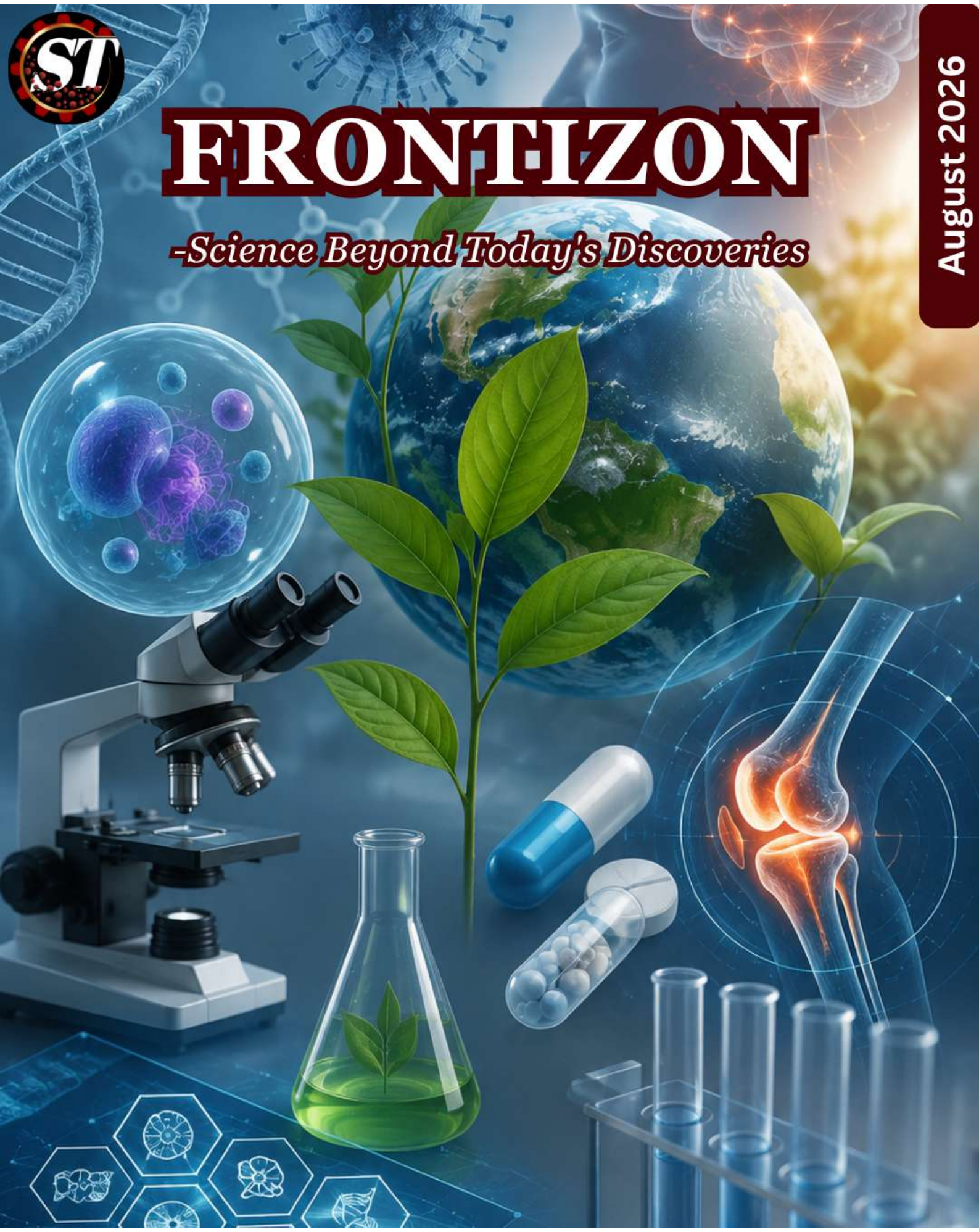

FRONTIZON
-Science Beyond Today's Discoveries
August 2026

Editorial Insights

Science at the Intersection of Health, Technology and Sustainability

This month, **FRONTIZON** presents a curated selection of scientific advances spanning biomedical research, healthcare, biotechnology, artificial intelligence, environmental sustainability, and mental well-being, featured on **Sci-Tech Bulletin**. Together, these developments reflect a growing shift toward more precise, predictive, accessible, and sustainable solutions to complex global challenges.

Advances in technologies such as **PEtracer,** portable nanopore sequencing, protein structure prediction, and standardized flow cytometry are expanding our ability to investigate biological systems with unprecedented detail. Meanwhile, innovations in cancer detection, digital health platforms, and emerging therapeutic approaches highlight the movement toward earlier diagnosis, informed decision-making, and more personalized healthcare.

Several studies also emphasize the long-term consequences of biological and medical interventions. Research on **Epigenetic Memory following Weight Loss** offers a new insight into why maintaining weight reduction can be challenging, while findings on early antibiotic exposure in preterm infants reinforce the importance of responsible antimicrobial stewardship.

Beyond healthcare, research into **Bioplastics** and **Cell-free Vitamin B12** production demonstrates how biotechnology can support more sustainable manufacturing. Collectively, this month's discoveries illustrate how the integration of molecular science, digital technologies, clinical research, and environmental innovation is shaping the future of science—and creating new possibilities for addressing real-world health and sustainability challenges.

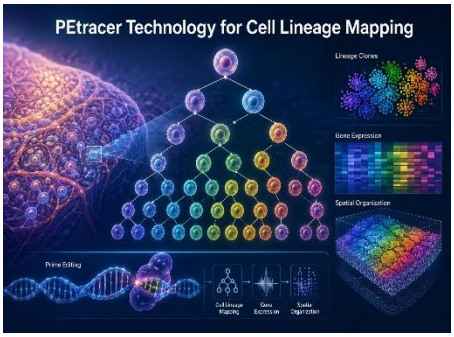
At a Glance

Epigenetic changes explain why we regain weight after weight loss

Fat cells retain persistent obesity-related gene expression and epigenetic changes even after body weight returns to normal. Single-nucleus RNA sequencing revealed that adipose tissue continues to exhibit obesity-induced transcriptional changes despite significant weight loss.

Portable Oxford Nanopore MinION for Forensic SNP Genotyping and DNA identification

Scientists have developed a portable MinION sequencer by Oxford Nanopore Technologies' that has a strong potential for forensic single nucleotide polymorphism (SNP) genotyping. The device can accurately genotype 51 of the 52 SNP markers tested, underscoring its promise for forensic DNA identification.



PEtracer Technology Revolutionizing Cell Lineage Mapping in Cancer Research

PEtracer is a novel prime editing-based lineage tracing technology that enables simultaneous mapping of cell lineage, gene expression, and spatial organization within intact tissues. By integrating prime editing with single-cell RNA sequencing and MERFISH spatial transcriptomics, cellular phylogenies are accurately reconstructed and tracked tumor evolution.

How Bioplastics Are Combating Plastic Pollution in the Anthropocene Era

Biodegradable and bio-based plastics, particularly those produced from agricultural and food waste, offer a promising pathway toward a circular bioeconomy. The current scientific evidences, emphasizes the need for innovation in sustainable materials, improved waste management, and collaborative efforts among researchers, industries, policymakers.

Bilberry Pomace Shows Promising Anticancer Effects Against Breast Cancer

Bilberry (Vaccinium myrtillus) peel-enriched pomace has recently been explored as a potential natural anticancer agent in breast cancer models. A preclinical study demonstrated the extract's antitumor potential, reducing tumor volume by up to 91% in a mouse model of triple-negative breast cancer and decreasing tumor-cell proliferation.

Early Antibiotic use increases Antibiotic Resistance in Preterm Infants

Study found that early antibiotic exposure affects antibiotic resistance in preterm infants. Analysis of meconium and stool samples from 30 preterm neonates, using metagenomic sequencing identified 175 antibiotic resistance genes (ARGs) across 15 drug classes. Beta-lactam, tetracycline, and aminoglycoside resistance are the most prevalent antibiotic resistance discovered.

JPred4: Advanced Protein Secondary Structure Prediction for Modern Bioinformatics

JPred4 is an upgraded protein secondary structure prediction server designed to help researchers analyze protein sequences when experimental structures are unavailable. Its JNet 2.3.1 algorithm combines neural-network prediction, PSI-BLAST-derived evolutionary information, multiple sequence alignments, and improved HMM processing. Blind testing of the server efficiency on 150 previously unseen sequences achieved 82.0% three-state secondary structure accuracy, while solvent accessibility prediction reached up to 90.0%.

