are evaluated experimentally.

Keywords: *Ocimum tenuiflorum*, Eugenol, Stress-responsive regulation, Inducible promoter.

AI-Driven Drug Discovery: Transforming Modern Healthcare

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Abstract

Artificial intelligence (AI) is transforming the drug discovery process and the design process to develop new drugs. Drug discovery is a lengthy, expensive and complex process. It usually takes 10 years and billions of dollars in research to get a drug to market. AI technologies such as machine learning, deep learning, natural language processing and predictive analytics dramatically speed up the process. These can analyse huge amounts of biological, chemical and clinical data with impressive speed and accuracy. Researchers can use these techniques to discover new drug targets, to predict molecular interactions, to optimise lead compounds and to rank drug candidates for experimental validation. AI also helps with precision medicine, which makes it possible to provide therapies that are tailored to an individual's genetic and clinical data, improving the efficacy of treatment and reducing side effects. Besides, AI-based drug repurposing helps to discover new therapeutic uses of existing drugs, reducing the cost and time for drug development. AI-assisted platforms have played an important role in the rapid identification of potential drug molecules and vaccine candidates during recent global health emergencies, emphasising their importance in the face of new healthcare challenges. However, the issues of data quality, transparency of algorithms, ethical issues, privacy protection, regulatory compliance and experimental validation are still challenging. Overcoming these challenges requires robust collaboration among biomedical scientists, clinicians, pharmaceutical industries, data scientists and regulatory agencies. AI-powered drug discovery is revolutionising modern healthcare by speeding up pharmaceutical innovation, improving therapeutic success rates, reducing research costs, and helping to develop safer, more effective, patient-centric medicines. Advances in AI to transform worldwide healthcare will significantly improve patient outcomes around the world.

Keywords: Artificial Intelligence, Drug Discovery, Machine Learning, Deep Learning, Precision Medicine, Drug Repurposing, Healthcare Innovation.



Nanobiotechnology-based Organic Nanobiofertilizers: A Sustainable Approach for Root-Associated Nutrient Delivery and Biological Nitrogen Fixation

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Abstract

With an increasing worldwide demand for environmentally friendly agriculture, the development of organic nano-biofertilizers based on nanobiotechnology as green alternatives to chemical fertilisers is being expedited and is thus creating innovative agricultural tools. These advanced biofertilizers integrate biodegradable nanomaterials with symbiotic, plant growth-promoting microbes dwelling on root interfaces such as root-colonising bacteria, nitrogen-fixing and plant growth-promoting rhizobacteria (PGPRs), in an attempt to enhance nutrient use efficiency and supply, improve soil fertility, and further ensure sustainable plant production. Through a nano-carrier system, plants can absorb essential nutrients directly in the rhizosphere effectively, and the controlled, targeted nutrient supply in the rhizosphere avoids nutrient loss from the environment, such as leachate, runoff and evaporation. Biofertilizer containing nutrients is coupled with micro-bio agents on the surface and within matrix to generate nano-bio-fertiliser that shows a combined effect including increased root occupation, facilitated nitrogen fixation from atmosphere, solubilized insoluble phosphorous, synthesis of phytohormones, and ultimately stimulate plant root, growth, stress tolerance ability and the efficiency of application, compared to traditional organic fertilizer; the enhanced ability of soil moisture holding and improve soil microbiome structure and composition can facilitate organic substance breakdown and improve soil fertility. The cutting-edge techniques involved in Nanobiotechnology are also used for the enhancement of multifunctional nano-biofertilizers, which are capable of not only supplying multiple nutrients for plant growth but simultaneously suppressing soilborne pathogens, enhancing stress tolerance to water stress, saline stress, biotic stress, and abiotic stresses with a controlled and sustainable release. Despite the promising potential advantages with a long list of benefits on improving nutrients-use efficiencies, this concept of eco-fertilizer technology is still in developmental stages facing enormous difficulties regarding bio-safety assessment, mass production, shelf life, regulatory approval, and cost-effective application by farmers to gain worldwide marketability, and would need more interdisciplinary researches, bio-inspired designs and sustainable formulation for widely usage if they were to come into practical application. Organic nano-biofertilizers, as an emerging approach based on nanotechnology for plants, help contribute to future sustainable Agriculture, Food Security and Health with minimised soil and environmental pollution with reference to the Sustainable Development Goals (SDGs).

Keywords: Nanobiotechnology, Organic Nano-Biofertilizers, Nitrogen Fixation, Rhizosphere, Plant Growth-Promoting Rhizobacteria (PGPR), Sustainable Agriculture, Soil Health.

Role of Nanoparticles in Modern Healthcare

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Abstract

Nanoparticles have emerged as one of the most revolutionary innovations in modern healthcare because of their unique physicochemical properties, nanoscale dimensions, and exceptional ability to interact with biological systems. Their extremely small size, high surface-area-to-volume ratio, and ease of functionalization make them ideal tools for a wide range of biomedical applications. Traditional treatment methods often face limitations such as poor drug solubility, low bioavailability, non-specific distribution, frequent dosing, and unwanted side effects. Nanotechnology addresses these challenges by enabling targeted drug delivery, controlled drug release, and improved therapeutic efficiency. Various nanoparticles, including lipid nanoparticles, polymeric nanoparticles, gold nanoparticles, silver nanoparticles, silica nanoparticles, magnetic nanoparticles, and quantum dots, are widely investigated for medical applications. In cancer therapy, nanoparticles selectively deliver anticancer drugs to tumour tissues while minimising damage to healthy cells, thereby improving treatment outcomes and reducing toxicity. They also play an important role in diagnostic imaging, biosensors, tissue engineering, regenerative medicine, wound healing, antimicrobial therapy, and gene delivery. Lipid nanoparticles gained worldwide recognition for their successful use in mRNA vaccines, demonstrating their importance in preventing infectious diseases. Furthermore, nanoparticles contribute significantly to precision medicine by enabling personalised diagnosis and treatment based on individual genetic and molecular profiles. Their application in cardiovascular diseases, neurological disorders, diabetes, and chronic inflammatory conditions continues to expand through ongoing research. Despite these remarkable advantages, concerns related to long-term toxicity, biodegradability, environmental impact, manufacturing costs, regulatory approval, ethical considerations, and clinical safety remain important challenges. Continuous scientific research is focused on developing biocompatible and environmentally safe nanomaterials while improving large-scale production and quality control. Strong collaboration among biomedical researchers, clinicians, pharmaceutical industries, engineers, and regulatory authorities is essential for translating laboratory discoveries into safe clinical applications. In conclusion, nanoparticles are transforming modern healthcare by improving disease diagnosis, enhancing targeted drug delivery, increasing therapeutic efficiency, and supporting the development of innovative, safer, and more effective treatments. Future advancements in nanotechnology are expected to revolutionise patient care, strengthen precision medicine, and significantly improve global healthcare outcomes for future generations.

