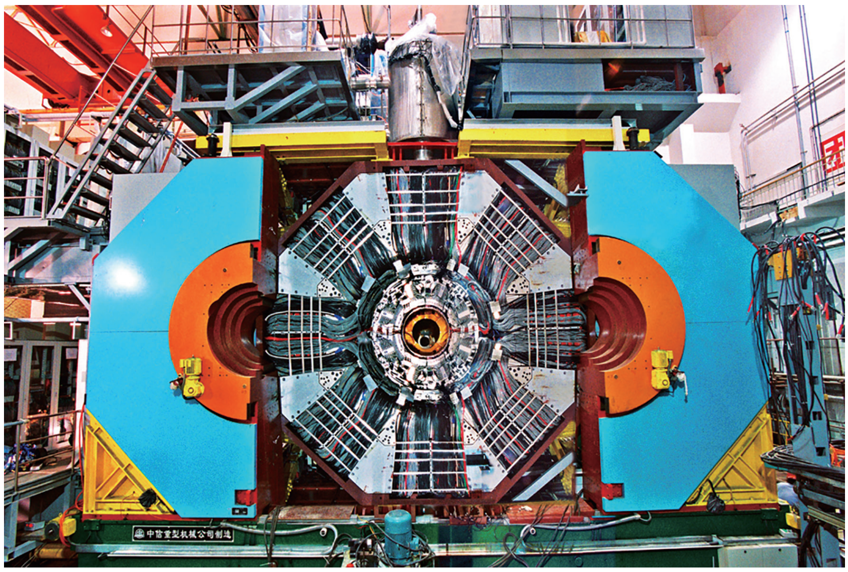
Precise Measurement of Decay Constant for the Charmed Meson D^+ at BESIII

Recently, taking advantage of the large volume of data collected by the detector, the BESIII International Collaboration successfully measured the decay constant for the charmed meson D^+ — with the best precision to date.

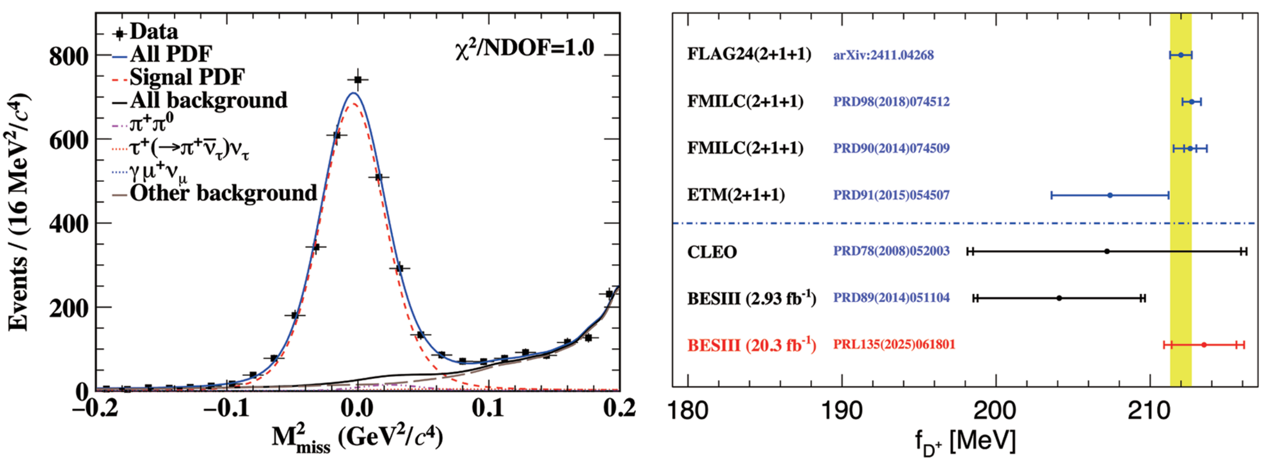
As an unstable particle, the charmed meson D^+ can decay via many different pathways, each with a different possibility. In the process of the decay, its constituent heavy charm quark can transform itself into other particles, thereby diverting the subsequent decay cascade into a different pathway or a different decay network.

The numerous decay pathways of D^+ meson, a direct consequence of the quantum rules described by the Standard Model (SM), provide a rich dataset for investigating the weak interaction, which governs the decay process.

Among these, the rarest "channel" has attracted the attention of particle physicists. In this case, the constituents of D^+ meson, the charm quark and the anti-down quark, annihilate directly to produce a positive muon μ^+ and a muon neutrino ν_μ. Since both produced particles are leptons, this type of decay is called "leptonic decay". Therefore, the probability of this annihilation is directly proportional to the square of a fundamental param-



The BESIII detector (Credit: IHEP)



Left: Signals of the leptonic decay $D^+\to\mu^+\nu_\mu$. Right: The comparison between the experimental measurements and theoretical calculations of the decay constant f_{D+} for the leptonic decay. (Credit: BESIII Collaboration) eter described in the SM — the Cabibbo-Kobayashi-Maskawa (CKM) matrix element.