Carcimun® Blood Test shows 95.4% accuracy in identifying cancer

Carcimun® is a blood-based multi-cancer early detection test that measures optical changes in plasma proteins. The test achieved 95.4% accuracy, 90.6% sensitivity, and 98.2% specificity in distinguishing cancer patients from healthy participants and individuals with inflammatory conditions. As a minimally invasive testing approach, Carcimun® offers a potentially sensitive and practical tool for early cancer detection and screening.

New Ebola Screening Platform, EBOV MiniG Plus, Advances High-Throughput Antiviral Drug Discovery

The EBOV MiniG Plus system could improve antiviral drug screening against Ebola virus under biosafety level 2 conditions. The study found that nucleocapsid proteins from several human coronaviruses, particularly SARS-CoV-2, significantly enhanced green fluorescent protein expression in the conventional Ebola virus minigenome system.

Therapeutic Gardens Support Stress Recovery and Mental Well-Being

Therapeutic gardens, designed by combining the natural elements for relaxation, physical activity, reflection, and meaningful activities are known to provide familiarity, safety, and a sense of belonging to the people experiencing stress-related illness. The natural environment, mindfulness exercises, garden activities, professional support, and personal choice increase self-awareness and help people recognise destructive stress patterns.

Breakthrough of the Month

A New Cell-Free Technology for Sustainable Vitamin B12 Manufacturing

A Sustainable method Vitamin B12 Production

Vitamin B12 is an essential nutrient with a remarkably complex molecular structure. It plays critical roles in DNA synthesis, methylation, and cellular metabolism, yet its natural biosynthesis is limited to prokaryotic organisms. For decades, industrial vitamin B12 production has therefore depended primarily on microbial fermentation. While fermentation can achieve substantial production levels, the long and complex biosynthetic pathway of vitamin B12 makes further metabolic engineering challenging.

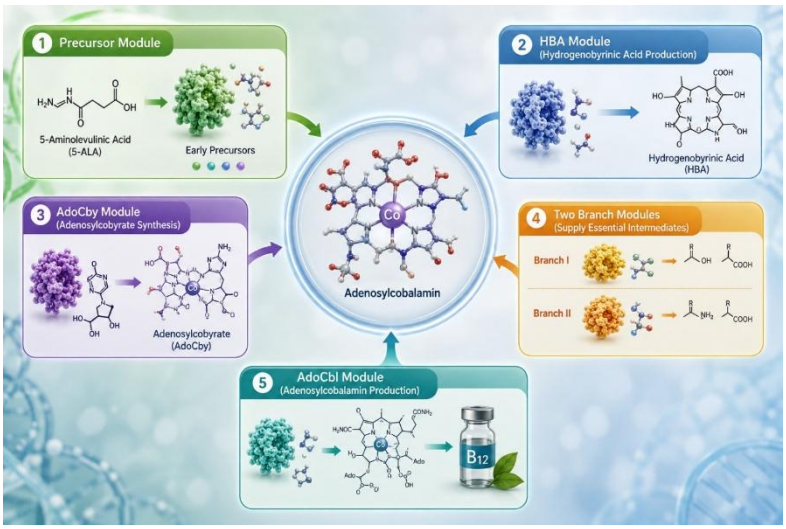
A platform developed by the scientists of **University of Chinese Academy of Sciences, China**, presents an alternative strategy of Vitamin B12 production. The platform offers a complete cell-free synthesis of adenosylcobalamin, or AdoCbl, one of the biologically active forms of vitamin B12. Using 36 enzymes and more than 30 biocatalytic reactions, vitamin B12 biosynthetic pathway is designed outside the cell using a systematic pathway which are optimised to overcome several major biochemical bottlenecks.

Rebuilding Vitamin B12 Biosynthesis Outside the Cell

The aerobic biosynthetic route is selected and divided the overall pathway into five interconnected synthetic modules.

These included

- Precursor module
- HBA module for hydrogenobyrinic acid production
- AdoCby module for adenosylcobyrate synthesis



- 2 branch modules supplying essential intermediates & final AdoCbl module for producing adenosylcobalamin

Identification of Bottlenecks to Improve Reactions

The platform is designed to overcome some of the major challenges of Vitamin B12 manufacturing, such as:

1) Solving the Problem of Unstable Intermediates

2) Engineering the Cofactor Regeneration for Higher Productivity

3) Coordinating Enzymes to Drive the Reaction Forward

4) Biomanufacturing 5-ALA to Active Vitamin B12

Under optimized conditions, the system produced 5.78 mg/L of AdoCbl within 14 hours.

The results are significant because they demonstrate the feasibility of producing one of the most structurally complex natural compounds through a fully reconstructed cell-free enzymatic system.

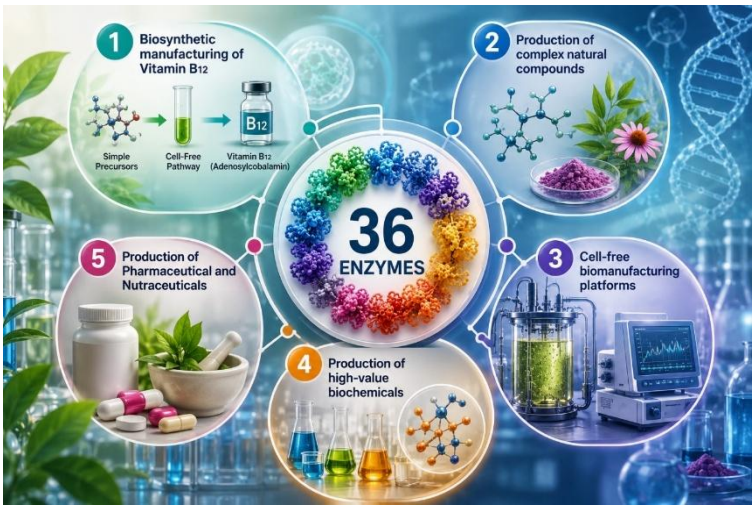
Complex cell-free biosynthesis depends on successfully integrating and balancing all reaction modules. Even when individual steps are optimized, overall productivity requires coordinated enzyme activity, efficient cofactor management, and controlled metabolic flow to achieve successful conversion from a simple substrate to the final product.

A 36-Enzyme Breakthrough: Practical Applications for Biotechnology and Biomanufacturing

1. Biosynthetic manufacturing of Vitamin B12

2. Production of complex natural compounds

3. Cell-free biomanufacturing platforms



4. Production of high-value biochemicals

5. Production of Pharmaceutical and Nutraceuticals

Future Insights

The 36-enzyme vitamin B12 system thus demonstrates that cell-free biotechnology can coordinate a remarkably complex network of biochemical reactions by providing flexible framework and optimizing the individual reaction modules with greater control over enzyme concentrations, substrates, intermediates, and reaction conditions.

Together, these capabilities demonstrate that the future of sustainable biomanufacturing may extend beyond engineered microorganisms. The potential of cell-free systems represents a way for sustainable production of complex and high-value molecules without relying entirely on living microorganisms.

Although further improvements will be necessary before this technology can be considered for large-scale commercial manufacturing, carefully designed cell-free systems could provide a powerful alternative for producing complex natural compounds, including active vitamin B12, with greater flexibility and control.

Read More for Detailed Research

Recommended

How Bioplastics Are Combating Plastic Pollution in the Anthropocene Era

Anthropocene and the Plastic Age

We as humans have been living in the Holocene epoch, thriving on the Earth's ecosystem for 1,700 years after the last ice age. Since the industrial revolution and commercialisation, we have now left the Holocene and are in the transition to the Anthropocene Era, where human activities in turn have started impacting the Earth's ecosystem.

From the middle of the last century, plastics have taken over as our most essential commodity and drastically transformed the modern society. From healthcare and transportation to food preservation and consumer products, plastics have enabled technological progress on an unprecedented scale. However, this convenience has come at a significant environmental cost.

Plastics account for a substantial proportion of marine litter, and millions of tonnes enter oceans annually. Since last century global plastic production increased from less than 2 million tonnes in 1950 to over 350 million tonnes annually. If current consumption continues, cumulative plastic production could exceed 30 billion tonnes by 2050. Europe alone produces approximately 65 million tonnes of plastics each year.

These figures demonstrate that waste management systems are struggling to keep pace with growing demand.

Recycling Alone Cannot Solve the Problem

One of the thought effective solutions adopted since last three decades is recycling the non-biodegradable plastic materials. Successful recycling involves improved waste collection and recycling systems that must be combined with broader strategies to reduce plastic production and increase the use of sustainable alternatives.