Keywords: Nanoparticles, Nanomedicine, Drug Delivery, Precision Medicine, Cancer Therapy, Biomedical Applications, Targeted Therapy.

AI-Driven Drug Repurposing for Leishmaniasis: A Review of Machine Learning and Molecular Docking Approaches

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Abstract

Leishmaniasis is a Neglected Tropical Disease (NTD) caused by protozoan parasites of the genus *Leishmania*. It continues to be a major public health problem in many tropical and subtropical countries. High costs, long development times, drug resistance and adverse side effects still hinder the development of novel anti-leishmanial drugs, despite ongoing efforts. Drug repurposing is a promising alternative approach to discover new therapeutic indications for existing approved drugs and has the potential to reduce the time and cost of drug development. This review emphasises the rising significance of Artificial Intelligence (AI) and Machine Learning (ML) in accelerating the drug repurposing process for leishmaniasis. Recent scientific literature has demonstrated that ML algorithms can analyse large biological and pharmacological datasets to predict potential drug candidates with increased speed and accuracy. The selected compounds can then be evaluated using molecular docking, a computational approach used to predict the interaction and binding energy of drug molecules with the target proteins of the *Leishmania* parasite. These computational approaches combined allow for efficient virtual screening and prioritisation of candidates before laboratory and clinical studies. This study further discusses the advantages, current challenges, and prospects of combining Machine Learning with molecular docking in computational biotechnology. Although computational predictions require experimental validation, these approaches provide valuable support during the early stages of drug discovery. The ongoing advances in artificial intelligence, bioinformatics and molecular modelling are expected to improve the development of cheap, effective and accessible therapeutic strategies for leishmaniasis and other neglected tropical diseases.

Keywords: Artificial Intelligence, Machine Learning, Molecular Docking, Drug Repurposing, Leishmaniasis, Computational Biotechnology, Bioinformatics.

Translational Research and Bioeconomy: A Review of Emerging Innovations for Sustainable Healthcare and Biotechnology

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Abstract

Translational research has been part of modern biotechnology to fill the gap between discoveries in the laboratory and their practical application in healthcare, agriculture, environmental management and industrial biotechnology. The effective translation of scientific knowledge into new products, technologies and healthcare solutions is important for the development of the bioeconomy, through the sustainable use of biological resources for the improvement of human well-being, economic development and environmental protection. This review gives an overview of the recent scientific literature on the contribution of translational research to the bioeconomy via new biotechnological innovations. It highlights the role of genomics, precision medicine, synthetic biology, bioinformatics, artificial intelligence and bioprocess engineering in accelerating the development of new diagnostics, vaccines, therapeutics, sustainable agricultural practices, biofertilizers, biodegradable materials and bio-based industrial products. The study also highlights the need for effective cooperation between academic institutions, health professionals, research organisations, industries, policy makers and regulatory authorities for effective transfer of technology and successful commercialisation of scientific breakthroughs. Translational research is encountering numerous challenges, including regulatory approval, funding constraints, ethical considerations, intellectual property issues, data sharing, and the need for multidisciplinary expertise. Despite these challenges, advances in biotechnology and computation continue to open new avenues for innovation, sustainability and better health outcomes around the globe. In a nutshell, translational research is the bridge between scientific discovery and societal benefit, and the bioeconomy is the sustainable platform to translate biological knowledge into practical solutions for improving public health, food security, environmental protection and economic development. As biotechnology contributes to sustainable development and future bioeconomy initiatives, sustained investment in research, education, innovation and international cooperation will enhance its contribution.

Keywords: Translational Research, Bioeconomy, Biotechnology, Sustainable Development, Precision Medicine, Bioinformatics, Innovation, Review.

Engineered Plant–Microbe Biohybrid System for Self-Adaptive Crop Protection and Nutrient Management: A Review

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Abstract

Engineered plant–microbe biohybrid systems represent an emerging approach in sustainable agriculture by integrating beneficial microorganisms with plant biology to improve crop productivity and resilience. Conventional farming practices often rely heavily on chemical fertilisers and pesticides, which may negatively affect soil health and the environment. Recent advances in biotechnology, synthetic biology, and computational tools have enabled the development of biohybrid systems capable of supporting crop protection and efficient nutrient management through natural biological interactions. This review summarises recent scientific literature on engineered plant–microbe biohybrid systems and their applications in self-adaptive crop protection and nutrient management. Beneficial microorganisms, including plant growth-promoting rhizobacteria and symbiotic fungi, can enhance nutrient uptake, suppress plant pathogens, improve stress tolerance, and promote sustainable crop growth. Engineering these interactions through modern biotechnological approaches has the potential to increase agricultural productivity while reducing dependence on chemical inputs. This review also discusses the contribution of computational biology and bioinformatics in understanding plant–microbe interactions, identifying engineered microbial strains, and optimising biohybrid designs for agricultural applications. Furthermore, current challenges such as field-level stability, biosafety, regulatory considerations, and large-scale implementation are highlighted. Although further experimental validation is required, engineered plant–microbe biohybrid systems offer great promise for sustainable agriculture. Continued interdisciplinary research integrating biotechnology, microbiology, computational biology, and agricultural sciences is expected to accelerate the development of next-generation sustainable farming strategies.