Furthermore, the leptonic decay of D^+ provides a clean background for precise comparison between theoretical predictions and experimental measurements. It is a sensitive probe to test chromodynamic calculations and the unitarity of CKM quark mixing matrix.

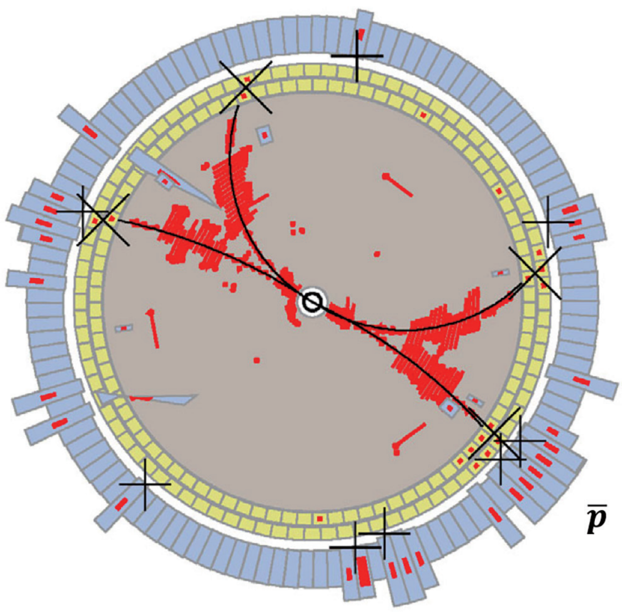
Using a total of 6.0×10^7 D^+ decay events collected by the BESIII detector, the BESIII Collaboration precisely measured the branching fraction of the D^+ leptonic decays, and reported their results in *Physical Review Letters* on August 4 (DOI: 10.1103/gb8v-4rnh).

The D^+ decay constant is determined to be $(213.5 \pm 2.1_{stat} \pm 1.1_{syst} \pm 0.8_{input} \pm 0.7_{EM})$ MeV, after correlating their measurement with the Fermi theory of weak interaction. The new measurement is 2.3 times more precise than the previously best measurement. Alternatively, using the value of the decay constant derived from a precise lattice quantum chromodynamics calculation, the precise value of the $c\rightarrow d$ CKM matrix element is extracted to be $0.2265 \pm 0.0023_{stat} \pm 0.0011_{syst} \pm 0.0009_{input} \pm 0.0007_{EM}$. With an accuracy of approximately 1%, this result unveils a new era in testing the unitarity of the CKM matrix in the SM.

Testing Quantum Local Realism in BESIII via Massive Hyperon-Antihyperon Pairs

The nonlocality of quantum correlations, as manifesting through the violation of Bell inequalities, constitutes a fundamental property of the microscopic world. In contrast to macroscopic systems, where spatially separated objects cannot influence each other instantaneously, entangled quantum particles maintain correlated properties even at large distances: Measurement of one particle in an entangled pair results in an immediate change in the state of its counterpart. While various forms of Bell inequalities have been experimentally confirmed in photonic and atomic systems, their exploration in high-energy physics contexts remains limited.

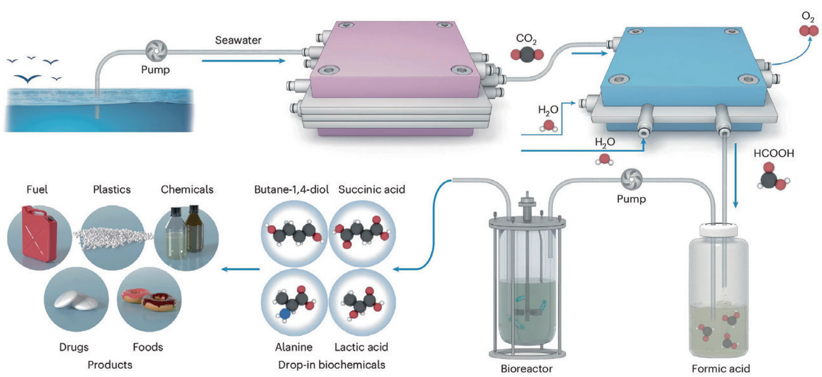
This gap has recently been addressed by the BESIII collaboration at the Institute of High Energy Physics (IHEP), Chinese Academy of Sciences. The collaboration analyzed $(10.087 \pm 0.044) \times 10^9$ J/ψ charmonium decay events recorded with the BESIII detector at the BEPCII collider. In these events, each J/ψ particle decayed promptly into a photon and an η_c meson, with the η_c subsequently decaying into a massive entangled hyperon–antihyperon pair. The hyperon and antihyperon then underwent strong and weak



Transverse view of the decay events of the charmonium J/ψ as well as the subsequent cascade decays as seen in the BESIII detector, giving the spatial trajectories of the charged tracks (black curves). The center of the view corresponds to the electron-positron collision point where the charmonium J/ψ is produced and instantaneously begins to decay. (Credit: BESIII Collaboration) decays, respectively. Through precise reconstruction of the angular distributions in both the initial and subsequent decay processes, the team observed a violation of local hidden variable theories—a Bell-type inequality—with a statistical significance exceeding 5.2σ. These findings were published online in *Nature Communications* on May 28. (https://doi.org/10.1038/s41467-025-59498-4).