Many thermoplastics can technically be recycled, but different polymer types require separation before processing. Thermosetting plastics present even greater challenges because they cannot simply be melted and reshaped.

The Future of Sustainable Plastics

To counteract this alarming phenomenon of growing plastic pollution and adverse Anthropocene, several practical solutions have been adopted like reducing unnecessary plastic consumption, improving recycling infrastructure, developing biodegradable materials, and adopting circular bioeconomy principles that transform agricultural and food waste into valuable resources.

Transition to Bioplastics

Currently, human population is driving the technology towards production of sustainable and environment friendly bioplastics.

Biodegradable and bio-based plastics as promising alternatives to conventional petroleum-derived materials. These can be readily used in Sustainable food packaging, Agricultural films, Disposable food-service products, vmedical materials and Consumer packaging

However, the developed bioplastics must be carefully evaluated for performance, environmental impact, and economic feasibility before widespread adoption.

Circular Bioeconomy

Studies strongly supports the concept of a circular bioeconomy, where renewable biological resources replace fossil-based raw materials.

Instead of relying on virgin petroleum, Bioplastics are being engineered from agricultural residues, food-processing by-products, marine biomass, organic waste streams and forestry residues, creating additional value from materials that would otherwise be discarded.

Waste-to-Resource Innovation

Since years food and marine waste are being used as feedstocks for next-generation bioplastics that eventually reduce landfill waste, lowers greenhouse gas emission, increase resource efficiency and are less competitive with food production.

Solving plastic pollution requires collaboration across multiple sectors.

To resolve the growing burden of plastic wastes released from the industries, commercial as well as manufacturing sectors can design biodegradable products and packaging materials by incorporating renewable feedstocks into manufacturing and supporting closed-loop recycling systems.

Meanwhile**, policymakers can strengthen progress by e**ncouraging separate waste collection, restricting unnecessary single-use plastics, funding bioplastics research. And promoting sustainable manufacturing through incentives and regulations.

Future Insights

Sustainable progress of the human race depends on integrating scientific research, industrial development, environmental policy, and consumer behaviour into a unified strategy. As industries worldwide seek sustainable alternatives, balancing environmental responsibility with technological advancement is an essential step toward a cleaner and more resilient future.

[Read more for Detailed Research]

Frontiers in Science & Technology

Health & Medicine

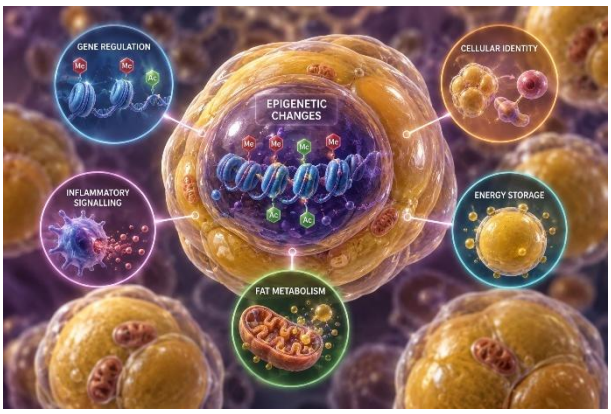
Epigenetic changes explain why we regain weight after weight loss

Why Does Weight Regain Happen So Often?

Millions of people successfully lose weight through dieting, exercise, medications, or bariatric surgery, yet many eventually regain much of it. While lifestyle factors certainly play an important role, scientists have long suspected that the body itself "remembers" obesity.

To prove this, **scientists from Department of Health Sciences and Technology, Zurich** have provided compelling evidence that fat tissue retains an epigenetic memory of obesity, even after substantial weight loss. The findings from their study help explain why maintaining weight loss is often much more difficult than losing it in the first place and may pave the way for future therapies that improve long-term obesity management.

Epigenetic memory persists



When single-nucleus RNA sequencing (snRNA-seq) was performed across cell types it was found that many obesity-related gene expression changes remain active long after significant weight loss. It was observed that body weight improves dramatically and numerous adipocyte genes associated with obesity continues to behave differently as compared to those of individuals who had never been obese.

Further investigations evaluated stable epigenetic alterations were observed within adipocytes, affecting Gene regulation, fat metabolism, inflammation, cellular identity and energy storage.

Fat cells do not fully reset after weight loss

Study conducted in a controlled mouse model revealed that mice who had previously been obese regained weight more rapidly than mice without prior obesity, when exposed to high weight diet.

Metabolic studies in the adipose tissue of these mice persistent molecular abnormalities, suggesting that outward clinical recovery may not fully reflect underlying cellular recovery.

How can we maintain weight loss for the long term?

- Weight maintenance requires long-term support and willpower
- Obesity should be viewed as a chronic disease that has a long-lasting impact at the molecular level.
- Future therapies could target epigenetic memory that can modify obesity-associated epigenetic changes
- Precision medicine for obesity based on an individual's biological profile may be capable of controlling the epigenetic signatures in long term

Future Insights

This landmark provides a compelling biological explanation for why sustained weight maintenance is so challenging and underscore the importance of long-term obesity management. They also open the door to future therapies designed to target epigenetic memory, with the potential to improve the durability of weight-loss interventions and reduce the cycle of weight regain.

[Read more for detailed Research]

Bilberry Pomace Shows Promising Anticancer Effects Against Breast Cancer

Bilberry Pomace and Breast Cancer

Breast cancer remains one of the most frequently diagnosed cancers among women worldwide and to find a potent therapeutic solution, researchers are shifting their interests towards natural compounds as a potential therapeutic molecule owing to their high molecular affinity and lowest toxicities. On similar principal scientists of **Comenius University in Bratislava, Slovakia** have investigated the anti-cancer potential of **peel-enriched bilberry (*Vaccinium myrtillus* L.) pomace**, also called as **European wild blueberry**. The peel and seed of the fruit retain most of the known bioactive molecules and these were studied for its anti-cancer properties.

Bilberry Pomace Shows Promising Anticancer Potential

Anti-cancer screening of the peel-enriched methanolic and hexane extracts was found to reduce tumour growth. In breast cancer cell. Notably, combination of these extracts with cisplatin had a profound synergistic additive anti-cancer effect in both 2D and 3D breast cancer models.

Further investigations revealed that the peel extracts activated the intrinsic apoptotic pathway, including mitochondrial membrane depolarization, cytochrome-c release, increased caspase-9 activity, and downstream activation of the apoptotic cascade.

Bilberry Pomace provides chemopreventive effects while reducing oxidative stress

When studied in NMU-induced Sprague-Dawley rats with mammary carcinogenesis, bilberry supplementation imparted chemopreventive effects. In addition, molecular studies confirmed the activation of pro-apoptotic signal cascade.

As found, high-dose bilberry supplementation reduced **CD133 expression by 23% and malondialdehyde (MDA)**, a marker of lipid peroxidation, **decreased by 75.5% at the higher dose**.

How Bilberry peel-extract be used for the prevention of Cancer Growth?

The Bilberry extracts can be used efficiently for nutraceutical development and sustainable food innovation, converting fruit-processing pomace into a potential high-value bioactive ingredient.

Adding to this, synergistic effect of the peel-extract with the cisplatin provides a rational for investigating bilberry-derived compounds as potential chemotherapy adjuncts.

Future Insights

In future, translational research may be designed further to confirm mechanisms, refine dosing, standardize formulations, and investigate biomarker-guided applications of the Bilberry extracts.

[Read More for Detailed Research]

Wheatgrass Juice Benefits for Anaemia, Immunity, Digestion, and overall Health

Wheatgrass Juice

Wheatgrass juice (WGJ), prepared from the young shoots of *Triticum aestivum*, has attracted growing interest as a functional food and natural health product. When studied for its nutritional components, WGJ is rich vitamins, minerals, amino acids, enzymes, flavonoids, phenolic acids, and other bioactive compounds.

Researcher from **Department of Yoga and Naturopathy, Under Ministry of Ayush, New Delhi**, India have explicitly explored the therapeutic potential of wheatgrass juice and its possible applications in preventive and supportive healthcare.

Nutritional Profile of Wheatgrass Juice

When evaluated, it was found that 100 ml of wheatgrass juice was reported to contain approximately **327 kcal**, containing protein, carbohydrate, dietary fibre, iron, potassium, phosphorus, calcium and vitamins, providing antioxidant, anti-inflammatory, antimicrobial, and immune-modulatory properties.