Keywords: Engineered Plant–Microbe Biohybrid System, Crop Protection, Nutrient Management, Synthetic Biology, Computational Biotechnology, Bioinformatics, Sustainable Agriculture.

To Study the Antifungal Potential of *Lactobacillus* Strains Against Some Food-Borne Fungi

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Abstract

Microbial contamination continues to pose a critical challenge across clinical, agricultural, and food industry sectors, where pathogenic fungi are responsible for severe human infections, extensive crop losses, and rapid food spoilage. Compounding this global issue is the alarming rise of antimicrobial resistance driven by the continuous reliance on conventional chemical fungicides and synthetic medications, creating an urgent need for sustainable alternative strategies. Food spoilage caused by fungi remains a critical threat to global food safety, consumer health, and the food industry, largely due to quality loss and the risk of harmful mycotoxin contamination in food articles like dairy, grains, and fresh produce. To address the growing demand for safe, chemical-free preservatives, biological control methods using Lactic Acid Bacteria (LAB) have gained significant attention in the past few decades. *Lactobacillus* species, included under Generally Recognised as Safe (GRAS) microorganisms, naturally suppress fungal growth by producing antifungal compounds such as organic acids, hydrogen peroxide, phenyl lactate, and bacteriocins, while offering added probiotic and mycotoxin-binding benefits. In this study, fungi were isolated and identified from various spoiled food samples, including paneer and Citrus sinesis. By screening these strains for their specific antifungal strength, this research highlights effective *Lactobacillus* isolates that can serve as natural bio- preservatives, offering a sustainable approach to extend shelf life and reduce reliance on synthetic chemicals. While testing different isolates for their antifungal potential, distinct differences were noticed in their potential to suppress fungal growth. The *Lactobacillus* strain obtained from curd formed a clearly defined zone of inhibition. On the other hand, the chilli-derived strain managed to slow down fungal expansion, though it didn't create a clearly defined zone. Overall, the strain isolated from the probiotic tablet proved to be the most effective, displaying significantly stronger antifungal performance than those from both curd and chilli.

Keywords: *Lactobacillus*, Antifungal Activity, Biological Control, Food Spoilage, Natural Biopreservatives, Mycotoxins.

Integrating Bio-AI and Computational Biotechnology to Predict the Therapeutic Potential of 2,3-Dichloro-1,4-Naphthoquinone

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Abstract

The integration of artificial intelligence (AI), computational biotechnology, and molecular modelling has transformed modern drug discovery by enabling the rapid identification and optimisation of therapeutic candidates. Among quinone derivatives, 2,3-dichloro-1,4-naphthoquinone (DCNQ) has garnered significant attention due to its distinctive redox properties and broad spectrum of biological activities, including anticancer, antimicrobial, antiviral, anti-inflammatory, and antiparasitic effects. This chapter examines the use of Bio-AI-driven computational approaches to predict the therapeutic potential of DCNQ by integrating molecular docking, molecular dynamics simulations, quantitative structure–activity relationship (QSAR) modelling, pharmacophore mapping, ADMET prediction, toxicity assessment, and systems biology analyses. Advanced machine learning and deep learning algorithms enable the prediction of molecular targets, binding affinities, pharmacokinetic profiles, and toxicity, thereby reducing the time and cost of traditional drug development. Additionally, network pharmacology and multi-omics data integration provide insights into the molecular mechanisms, signalling pathways, and protein interaction networks that are modulated by DCNQ. This chapter also reviews recent progress in AI-assisted virtual screening, precision medicine, and computational biotechnology that support lead optimisation and the development of safer, more effective therapeutic agents. By synthesising experimental evidence with computational predictions, the potential of DCNQ as a versatile drug candidate is highlighted, underscoring the critical role of Bio-AI platforms in accelerating translational pharmaceutical research. The convergence of computational intelligence and biotechnology offers a promising approach to the rational design of next-generation therapeutics targeting complex human diseases.

Keywords: 2,3-Dichloro-1,4-naphthoquinone, Artificial Intelligence, Drug Discovery, Molecular Docking, Virtual Screening.

In Silico Structure-Based Screening of Novel Heterocyclic Analogues as USP7 Inhibitors for Cancer Treatment

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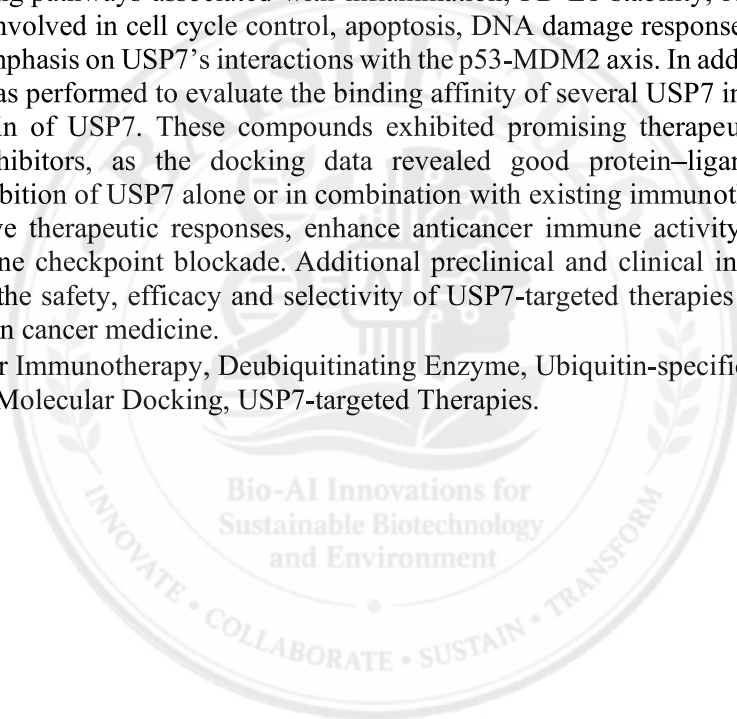
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Abstract