Health Benefits of Wheatgrass Juice

Wheatgrass Juice provides several potential wheatgrass juice benefits, particularly in relation to oxidative stress, anaemia, immunity, gastrointestinal health, cardiovascular health, and supportive cancer care, suggesting that the wheatgrass juice as a promising supportive functional food along with conventional medical treatment.

For gastrointestinal health, the dietary fibre content of wheatgrass juice supports digestion and help alleviate constipation. In addition, potential detoxifying effects of WGJ provides support for liver and renal health as well.

Wheatgrass juice also has a potential application in diabetes management through possible improvements in glycemic control and insulin sensitivity.

Future Insights

Studies strongly highlights that Wheatgrass juice is a promising functional food, rich in nutrients that could complement a balanced diet. Its nutritional composition makes it particularly interesting for research involving micronutrient intake, antioxidant support, digestive health, and supportive nutrition.

In future, studies could evaluate standardized preparations, appropriate doses, long-term safety, interactions with conventional treatments, and clinically meaningful outcomes.

Wheatgrass juice may provide nutritional benefits as an adjunct, but its use as a standalone therapy for chronic disease is not suggested.

Other practical challenges could be addressed in future, including the short shelf life and strong taste of wheatgrass juice. Excessive consumption may also produce mild adverse effects such as nausea, while sensitive individuals may experience allergic reactions.

[Read More at Detailed Research]

Biotechnology

Early Antibiotic use increases Antibiotic Resistance in Preterm Infants

Early use of antibiotics in preterm infants

Preterm infants are particularly vulnerable to infection because their immune systems and intestinal microbiomes are still developing. Early-onset sepsis can occur during the first 72 hours of life due to major risk factors including premature delivery, prolonged rupture of membranes, maternal infection, and Group B Streptococcus colonization. Early potential risk of sepsis in preterm newborns can be difficult to interpret due to overlapping symptoms.

To prevent a preterm infant from the fatal sepsis, clinicians frequently use empiric antibiotics when infection is suspected. Although antibiotics can be lifesaving when infection is present, early exposure of these antibiotics may disrupt beneficial microbial colonization and create conditions favouring antibiotic-resistant organisms, presenting a difficult clinical balance.

Antibiotic Resistance in Preterm Infants

Researchers from **University of Florida, USA** investigated this problem by examining antibiotic resistance genes (**ARGs)** and microbial communities in preterm infants. Metagenomic sequencing with **Oxford Nanopore's MinION** identified 175 unique antibiotic resistance genes across 15 drug classes. This high burden of resistance genes was found even among infants who had not received direct antibiotic treatment. **Beta-lactam** resistance was dominant, accounting for **62.3% of the identified ARGs**, followed by **tetracycline** resistance at **9.7%** and **aminoglycoside** resistance at **6.3%**.

The results suggest that early antibiotic exposure may not simply increase the number of resistance genes. Instead, it may reshape which resistance mechanisms become more prominent within the developing gut ecosystem.

Maternal and Pregnancy Factors Also Matter

Neonatal antibiotic resistance has also been found associated with maternal exposure to antibiotics during pregnancy and antibiotic administration during delivery. In addition, **prolonged rupture of membranes (more than 18 hours)** has been found to be associated with beta-lactam-associated ARGs in 99% of cases.

The study highlights the need for more precise and practical implications for NICUs, such as:

- **Strengthening the antibiotic stewardship.**
- **Considering maternal and intrapartum exposures.**
- **Improving antenatal risk assessment.**
- **Strengthening GBS screening.**
- **Monitoring the developing microbiome and resistome.**

[Read More for Detailed Research]

Carcimun® Blood Test shows 95.4% accuracy in identifying cancer

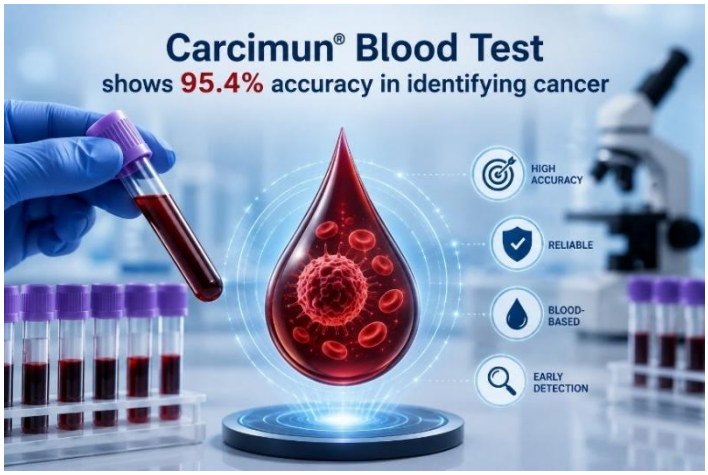
Why Early Cancer Detection Matters?

Early cancer detection is one of the most important challenges in modern oncology. Detecting cancer before it enters the advanced stages can create more opportunities for timely treatment and potentially improve patient outcomes. However, conventional diagnostic approaches often depend on imaging, tissue biopsy, or screening methods designed for individual cancer types. These approaches can be invasive, costly, or less effective when cancers are asymptomatic or difficult to access.

The Carcimun® test, developed by scientist of **University Hospital Regensburg, Germany,** uses optical extinction measurements to detect conformational changes in plasma proteins, offering a sensitive and universal marker for minimally invasive testing approach for early cancer detection and screening.

A Standardized Blood-Based Measurement

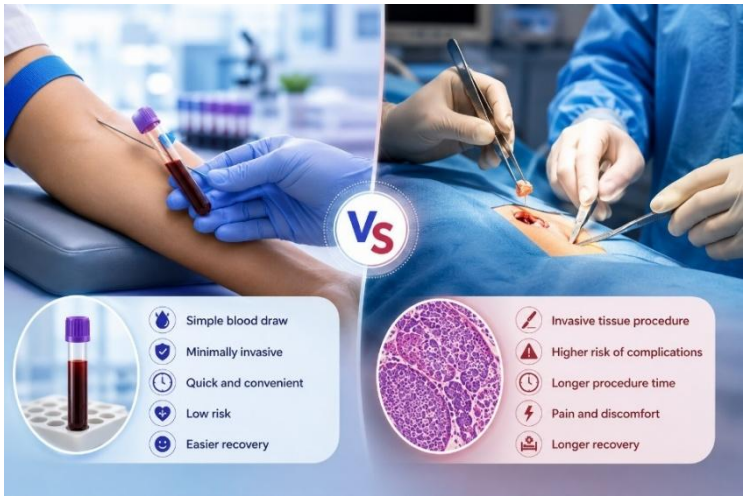
Carcimun® test uses blood plasma for analysis in the Indiko™ Clinical Chemistry Analyzer and compared with the established extinction-value threshold of 120, for differentiation between cancer from non-cancer samples



On evaluation, the Carcimun® test achieved 95.4% overall accuracy, 90.6% sensitivity, 98.2% specificity.

The primary merit of the test lies in its effectivity to distinguish many inflammatory conditions from cancer. This is important because inflammation can produce systemic biological changes that may resemble cancer-associated signals.

Less invasive early cancer detection

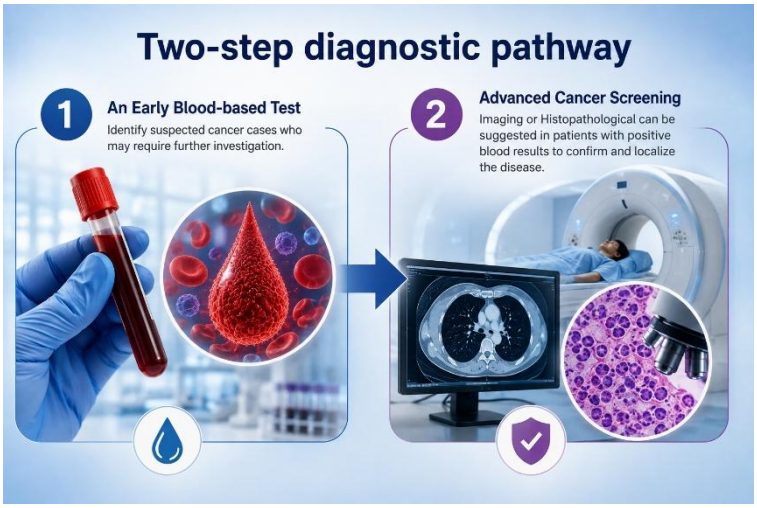


The Carcimun® test requires a blood sample rather than an invasive tissue procedure, and could potentially be incorporated into routine health assessments or cancer screening pathways.

It may be particularly useful for people with mild or non-specific symptoms, such as persistent fatigue, unexplained weight loss, or ongoing inflammation.

A sensitive 2-step diagnostic pathway

The Carcimun® test provides a blood-based preliminary screening while those patients identified with abnormal readings are suggested for advanced Cancer Screening such as imaging or histopathological evaluation



[Read More for Detailed Research]

AI & Technology

Portable Oxford Nanopore MinION for Forensic SNP Genotyping and DNA identification

Why SNP Genotyping Matters in Forensic Science?

Advances in DNA sequencing continue to reshape forensic science. For many years, short tandem repeats (STRs) have been the standard markers used in forensic DNA profiling. However, SNPs offer several advantages as it uses very short DNA fragments, have lower mutation rates than STRs while Large SNP panels can achieve discrimination power comparable to conventional STR profiling.

Scientists at the **Laboratory of Pharmaceutical Biotechnology, Ghent University, Belgium** developed a **MinION by Oxford Nanopore Technologies (ONT),** a portable next-generation sequencing (NGS) platform capable of generating DNA sequence data in real time. The study represents a proof-of-principle evaluation of the MinION platform for forensic DNA analysis, assessing its technical feasibility, identifying the technical limitations, and highlighting improvements needed before routine forensic implementation.

Portable DNA Sequencing offers High Overall Genotyping Accuracy

Modern MinION flow cells produce far more data than required for a single forensic sample, creating opportunities for cost-effective multiplexing.

Portable Forensic DNA Analysis

One of the MinION platform's greatest advantages is portability. The MinION is compact and capable of generating sequencing data in real time. This portability creates opportunities for more flexible forensic workflows where rapid DNA analysis may be beneficial with multiple samples.

Analysis of Degraded DNA

Forensic samples are mostly degraded and well suited for SNP assays as they rely on short PCR amplicons. The study supports continued development of nanopore-based SNP analysis for situations where STR profiling may be less effective.

Future Insights

In future, improved forensic SNP panels can be designed specifically optimized for nanopore sequencing. In addition, avoiding SNPs located near homopolymer regions could substantially improve genotyping robustness.

As sequencing chemistry, software, and SNP panel design continue to advance, nanopore technology may become an increasingly valuable tool for forensic DNA analysis, particularly in applications requiring rapid, flexible, and high-throughput genotyping.

[Read more for Detailed Research]

PEtracer Technology: Revolutionizing Cell Lineage Mapping in Cancer Research

High-Resolution Cell Lineage Mapping: A New Era in Biomedical Research

Understanding how cells grow, divide, migrate, and evolve has long been one of biology's greatest challenges. Cells continuously divide, differentiate, and migrate throughout development and disease progression. Existing lineage tracing methods generally suffer from limitations including limited temporal resolution, poor spatial information, inability to simultaneously analyze gene expression and difficulty reconstructing complete cellular family trees.

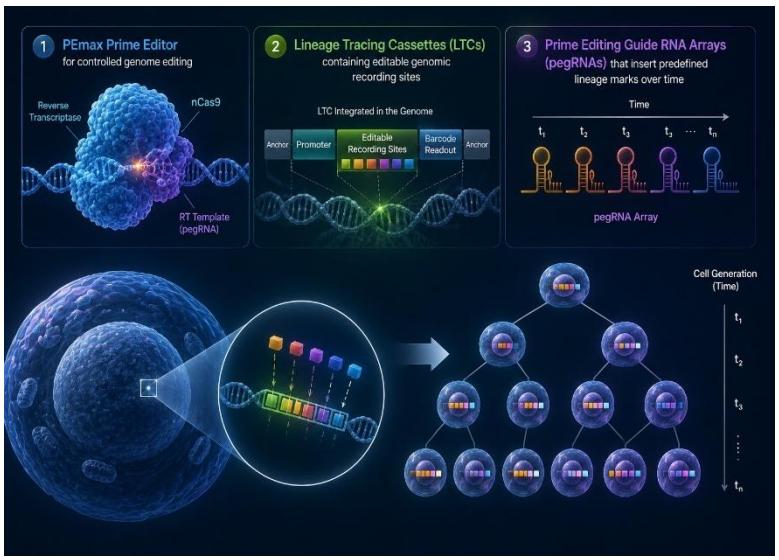
Although CRISPR-based lineage tracing has significantly improved lineage reconstruction, integrating lineage history with spatial transcriptomics has remained technically challenging.

PEtracer Technology is specifically engineered by scientists from **Harvard and Cambridge** to bridge this gap. It is an innovative prime editing-based lineage tracing technology that overcomes these limitations. By combining prime editing, single-cell RNA sequencing (scRNA-seq), and MERFISH spatial transcriptomics, PEtracer has enabled researchers to simultaneously monitor cellular lineage, gene expression, and spatial organization at single-cell resolution in living tissues.

High-Resolution Cell Lineage Mapping with PEtracer

PEtracer system consists of three components that is capable of introducing precise DNA modifications without creating double-stranded DNA breaks.

- **PEmax prime editor** for controlled genome editing
- **Lineage tracing cassettes** (LTCs) containing editable genomic recording sites
- **Prime editing guide RNA arrays** (pegRNAs) that insert predefined lineage marks over time



PEtracer installs carefully designed five-nucleotide lineage marks at multiple genomic edit sites that accumulate throughout cell divisions, creating an evolving molecular record of each cell's ancestry.

On the top, the dual (RNA-sequencing & MERFISH imaging for spatial transcriptomics) read-out capability of PEtracer allows to correlate lineage history with gene expression while preserving tissue architecture.

Mapping Tumor Evolution in Metastatic Breast Cancer

Upon single-cell **RNA sequencing** validation across nearly 6,900 cells, the system achieved:

- 98.5% true-positive integration barcode detection
- 99.9% lineage mark calling accuracy

While using high-resolution **MERFISH imaging**, over 5,600 cells were analysed, achieving:

- Approximately 82% integration barcode detection
- 99.4% lineage mark classification accuracy

The PEtracer could successfully analyse more than 368,000 individual cells across multiple tumours in the aggressive 4T1 tumor mouse model of metastatic breast cancer, generating one of the most comprehensive spatial lineage datasets reported to date.

PEtracer Technology is a breakthrough in cell lineage mapping

It can:

1. Reconstruct the three-dimensional tumor growth
2. Discover distinct tumor cell modules
3. Spatially organize and influence the cancer fitness

4. Identify heritable growth programs in cancer population

PEtracer Represents a Significant Advancement

Several features distinguish PEtracer from previous lineage tracing systems:

- Simultaneous lineage and gene expression profiling
- Compatibility with both sequencing and imaging
- Preservation of spatial tissue architecture
- High editing precision with minimal unwanted mutations
- Tunable recording rates for experiments lasting days to months
- Accurate reconstruction of complex phylogenetic trees

Together, these innovations enable researchers to study biological systems with an unprecedented combination of temporal, spatial, and molecular resolution.

Future Directions

The technology can be successfully applied in cancer research, developmental biology, immunology and regenerative & precision medicine.

These developments could further enhance our understanding of development, tissue regeneration, and disease progression.

As spatial omics technologies continue to evolve, PEtracer is poised to become a foundational platform for studying complex biological systems with unprecedented resolution.

Read More for Detailed Research

New Ebola Screening Platform, EBOV MiniG Plus, Advances High-Throughput Antiviral Drug Discovery

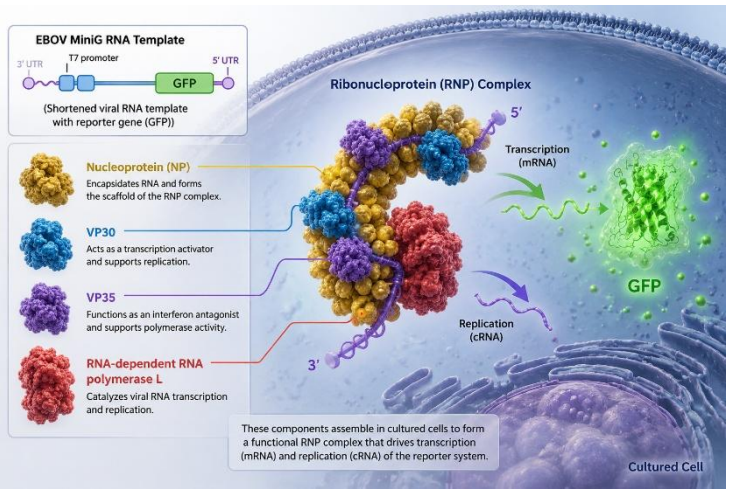
Ebola virus and challenges of screening antiviral drug

Ebola virus, a member of the Filoviridae family, causes severe viral hemorrhagic disease and requires specialized high-containment laboratories for research involving infectious virus. Traditional Ebola virus research involving live infectious virus requires biosafety level 4 facilities and specialized infrastructure, strict containment procedures, and highly trained personnel, creating barriers to large-scale antiviral screening and limit the speed, accessibility, and cost-effectiveness of antiviral drug discovery.