Although cancer immunotherapy has revolutionised the treatment of various cancers, drug resistance, immunological escape and inconsistent patient response are major therapeutic problems. Ubiquitin-specific protease 7 (USP7) is an important deubiquitinating enzyme that plays a critical role in regulating oncogenic signalling, immune checkpoint pathways, tumour suppressor proteins, and immune cell function, making it an attractive therapeutic target. The work highlights USP7 as a promising target to enhance cancer immunotherapy and provides a comprehensive overview of the molecular pathways involved in USP7-mediated tumour development and immune regulation. Signalling pathways associated with inflammation, PD-L1 stability, regulatory T-cell function, proteins involved in cell cycle control, apoptosis, DNA damage response, and antitumor immunity and an emphasis on USP7's interactions with the p53-MDM2 axis. In addition, molecular docking analysis was performed to evaluate the binding affinity of several USP7 inhibitors toward the catalytic domain of USP7. These compounds exhibited promising therapeutic potential as possible USP7 inhibitors, as the docking data revealed good protein–ligand interactions. Pharmacologic inhibition of USP7 alone or in combination with existing immunotherapies has the potential to improve therapeutic responses, enhance anticancer immune activity and overcome resistance to immune checkpoint blockade. Additional preclinical and clinical investigations are needed to confirm the safety, efficacy and selectivity of USP7-targeted therapies and to advance their use in precision cancer medicine.

Keywords: Cancer Immunotherapy, Deubiquitinating Enzyme, Ubiquitin-specific Protease 7 (USP7) Inhibitors, Molecular Docking, USP7-targeted Therapies.



Artificial Neural Network-Based Optimisation of Laccase Production by *Aspergillus flavus* under Solid-State Fermentation Using Agro-Industrial Residues

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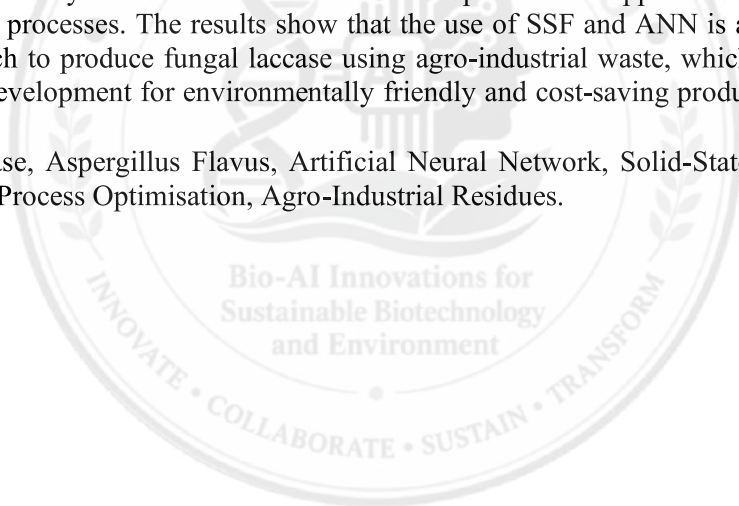
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Abstract

Laccase is a multicopper oxidase that has important applications in the field of bioremediation, pulp and paper, textile wastewater treatment and lignin valorisation. In the present study, optimisation of laccase production of *Aspergillus flavus* under solid-state fermentation (SSF) conditions with low-cost agro-industrial residues by using Artificial Neural Network (ANN) modelling was undertaken. Mustard oil cake was found to be the best substrate for enzyme production. The impact of other process variables such as pH, temperature, moisture content, incubation period, carbon source and nitrogen source was determined to achieve maximum enzyme production. The laccase activity was modelled using a feed-forward ANN model from experimental data obtained from SSF. The ANN showed good predictive power and was able to model the nonlinear interactions between the fermentation variables and enzyme production well. Optimisation of fermentation conditions using the model indicated optimal conditions that resulted in an increase in laccase production when compared with the unoptimised conditions. The study highlights the superiority of ANN over conventional optimisation approaches for modelling complex biological processes. The results show that the use of SSF and ANN is an effective and sustainable approach to produce fungal laccase using agro-industrial waste, which would lead to better bioprocess development for environmentally friendly and cost-saving production processes in industry.

Keywords: Laccase, *Aspergillus Flavus*, Artificial Neural Network, Solid-State Fermentation, Mustard Oil Cake, Process Optimisation, Agro-Industrial Residues.



Nano-enabled Drought Stress Management in Wheat Using Green-Synthesized Zinc–Potassium Nanocomposites

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Abstract

Drought stress is one of the major abiotic factors limiting wheat (*Triticum aestivum* L.) productivity by impairing germination, growth, photosynthesis, nutrient uptake, and grain yield. Nanotechnology has emerged as a promising strategy to enhance crop resilience under water-limited conditions. Among various nanomaterials, zinc–potassium nanocomposites (Zn-K NCs) combine the physiological benefits of zinc, an essential micronutrient involved in antioxidant defence and enzyme activation, with potassium, a key macronutrient regulating osmotic balance, stomatal conductance, and water-use efficiency. The present study investigates the role of green-synthesised Zn-K nanocomposites in mitigating drought stress in wheat through seed priming and foliar application. Zn-K nanocomposites were characterised using UV–Visible spectroscopy, FTIR, XRD, SEM, TEM, EDX, DLS, and zeta potential analyses to confirm their physicochemical properties. Their effects were evaluated under normal and drought conditions by assessing germination, growth attributes, chlorophyll content, relative water content, membrane stability, proline accumulation, antioxidant enzyme activities, and the expression of drought-responsive genes. Application of Zn-K nanocomposites significantly improved plant growth, physiological performance, and biochemical defence mechanisms while reducing oxidative damage under drought stress. Enhanced antioxidant activity and osmotic adjustment contributed to improved drought tolerance, resulting in better biomass accumulation and yield-related traits. These findings demonstrate that green-synthesised Zn-K nanocomposites represent an eco-friendly and sustainable nano-enabled approach for improving wheat productivity under water-deficit conditions and offer considerable potential for climate-resilient agriculture.