Researchers at the **Institute of Preventive Medicine, National Defense Medical Center, Taipei, Taiwan** developed an enhanced Ebola virus minigenome system, called **EBOV MiniG Plus,** that improves the detection of viral replication and transcription activity under biosafety level 2 conditions. The platform may provide a more efficient and practical tool for screening potential antiviral compounds without requiring experiments with infectious Ebola virus.

The EBOV MiniG Plus System

The conventional EBOV MiniG system contains a shortened viral RNA template carrying a reporter gene, such as green fluorescent protein (GFP), together with four essential Ebola virus proteins including a nucleoprotein, VP30, VP35, and RNA-dependent RNA polymerase L.



Introduction of these components in the cultured cells produces a functional ribonucleoprotein complex capable of driving the transcription and replication of the

reporter GFP system that can be detected directly using fluorescence microscopy or flow cytometry without requiring additional substrates or extraction procedures.

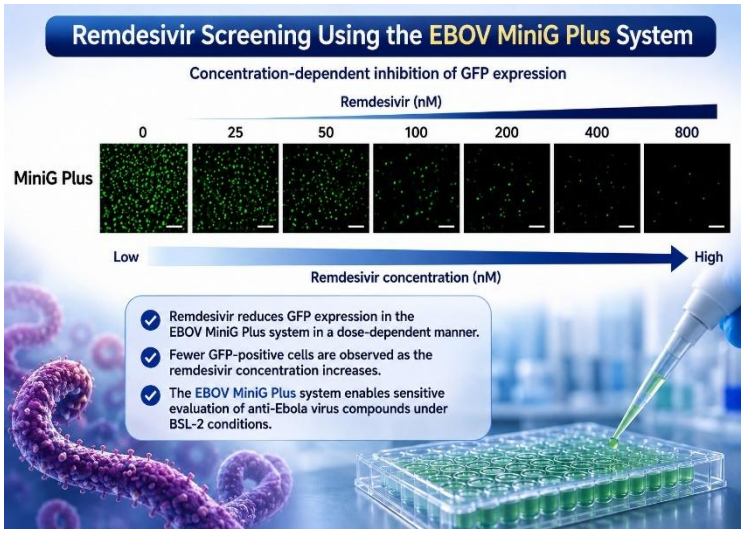
This reduces the operational complexity and support automated imaging-based screening approaches, allowing investigation of viral mechanisms and antiviral compounds in a safer and more accessible laboratory environment.

Coronavirus Nucleocapsid Proteins Enhances signals in EBOV MiniG Plus system

Surprisingly, it was observed that the nucleocapsid proteins from human coronaviruses, particularly, SARS-CoV-1, and SARS-CoV-2significantly increased the proportion of GFP-positive cells. SARS-CoV-2 nucleoprotein has increased the signals by 1.6 folds as compared with the conventional MiniG system. The findings also highlighted that nucleocapsid protein functions as an activator that enhances the activity of the complete Ebola virus minigenome system.

EBOV MiniG Plus for Antiviral Drug Screening

The practical value of the EBOV MiniG Plus system was evaluated using Remdesivir, an RNA polymerase inhibitor and Rupintrivir, a protease inhibitor, used as a negative control.



As found, Remdesivir produced concentration-dependent inhibition MiniG Plus systems, producing a stronger initial fluorescent signal making detection highly feasible.

In addition, Z-factor was measured as a statistical parameter and an indicator of the screening quality determined the suitability of the assay for high-throughput drug screening. Interestingly, the system achieved a higher Z-factor of 0.72, indicating improved assay performance and a greater ability to distinguish meaningful biological effects from experimental variability.

Practical Applications and Future Potential

The EBOV MiniG Plus system offers several practical advantages.

1. It provides a safer alternative for studying Ebola virus transcription and replication mechanisms under lower biosafety conditions.

2. The improved GFP signal can increase the sensitivity and reliability of antiviral drug screening.

3. The platform may reduce the cost and technical complexity associated with high-throughput screening.

4. The concept may extend beyond Ebola virus research. Similar enhancement strategies could potentially be explored in minigenome systems developed for other high-risk RNA viruses.

Future Insights

EBOV MiniG Plus system is presented as a stronger and more sensitive platform for antiviral drug screening while maintaining its ability to measure the antiviral activity accurately. It holds a potential to provide a safer, faster, and more efficient early-stage screening of antiviral compounds without requiring huge cost or technical complexities.

As researchers continue to prepare for emerging infectious diseases, improved laboratory models such as EBOV MiniG Plus could help accelerate the discovery of new treatments while reducing dependence on experiments involving infectious high-risk viruses.

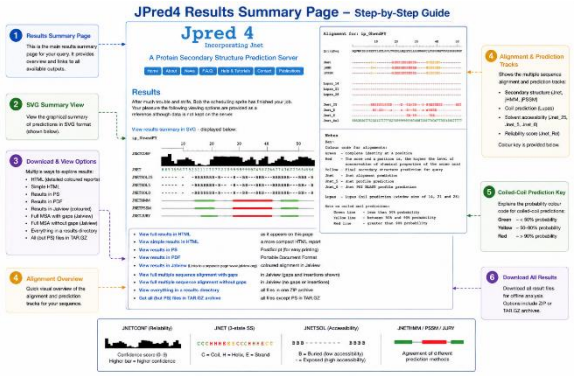
Read More at Detailed Research

JPred4: Advanced Protein Secondary Structure Prediction for Modern Bioinformatics

Protein Secondary Structure Prediction: Why It Matters

Understanding how a protein folds into its three-dimensional structure is fundamental to understanding its biological function. Protein secondary structure describes local structural elements such as alpha-helices, beta-strands and coils. Although secondary structure does not provide the complete three-dimensional structure of a protein, it offers valuable information for protein modelling, fold recognition, functional-domain identification and experimental design.

Scientists **University of Dundee, UK have developed JPred4**, an upgraded protein secondary structure prediction server which provides an accessible computational method for predicting structural characteristics directly from amino acid sequences.



JPred4 is Making Bioinformatics More Practical

JNet 2.3.1: The prediction engine

The central prediction engine in JPred4 is JNet 2.3.1, a neural-network-based algorithm designed to predict protein secondary structure and solvent accessibility. This engine is developed by retraining

Upon evaluation of 150 sequences from 150 superfamilies, JPred4 provided increased accuracy of **82%** for the three-state secondary structure prediction accuracy, or Q3 score. This means the system correctly predicts whether residues belonged to an alpha-helix, beta-strand or coil approximately 82% of the time in the blind test.

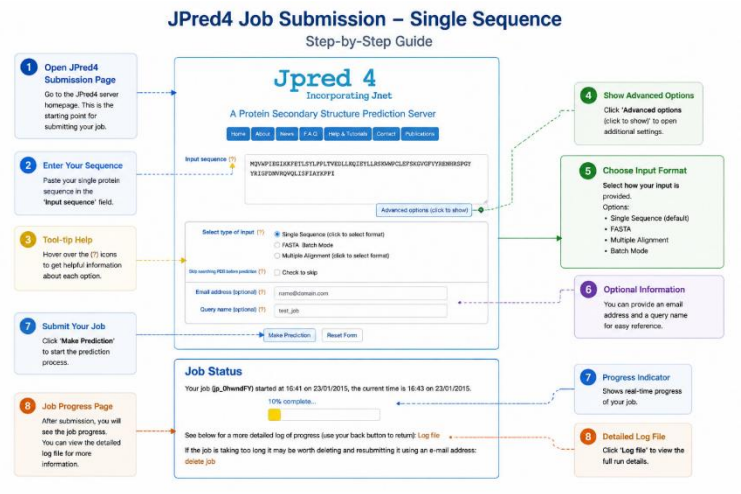
Improvements are visible in solvent accessibility prediction with:

- 90.0% for residues with more than 0% relative solvent accessibility
- 83.6% for residues with more than 5% accessibility

- 78.1% for residues with more than 25% accessibility

These results improved upon JNet 2.0, which achieved 88.9%, 82.4% and 77.8%, respectively.

JPred4: Applications for Protein Structure Prediction



The most important contribution of JPred4 is not simply its accuracy. Its practical value comes from making protein sequence analysis faster and more accessible. The server could efficiently:

1. Support Protein Structure Modelling

2. Improve Fold Recognition

3. Identify Functional Regions

4. Guide Mutation Experiments

5. Accelerate Large-Scale Sequence Analysis

The JPred4 upgrade is not limited to algorithmic performance. The web server is redesigned using Bootstrap and JavaScript, improving usability across different screen sizes and devices.

The JPred4 presents as useful scientific software that is capable of providing a scalable vector graphics (SVG), expands multiple sequence alignment visualization and improves reporting. The system also introduces improved email summaries and batch-result reporting. Instead of receiving separate emails for every sequence in a batch, users could receive a consolidated summary and archive of results.

[Read More for Detailed Research]

An Evidence-Based Digital Platforms Can Help Cancer Patients Make Informed Decisions

Why Reliable Online Cancer Information Matters

Cancer patients often face a large volume of medical information while simultaneously making important decisions about diagnosis, treatment, nutrition, side effects, and supportive care. Although the internet has become a major source of health information, online cancer content can vary substantially in quality, readability, and reliability. This creates a practical challenge: patients need information that is not only evidence-based but also understandable and easy to access.

To address this, a study conducted at **Institute of Psychosocial Medicine, Jena University Hospital, Germany** examined how cancer patients and patient navigators used a web-based knowledge database developed as part of the PIKKO project.

For this, a database, called "My PIKKO," was designed to provide quality-assured, evidence-based cancer information in language suitable for medical laypersons. The study evaluated who used the platform, how frequently it was used, which topics attracted the greatest interest, how users evaluated the database, and whether its use was associated with changes in health literacy.

The study strongly suggests that digital health platforms should not simply transfer technical or scientific information onto a website. Instead, evidence quality, readability, neutrality, and the needs of the target population should all be considered during content development.

What Cancer Information Did Patients Search For?

As observed, among patients who could potentially access the web-based knowledge database, **65.9%,** used their login at least once. Approximately 2/3rd of patients used the platform that helped them to find relevant information and make more informed decisions.

For patients, some the major information sources searched were therapy, nutrition, side-effects, carcinogenesis and psychological support. Among patient navigators, on the other

hand, different pattern of use is observed where they search more for therapy, naturopathy, legal regulations and financial support.

Among patients who reported never using the platform, the most common reasons were technical difficulties, perceived lack of need, lack of time, avoiding information related to cancer, health-related limitations, lack of motivation.

A successful cancer information platform should, thus cover medical, psychological, lifestyle, and social needs because a cancer care does not end with information about treatment alone.

Patients Reported Better Support for Informed Decisions

Among surveyed users:

- **68.9%** reported that the database helped them make more informed decisions.
- **75.7%** said they found the information they were looking for, while
- **89.8%** considered the database an appropriate way to provide information about diseases.

Noteworthy, the platform received an average rating of 2.16 on the German school grading scale, corresponding to a rating of "good."

These findings have important implications for healthcare organizations implementing digital patient education tools. Providing a website or application is not sufficient by itself. Patients may need technical support, clear instructions, and encouragement from healthcare professionals. Digital literacy and emotional readiness can also influence whether patients choose to seek information online.

Digital health tools may be most easily used by people who already have relatively strong health literacy and experience seeking information online. In fact, database users were significantly more likely than non-users to report that they usually used the internet to search for information.

The PIKKO study offers several practical recommendations

1. Evidence-based content should be presented in patient-friendly language.

2. Digital cancer information should cover the full patient journey.

3. Healthcare professionals and patient navigators can act as important intermediaries.

4. Digital platforms require continuous improvement.

Future Insights

Building Better Digital Cancer Information Systems

The study thus highlights that, evidence-based digital information can complement, rather than replace, communication with healthcare professionals. Patients may use online resources before appointments to prepare questions or afterward to better understand the information they received.

In future, digital health interventions should consider additional strategies for patients with lower health literacy or limited digital skills. Simplified navigation, multimedia content, guided onboarding, patient navigator support, and interactive assistance could potentially reduce these barriers.

For hospitals, cancer centres, healthcare organizations, and digital health developers, trustworthy online cancer information can be a valuable component of patient-centered care.

[Read More for Detailed Research]

Environment

Therapeutic Gardens Support Stress Recovery and Mental Well-Being

Nature-Based Therapy for Stress Recovery

Stress-related illness can profoundly affect daily functioning, work capacity, and overall quality of life. As interest is growing in holistic and supportive approaches to mental health, nature-based therapy (NBT) has emerged as a promising intervention that combines therapeutic practices with meaningful experiences in natural environments.

Study conducted at the **Nacadia Therapy Garden in Denmark by the researchers of University of Copenhagen**, provides valuable insight into how people with severe stress-related symptoms experience nature-based therapy. The therapy garden itself was intentionally designed as part of the intervention with physical environment and therapeutic activities being closely connected. This natural setting provided opportunities for solitude, social interaction, sensory experiences, physical activity, and reflection.

The research explored how participants experienced the therapeutic process and which elements helped them develop new strategies for managing everyday life.

What Did the Nature-Based Therapy Programme Include?

The Nacadia programme lasted 10 weeks, with participants attending three times per week for three hours per session. The intervention integrated five interconnected components:

1. Individual therapeutic conversations, incorporating mindfulness-based cognitive therapy.

2. Physical and mental awareness exercises, including meditation and body scanning that aid notice sensory experiences.
3. Garden activities, such as collecting herbs and chopping wood.
4. Personal time, allowing participants to choose how they wanted to use the therapeutic environment and develop mindfulness.
5. Homework, designed to help participants practise therapeutic techniques in everyday life.

Notably, the programme was flexible and allowed participants to select activities and environments according to their changing physical and psychological capabilities.

The Importance of Choice and Flexibility in Stress Recovery

A particularly important outcome of the study was the development of safety and freedom. Participants value places where they feel sheltered and less exposed. Feeling of being protected reduce external demands and create psychological space for exploration.

During the exposure to NBT in the Therapeutic Garden, it was found that peoples capabilities change from day to day. On the other hand, availability of different options allow people to respond more appropriately to their current needs. For example, some participants prefer repetitive physical tasks when their minds are restless, while others sought quiet locations for reflection. On the other hand, some want social interaction, whereas others prefer solitude.

Nature as a Tool for Mindfulness and Self-Reflection

People recognise tendencies related to performance pressure, competition, or the need to complete tasks quickly. These patterns resemble the behaviours they experienced in everyday life and, in some cases, associated with stress.

A therapeutic natural environment should:

- Provide a Sense of Safety
- Offer Different Types of Experiences
- Support Personal Choice
- Integrate Nature with Professional Support
- Encourage Transfer to Everyday Life

Future Insights

The findings suggest that a carefully designed natural environment can provide more than a pleasant setting. When combined with psychological support, mindfulness-based practices, meaningful activities, and personal freedom, a therapeutic garden may create conditions that help individuals feel safe, become more aware of their needs, and develop practical coping strategies.

A supportive space should not simply be visually attractive. It should provide different degrees of privacy, sensory stimulation, activity, and social interaction. Therapeutic gardens can function as supportive environments for people experiencing severe stress-related illness.

The healthcare providers, therapists, landscape architects, and organisations developing stress recovery programmes should focus on developing a therapeutic environment that could provide safety, flexibility, meaningful experiences, and opportunities for individuals to discover their own pathways toward recovery from stress.

Read More for Detailed Research

Frontizon Focus

Latest Innovations in Knee Osteoarthritis: From Molecular Research to Next-Generation Therapies

Knee Osteoarthritis: Moving Ahead to Find Better Cure

Knee osteoarthritis (KOA) is one of the most common forms of osteoarthritis and a major cause of chronic pain, impaired mobility, and reduced quality of life. As populations age and obesity and other lifestyle-related risk factors become more prevalent, the burden of knee osteoarthritis is expected to continue increasing. Treatment strategies for KOA are gradually moving beyond symptom relief toward molecularly targeted and potentially disease-modifying therapies.

What Is Knee Osteoarthritis?

Knee osteoarthritis is a progressive degenerative disease involving the entire joint rather than cartilage alone. The disease is characterized by deterioration of articular cartilage, changes in subchondral bone, synovial inflammation, vascular alterations, and instability of surrounding structures such as ligaments and tendons.