Keywords: Zinc–potassium Nanocomposites, Green Synthesis, Wheat (*Triticum aestivum* L.), Drought Stress, Nanotechnology, Seed Priming, Antioxidant Enzymes.

AI-driven Personalised Medicine for Drug Discovery and Targeted Drug Delivery

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Abstract

Artificial Intelligence (AI) is transforming modern healthcare by enabling personalised medicine, accelerating drug discovery, and improving targeted drug delivery systems. Personalised medicine focuses on tailoring treatments according to an individual's genetic profile, lifestyle, and clinical data, leading to more effective therapies with fewer adverse effects. AI techniques, including machine learning, deep learning, and predictive analytics, analyse complex biomedical datasets to identify novel drug targets, predict drug–target interactions, and optimise drug candidates, significantly reducing the time and cost of traditional drug development. Furthermore, AI enhances targeted drug delivery by designing intelligent nanocarriers and predicting optimal drug release patterns, ensuring precise delivery to diseased tissues while minimising damage to healthy cells. The integration of AI with genomics, bioinformatics, and nanotechnology has opened new opportunities for precision medicine in the treatment of cancer, cardiovascular diseases, neurological disorders, and other complex conditions. Despite challenges such as data privacy, model interpretability, and regulatory approval, AI-driven personalised medicine has the potential to revolutionise healthcare by making treatments safer, faster, and more patient-specific. This review highlights recent advancements, applications, challenges, and prospects of AI-driven personalised medicine for drug discovery and targeted drug delivery.

Keywords: Personalised Medicine, Targeted Drug Delivery, Bioinformatics, Nanotechnology, Genomics, Predictive Analytics.

Transforming Bioremediation Strategies through AI-Enabled Microbial Research

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Abstract

Environmental pollution has emerged as a major global concern as it leads to the accumulation of hazardous contaminants in soil, water, and air. Bioremediation, which utilises the natural metabolic capabilities of microorganisms to degrade or detoxify pollutants, has gained recognition as an environmentally friendly and cost-effective alternative to conventional remediation methods. However, the successful implementation of bioremediation is often limited by the complexity of microbial communities, variations in environmental conditions, and challenges in identifying efficient pollutant-degrading microorganisms. Recent advances in artificial intelligence (AI) have created new opportunities to overcome these limitations by enabling rapid analysis of large-scale biological and environmental datasets. AI techniques, including machine learning and deep learning, are increasingly used to analyse metagenomic data, identify novel microbial species, predict enzyme functions, reconstruct metabolic pathways, and optimise microbial consortia for enhanced biodegradation. These approaches have accelerated the discovery of microorganisms capable of degrading diverse contaminants, including hydrocarbons, pesticides, plastics, dyes, pharmaceutical residues, and heavy metals. Furthermore, AI supports the integration of multi-omics data, improving our understanding of microbial interactions and facilitating the development of more targeted and efficient bioremediation strategies. The integration of AI with microbial biotechnology offers a promising pathway toward developing innovative, sustainable, and highly efficient solutions for environmental restoration and long-term pollution management. The AI tools can identify promising pollutant-degrading microorganisms, predict enzyme activities, interpret metagenomic datasets, and model microbial interactions with greater speed and accuracy than conventional approaches.

Keywords: AI in microbial biotechnology, bioremediation, metagenomics.

In vitro Antifungal Efficacy of ZnO–Chitosan–Mancozeb Nanoconjugate against *Aspergillus niger*

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Abstract

Wheat (*Triticum aestivum* L.) is a globally important cereal crop, providing carbohydrates, proteins, dietary fibre, and essential nutrients to the human population. Its productivity is often compromised by seed-borne fungal pathogens, with *Aspergillus niger* being particularly destructive. Conventional fungicides are widely used for disease control, but their overuse has led to environmental concerns, pathogen resistance, and adverse effects on non-target organisms. Nanotechnology offers a sustainable solution by enhancing fungicide efficacy at reduced dosages. In this study, a ZnO–Chitosan–Mancozeb nanoconjugate was synthesised and tested against *A. niger* under both in vitro and in vivo conditions. Laboratory assays revealed that the Mancozeb nanoconjugate at 250 ppm achieved complete inhibition of fungal growth at 3 and 5 days and maintained 92.08% inhibition after 7 days. ZnO–Chitosan formulations also showed improved antifungal activity compared to individual components, with Chitosan + ZnO NPs @ 150 ppm recording 64.84% inhibition. Field evaluation demonstrated significant improvements in plant height, root length, tiller number, leaf area, and spike length, confirming growth-promoting effects. Overall, ZnO–Chitosan–Mancozeb nanoconjugate, especially Mancozeb NC @ 250 ppm, proved highly effective in suppressing *A. niger* while enhancing wheat growth and yield, representing a promising eco-friendly alternative for integrated disease management.

Keywords: *Triticum Aestivum*, ZnO Nanoparticles, Mancozeb Nanoconjugate, *Aspergillus niger*.

Predicting Vaccine Safety and Efficacy via Machine Learning

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Abstract

Artificial intelligence (AI) is helping in many areas, including scientific research. When it comes to developing vaccines, AI can predict how well a vaccine might work and if it's safe even before starting clinical trials. It uses machine learning and genetic data to find the best parts of a virus to target. Normally, vaccines train our immune system to fight a specific version of a virus. But when the virus changes, the vaccine might not work as well, so it needs to be updated often, which takes a lot of time. Using AI helps speed up this process, saving time and effort and providing quicker results. Scientists use machine learning and huge sets of virus data with millions of virus parts and proteins. They put all this into an AI system that looks for parts of the virus that don't change much and are hard for the virus to mutate. The AI then checks these parts against human DNA to make sure they won't cause harmful side effects. In June 2026, scientists at the University of Cambridge and a company called DIOSynVax made a big breakthrough. They tested the world's first coronavirus vaccine designed completely by AI on people. The vaccine was safe, worked well, and didn't cause any major side effects. This research proves that AI can handle the whole vaccine development process, starting from the basic idea all the way to predicting how effective the vaccine will be. AI is more accurate than traditional methods, which often take longer and have more chances for mistakes. Because the human body is very complex, testing vaccines can be tricky and sometimes errors happen during clinical trials. AI helps reduce these errors by carefully predicting how the vaccine will work in people before the tests even start. This not only makes the trials safer but also saves a lot of time and effort for the scientists working on the vaccine. Overall, AI makes vaccine development faster, safer, and more efficient.

Keywords: Artificial Intelligence, Vaccine Development, Machine Learning.

Prostate Cancer in the Era of Precision Medicine: Biomarkers, Genetics, and Emerging Therapeutics

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Abstract

Prostate cancer remains one of the most commonly diagnosed malignancies and a leading cause of cancer-related mortality among men worldwide. Despite advances in early detection and management, challenges persist in accurately distinguishing indolent from aggressive disease, avoiding overdiagnosis and overtreatment, and identifying optimal therapeutic strategies for advanced and treatment-resistant disease. This review provides a comprehensive overview of recent developments across the prostate cancer care continuum, from biomarker discovery to therapeutic innovation. The review will explore the evolving role of prostate-specific antigen (PSA) alongside emerging biomarkers including the Prostate Health Index (PHI), 4Kscore, PCA3, and urinary and blood-based molecular signatures that offer improved specificity for risk stratification and reduce unnecessary biopsies. Advances in imaging, particularly multiparametric MRI and PSMA-based PET imaging, are discussed for their transformative impact on diagnostic accuracy, staging, and biopsy targeting. The review further explores the genetic and genomic landscape of prostate cancer, including germline mutations (BRCA1/2, ATM, and other DNA damage repair genes), somatic alterations, and polygenic risk scores, highlighting their implications for hereditary risk assessment, screening protocols, and eligibility for targeted therapies such as PARP inhibitors. We discuss the expanding molecular classification of prostate cancer and its role in guiding personalised treatment decisions. On the therapeutic front, we review the evolving management landscape, including advances in androgen receptor pathway inhibitors, the growing role of PARP inhibitors and other targeted agents in DNA repair-deficient tumours, PSMA-targeted radioligand therapy, immunotherapy approaches, and strategies to overcome resistance in castration-resistant and metastatic disease. Finally, we address current limitations, unmet clinical needs, and future directions, emphasising the importance of integrating biomarker-driven diagnostics with genomically informed, personalised treatment strategies to improve outcomes and reduce the burden of overtreatment in prostate cancer care.

Keywords: Prostate Cancer, Biomarkers, PSMA PET, Genomics, BRCA, PARP Inhibitors, Precision Medicine.

Whole Genome Sequence Analysis of *Acinetobacter Baumannii* for the Prediction of blaOXA-23-Mediated Carbapenem Resistance Using AI-Assisted Bioinformatics

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Abstract

Antimicrobial resistance (AMR) is a growing threat to global health, and it is increasing every year. Carbapenem-resistant *Acinetobacter baumannii* (CRAB) is considered one of the most threatening resistant pathogens. This is because of its ability to cause severe nosocomial infections and difficulty in treatment. CRAB is highly resistant and is a WHO Priority 1 (Critical) pathogen. One of the main reasons for this resistance is the presence of the blaOXA-23 gene, which produces enzymes that can break down carbapenem antibiotics. Therefore, rapid detection of this gene is important for appropriate therapy selection and improved infection control strategies. In this study, we present an AI-assisted bioinformatics workflow to predict the presence of the blaOXA-23 gene from Whole Genome Sequencing (WGS) data. The first step of the workflow is the sequence quality assessment with FastQC. SPAdes assembles the high-quality reads, and Prokka performs the genome annotation. The CARD and ResFinder databases are utilised for the identification of antimicrobial resistance genes, and a single-nucleotide polymorphism (SNP) analysis is conducted to identify important genomic variations. To increase the reliability of the results, the curated AMR databases and published genomic studies further confirm the predicted results. This workflow integrates genomics, bioinformatics and artificial intelligence into a simple and effective strategy for rapid AMR surveillance. It may be helpful in quicker detection of resistant strains, better genomic interpretation and aid in precision antimicrobial therapy. To summarise, the present study emphasises the increasing importance of AI-assisted bioinformatics to understand multidrug-resistant *A. baumannii* and to improve future surveillance strategies for antimicrobial resistance.

Keywords: *Acinetobacter Baumannii*, blaOXA-23, Whole Genome Sequencing (WGS), Single Nucleotide Polymorphism (SNP), Carbapenem Resistance, Antimicrobial Resistance (AMR), Bioinformatics, Genome Annotation, Precision Antimicrobial Therapy.

Molecular Docking and ADMET Profiling of Ocimum sanctum-Derived Phytochemicals Against Validated Anticancer Protein Targets

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Abstract

Cancer remains one of the leading causes of mortality worldwide, and the search for effective low-toxicity therapeutic agents from natural sources continues to gain importance in drug discovery. *Ocimum sanctum*, commonly known as Tulsi, is a medicinal plant widely used in traditional systems of medicine and reported to possess diverse pharmacological properties, including anticancer activity. In this study, phytochemicals from *Ocimum sanctum* were isolated and characterised through extraction and analytical methods, leading to the identification of bioactive compounds. These compounds were subjected to molecular docking studies against validated anticancer protein targets. To further assess drug-likeness and pharmacokinetic suitability, ADMET profiling was performed using [tool name, e.g. SwissADME, pkCSM], evaluating parameters such as absorption, distribution, metabolism, excretion and toxicity. The results indicated favourable oral bioavailability, acceptable toxicity profiles and compliance with Lipinski's rule of five for the lead compounds. These findings suggest that phytochemicals derived from *Ocimum sanctum* hold promising potential as anticancer lead molecules and warrant further experimental validation through in vitro and in vivo studies. This integrated approach combining isolation, characterisation, and computational evaluation demonstrates the value of bridging traditional phytochemistry with modern computer-aided drug discovery techniques and supports the development of plant-based therapeutics for cancer management.