A central feature of KOA is the disruption of cartilage homeostasis. The extracellular matrix, which contains structural components including collagen and proteoglycans, gradually breaks down. As cartilage is damaged, chondrocytes attempt to compensate, but this response can also increase the production of inflammatory

mediators and matrix-degrading molecules. The result is a self-perpetuating cycle of inflammation, tissue destruction, and joint dysfunction.

Symptoms of Knee Osteoarthritis Symptoms

The symptoms of knee osteoarthritis can vary depending on disease severity, but commonly include:

- Persistent or activity-related knee pain
- Joint stiffness and reduced flexibility
- Difficulty walking, climbing stairs, or standing for long periods
- Reduced physical function
- Progressive joint degeneration
- In advanced disease, substantial cartilage loss and impaired joint mechanics

Current management focuses largely on reducing these symptoms. Exercise, weight management, patient education, physical therapy, analgesics, nonsteroidal anti-inflammatory drugs, and intra-articular corticosteroids remain important treatment approaches. However, the currently available treatments generally provide symptomatic benefit and that no established medication can reliably stop or reverse KOA progression.

Major Molecular Players Driving Knee Osteoarthritis

Understanding the molecular mechanisms of knee osteoarthritis is essential for developing targeted therapies.

Matrix Metalloproteinases and ADAMTS

Matrix metalloproteinases, particularly MMP-13, and members of the ADAMTS family are important enzymes involved in cartilage destruction. These molecules degrade components of the extracellular matrix, including type II collagen and aggrecan. Their increased activity contributes directly to progressive cartilage loss.

For this reason, MMP and ADAMTS inhibitors are being investigated as potential disease-modifying osteoarthritis drugs.

AQU-019, an allosteric MMP-13 inhibitor, has shown promising preclinical properties. Similarly, GLPG1972/S201086 was developed to inhibit ADAMTS5 and demonstrated chondroprotective activity in preclinical research. However, despite acceptable tolerability, its Phase II development did not achieve the required clinical efficacy endpoints.

Inflammatory Cytokines: IL-1β, IL-6, and TNF-α

Inflammation is another major component of KOA. Interleukin-1 beta (IL-1β), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) promote inflammatory signalling and stimulate the production of cartilage-degrading enzymes.

- IL-1β activates pathways including NF-κB and MAPK, promoting the expression of MMPs and cyclooxygenase-2.
- IL-6 can enhance MMP production and osteoclast activity, while
- TNF-α activates inflammatory pathways including NF-κB and PI3K/Akt. Together, these signalling networks create an environment that promotes inflammation and structural damage.

Wnt Signalling and Cathepsin K

The Wnt signalling pathway also contributes to joint degeneration. Hyperactivation of this pathway promote cartilage breakdown, cell death and abnormal shift in structural proteins from type II to type X collagen leading to matric degradation, chondrocyte hypertrophy, apoptosis and subchondral bone remodelling. Lorecivivint, a Wnt pathway inhibitor, has progressed through clinical trials and has shown encouraging results, including pain reduction and improved joint function after intra-articular administration.

Cathepsin K is another important molecular target. it destroys joint cartilage and subchondral bone by splitting type II collagen and other matrix components, driving the progressive wear and loss of joint tissue leading to cartilage breakdown, enzyme overexpression, subchondral bone resorption and matric amplification. The inhibitor MIV-711 demonstrated reduced bone remodelling and less cartilage loss compared with placebo in a Phase II trial. However, structural improvement did not translate into statistically significant pain reduction during the relatively short study period,

highlighting an important challenge in KOA research: changes in joint structure and symptom improvement do not always occur simultaneously.

Innovations for Early Diagnosis of ROA

At present, clinical assessment and imaging remain central to evaluating disease severity and structural changes. Molecular characterization may become increasingly important in future KOA management.

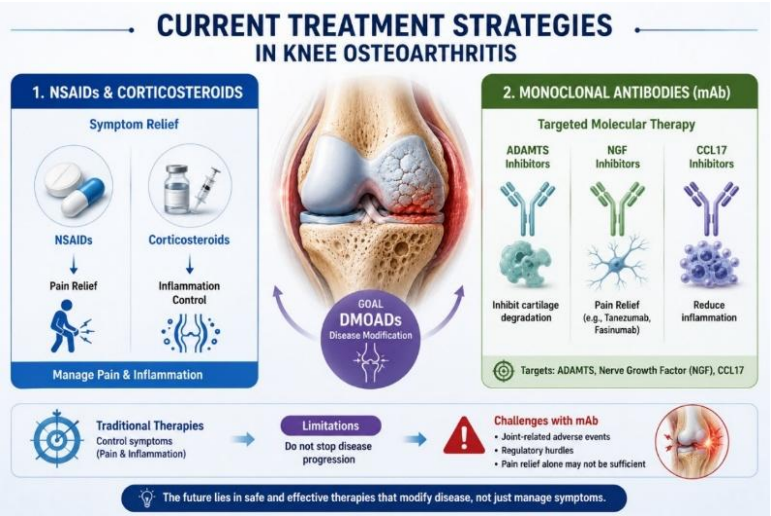
Magnetic resonance imaging has been a major breakthrough that has been used to monitor cartilage thickness, cartilage loss, bone remodelling, and subchondral bone changes during clinical trials.

Next diagnostic step ahead

A future diagnostic strategy may combine imaging with molecular biomarkers such as inflammatory cytokines, MMP activity, ADAMTS activity, and characteristics of the joint microenvironment. Such approaches could potentially identify biologically distinct forms of KOA and allow treatment to be selected according to the dominant disease mechanism.

Treatment of KOA: From Pain Relief to Targeted and Disease-Modifying Strategies

Current treatment strategies using NSAID, corticosteroids and mAb



One of the most important developments in knee osteoarthritis research is the search for disease-modifying osteoarthritis drugs, often referred to as DMOADs.

Traditional treatments such as NSAIDs and corticosteroids primarily control pain and inflammation while targeted therapies attempt to interfere with the molecular processes

responsible for cartilage destruction, inflammation, bone remodelling, or abnormal signalling.

On the other hand, monoclonal antibodies have been investigated against targets including ADAMTS, nerve growth factor, and CCL17. Antibodies against nerve growth factor, such as Tanezumab and Fasinumab, produced substantial pain relief in some studies. However, concerns regarding joint-related adverse events created major barriers to regulatory approval and clinical development. This illustrates that suppressing pain alone may not be sufficient if the underlying disease process continues or safety risks emerge.

Nanotechnology, Gene Therapy, and Regenerative Medicine

1. Nanocarrier-based therapy is another promising area of KOA research. Nanoparticles, liposomes, micelles, and dendrimers can potentially improve drug retention within the joint, increase cartilage penetration, and reduce systemic exposure.

The nanocarriers can deliver active compounds directly to the knee joint and influence inflammatory pathways such as NF-κB and MAPK. Liposomal formulations have already reached clinical testing. For example, Liposomal Dexamethasone was developed to provide sustained pain relief and improve joint function while limiting systemic exposure.

2. Gene therapy may offer longer-lasting therapeutic effects by suppressing harmful gene activity or increasing the expression of protective factors. TissueGene-C has shown evidence of increased cartilage thickness and slower progression of subchondral bone changes in clinical research. Other approaches, including XT-150 and adeno-associated viral vector therapies, are also being investigated, although several remain in early-stage development.

3. Cell-based therapies are also attracting attention. Mesenchymal stem cells may support cartilage repair and regulate inflammation, while mesenchymal stem cell-derived exosomes may promote chondrogenesis, autophagy, and extracellular matrix synthesis. Nevertheless, current clinical evidence remains limited, and optimal treatment protocols have not yet been established.

The Future of Knee Osteoarthritis Treatment

Knee osteoarthritis research is entering an important transition. The goal is no longer limited to relieving pain. Scientists are increasingly focusing on:

- Preservation of cartilage
- Regulation of inflammation
- Modifying destructive molecular pathways
- Regeneration of damaged joint tissue.

Although a definitive cure for KOA has not yet been achieved, targeted inhibitors, monoclonal antibodies, nanomedicine, gene therapy, stem cells, and exosome-based therapies provide multiple pathways toward more effective treatment.

The future of knee osteoarthritis management may depend on identifying the right molecular target, delivering the therapy precisely to the affected tissue, and combining structural protection with meaningful symptom relief.

[Read More for Detailed Research]