Keywords: *Ocimum sanctum*; anticancer phytochemicals; molecular docking; ADMET profiling; computational drug discovery; validated protein targets

BioKavach: Smart Nanofiber Combat Gear for Sub-Zero Hemostasis and CBRN Neutralisation in High-Altitude Warfare

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Abstract

High-altitude combat zones like Siachen and Eastern Ladakh present extreme survival challenges for military personnel. At sub-zero temperatures, standard medical supplies like regular clotting bandages fail because natural human biological clotting slows down significantly due to hypothermia. On top of that, modern warfare brings constant threats from Chemical, Biological, Radiological, and Nuclear (CBRN) agents, which normal uniform fabrics can only passively absorb rather than destroy. Current military gear addresses trauma and toxic defence separately, creating extra weight and logistical burden for troops in difficult terrains. This project proposes an integrated combat apparel system built on nanobiotechnology that solves both problems simultaneously. The inner lining of the combat gear uses electrospun nanofibrous sheets loaded with two main components: temperature-resistant peptide-chitosan nanoparticles and immobilised nano-zymes. When severe physical injury occurs in freezing conditions, the micro-encapsulated nano-hydrogel instantly triggers physical micro-clotting upon contact with blood, stopping severe bleeding in under 30 seconds without relying on human body warmth. Simultaneously, the nano-zymes permanently coated on the outer fibre surface actively break down hazardous biological toxins and organophosphate nerve agents into harmless molecules on contact, changing colour instantly to alert the squad to hidden chemical threats. This system directly aligns with India's high-altitude military needs and the Aatmanirbhar Bharat vision by reducing dependence on imported, high-cost specialised trauma kits. For the Indian Armed Forces, it lowers casualty rates from hypothermia-induced severe blood loss and provides lightweight, zero-power CBRN protection in extreme border conditions. To prove this concept in a lab setting, electrospinning can be used to fabricate the polymeric nanofiber mesh, which is then surface-functionalized with organophosphate-hydrolase enzymes. The sub-zero hemostatic performance can be tested using simulated blood plasma inside a temperature-controlled freezing chamber (at -20°C to -40°C) to measure liquid-to-gel transition speed. For toxin degradation, spectrographic analysis can monitor the rate at which nano-zymes neutralise organophosphate trace samples, proving the feasibility of this lightweight, life-saving military textile.

Keywords: Nanobiotechnology, Sub-Zero Hemostasis, CBRN Neutralisation, Nano-zymes, Smart Combat Apparel, High-Altitude Defence.

Bioremediation and Its Role in Safeguarding Cultural Heritage from Environmental Hazards

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Abstract

The structural integrity and aesthetic attractiveness of historic buildings can be harmed by environmental contaminants such as heavy metals, airborne poisons, and microbiological growth. Instead of making physical repairs, traditional conservation methods occasionally overlook the environmental factors that cause these structures to deteriorate. Case studies that illustrate the benefits and drawbacks of employing biological treatments in preservation efforts serve as examples of successful bioremediation applications in heritage conservation. The study also highlights how bioremediation is superior to conventional methods since it can protect the building and its surroundings, is less damaging to the environment, and is more affordable. By incorporating bioremediation into heritage preservation strategies, architectural landmarks with cultural and historical significance can be better protected while addressing environmental degradation. The current study assessed the bioremediation capacity of two sulfate-reducing bacterial species, *Thiosulfati reducens* spp. and *Thermolithotrophum* spp., for the repair of tile surfaces damaged by pollutants. In order to replicate the pollutant buildup frequently seen on heritage stone surfaces, the bacterial cultures were made into a paste and applied to blackened home ceramic tiles. Following treatment, the bacterial cultures metabolised and degraded the accumulated pollutants on the tile surface. This biodegradation process resulted in a noticeable reduction of the black deposits, with the treated surfaces gradually reverting to their original white appearance. The findings indicate that both *Thermolithotrophum* spp. and *Thiosulfati reducens* spp. possess significant potential for removing pollutant layers through biological activity without causing visible damage to the underlying substrate. These results demonstrate that sulfate-reducing bacteria can serve as effective biological agents for surface cleaning and conservation. The observed transformation from blackened to white tile surfaces highlights the capability of these microorganisms to degrade pollutant deposits, supporting their potential application in environmentally sustainable heritage conservation and restoration.

Keywords: Bioremediation, Architectural, Contamination, Microbes, Pollutant

Green Synthesis of Zinc Oxide Nanoparticles and their Electrochemical Activities in Various Applications

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Abstract

Zinc oxide nanoparticles (ZnO-NPs) have gained attention due to their high sensitivity, large surface area, non-toxicity, and high isoelectric point, making them suitable for various applications. Green synthesis of ZnO-NPs has emerged as an eco-friendly alternative to conventional chemical methods, utilising plant extracts, algae, and other biological materials as reducing and stabilising agents. This approach minimises the use of hazardous chemicals while enhancing biocompatibility. Green-synthesised ZnO-NPs have demonstrated excellent electrochemical properties, making them suitable for energy storage applications such as sodium-ion batteries and supercapacitors. ZnO-NPs synthesised using *Chromolaena odorata* leaf extract exhibited improved cyclability at high temperatures. In contrast, those synthesised with *Ruta chalepensis* leaf extract showed enhanced electrode reversibility and reduced charge transfer resistance. ZnO-NPs derived from *Ulva fasciata* algae extract displayed a high specific capacitance of 45 F/g, confirming their potential for supercapacitor applications. These nanoparticles have also been explored for their photocatalytic activities, with ZnO-NPs synthesised using sugarcane juice and *Padina pavonica* extract exhibiting high efficiency in the degradation of methylene blue dye. Their antimicrobial properties have been validated against pathogenic bacteria and fungi, with ZnO-NPs synthesised from *Newbouldia laevis* leaves showing significant antifungal activity. Additionally, green-synthesised ZnO-NPs have proven effective in environmental remediation, particularly in wastewater treatment, where they have demonstrated high dye removal efficiency. In biomedical applications, ZnO-NPs synthesised using *Papaver somniferum* seed extract exhibited high conductivity and quasi-reversible electrochemical properties, making them suitable for biosensing. Moreover, ZnO nanoparticles derived from *Myristica fragrans* fruit extract displayed promising larvicidal and leishmanicidal activities for vector control and treating parasitic diseases. Despite their promising potential, challenges such as achieving uniform particle size distribution, high crystallinity, and large-scale production remain. Future research should optimise synthesis parameters and explore new biological sources to enhance their applicability in flexible electronics, biomedical devices, and advanced energy storage systems.

Keywords: Nanoparticles, Catalytic Activity, Antimicrobial Activities, Biosensing, Energy Storage, Biocompatibility.

Anhydrous Calcium Sulfate as a Novel Biocompatible Particle for Studying Phagosome Formation, Maturation, and Turnover in Mammalian Cells

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Abstract

Phagocytosis is a fundamental cellular process by which cells recognise, engulf, and degrade foreign particles, debris, and pathogens, playing a central role in immune defence and tissue homeostasis. Gypsum (calcium sulfate dihydrate) undergoes a marked transformation in physicochemical identity when subjected to high-temperature calcination, losing structural water and reorganising into anhydrous calcium sulfate (ACS) with an altered crystal lattice. In this study, gypsum was thermally processed at 700°C to drive this dehydration and structural rearrangement, and the resulting ACS particles were characterised by X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FT-IR), confirming their crystal structure and chemical composition relative to the parent gypsum. Unlike native gypsum, which is largely inert to mammalian cells, ACS particles were efficiently recognised and internalised, inducing massive cytoplasmic vacuolation in cells, indicating phagocytic reactivity. Exposure to ACS triggered a complete phagocytic sequence: particle engulfment, phagosome formation, phagosome maturation, cargo degradation, and vacuolar turnover. Phagosome formation and acidification were confirmed using neutral red and acridine orange staining, both pH-sensitive, lysosome-associated dyes that localise to acidic intracellular compartments. Despite this extensive processing, treated cells showed no loss of viability. These conclusions establish thermally transformed ACS as a structurally well-defined, biocompatible particle that recapitulates the full phagocytic cascade, offering a practical model for dissecting phagocytic stages in cells and screening pharmacological modulators of phagocytic function.

Keywords: Anhydrous Calcium Sulfate (ACS), Phagocytosis Assay, Calcination, Vacuolization, Acidification, Maturation, Degradation.

Effect of Bio-fertilisers on Growth and Yield of Rice (*Oryza sativa* L.): A Review

Affan Khan and Shipra Chaudhry

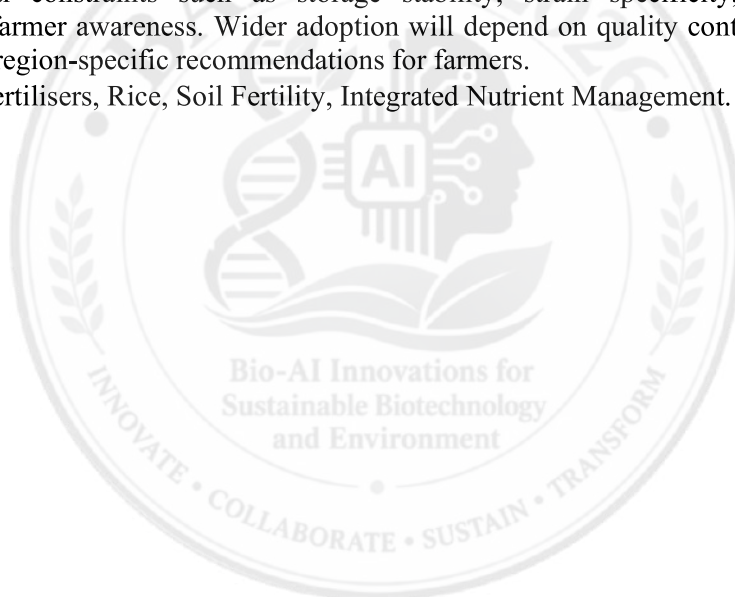
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Abstract

Rice is a staple food crop for more than half of the global population, and sustainable intensification of its production is essential for food security. Bio-fertilisers offer an eco-friendly strategy to improve rice growth by enhancing nutrient availability, root development, and soil biological activity while reducing dependence on synthetic fertilisers. This review summarises the main bio-fertiliser groups used in rice cultivation, including nitrogen-fixing bacteria, phosphate-solubilising bacteria, potassium-solubilising bacteria, and vesicular-arbuscular mycorrhizal fungi. These microorganisms support crop performance through biological nitrogen fixation, nutrient mobilisation, phytohormone production, improved water use, and better rhizosphere health. Literature consistently shows that seed treatment, seedling root dipping, and soil application of bio-fertilisers can improve germination, tiller number, panicle formation, grain filling, and overall yield, especially when combined with organic manure or balanced nutrient management. The review also highlights practical constraints such as storage stability, strain specificity, variable field performance, and farmer awareness. Wider adoption will depend on quality control, formulation improvement, and region-specific recommendations for farmers.

Keywords: Bio-fertilisers, Rice, Soil Fertility, Integrated Nutrient Management.



International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment

This volume presents abstracts of selected papers for the International Conference on Bio-AI Innovations for Sustainable Biotechnology and Environment held on 21-23 August 2026.

The conference brought together academicians, researchers, innovators and entrepreneurs to discuss the emerging role of Artificial Intelligence in Biotechnology, transforming education, business models, innovation ecosystems and entrepreneurial development.

The conference aims to provide an international platform for presenting innovative research, promoting interdisciplinary collaboration, and discussing emerging technological advancements in Bio-AI, Computational Biotechnology, Sustainable Biotechnology, AI-driven Healthcare, Nano-biotechnology, Bioeconomy, Environmental Biotechnology, and Biopharmaceutical Innovations. Book of Abstracts highlights 151 research contributions on interdisciplinary research, practical applications and emerging opportunities in the integration of AI in biotechnology and academic systems.

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