From Seawater to Bioplastic

Oceans absorb about one-third of atmospheric carbon dioxide emissions, but converting this dissolved inorganic carbon into useful products has remained a major challenge. A research team led by Dr. GAO Xiang from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences and Dr. XIA Chuan from the University of Electronic Science and Technology of China has now developed an artificial oceanic carbon recycling system that captures CO_2 from seawater and directly converts it into succinic acid—a key building block for biodegradable plastics.



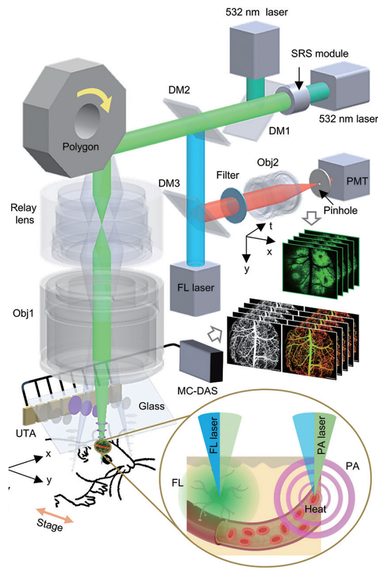
Schematic illustration of the artificial ocean carbon recycling system that captures and converts oceanic CO_2 into drop-in biochemicals through decoupled electro-biocatalytic processes. (Image by SIAT)

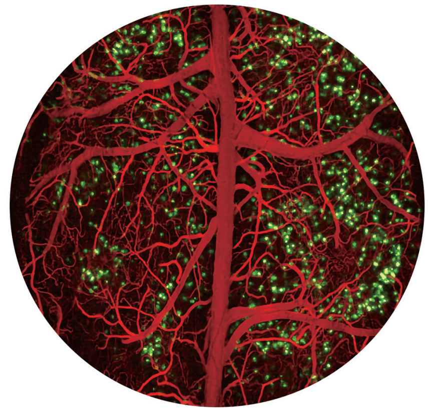
As reported in *Nature Catalysis* (doi: 10.1038/s41929-025-01416-4) on October 6, 2025, the system combines electrochemistry with microbial fermentation in a cascade process. Seawater flows into a five-chamber electrochemical reactor where an electric field generates protons that acidify the water, converting dissolved carbonate into gaseous CO_2. A hollow-fiber membrane separates the CO_2 and delivers it to a second reactor containing a bismuth-based catalyst that reduces CO_2 to formic acid. Finally, an engineered strain of *Vibrio natriegens* ferments the formic acid into succinic acid. The system operated continuously for over 530 hours using natural seawater from Shenzhen Bay, achieving a 70% efficiency of carbon capture—far exceeding previous devices that typically run for only a few hours. The estimated capture cost of approximately \$230 per metric ton of CO_2 is competitive with current carbon capture technologies. By incorporating different engineered microbes, the platform can produce various industrial chemicals including lactic acid, alanine, and 1,4-butanediol. This study presents a sustainable strategy for upcycling ocean-derived CO_2, opening new avenues for electrochemically driven biochemical synthesis.

Seeing the Whole Brain at Work

When neurons fire, blood vessels nearby respond by expanding to deliver more oxygen and nutrients—a process called neurovascular coupling. This dynamic interaction is not only essential for normal brain function, but also critical for robotic limbs or computer cursors: It allows for the development of a non-invasive brain-computer interfaces to control such external devices. However, existing imaging technologies cannot simultaneously capture both neural activity and blood vessel changes across the whole cortex with sufficient speed and resolution. Researchers from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences have now developed a microscope that overcomes these limitations.

As reported in *Science Advances* (doi: 10.1126/sciadv.adw5275) on July 23, the new system, called LiTA-HM (linear transducer-array-based hybrid microscope), combines multiple imaging techniques to visualize neurons and blood vessels across the whole cortex of awake mice in real time. The microscope achieves 6-micrometer resolution over a 6 mm × 5 mm field of view at 1.25 frames per second, capturing details down to individual neuron cell bodies and tiny capillaries across the entire cortex. The team successfully used LiTA-HM to study brain disease models and functional activity in awake mice. This technology provides a powerful new tool for brain research and could advance the development of non-invasive brain-computer interfaces.

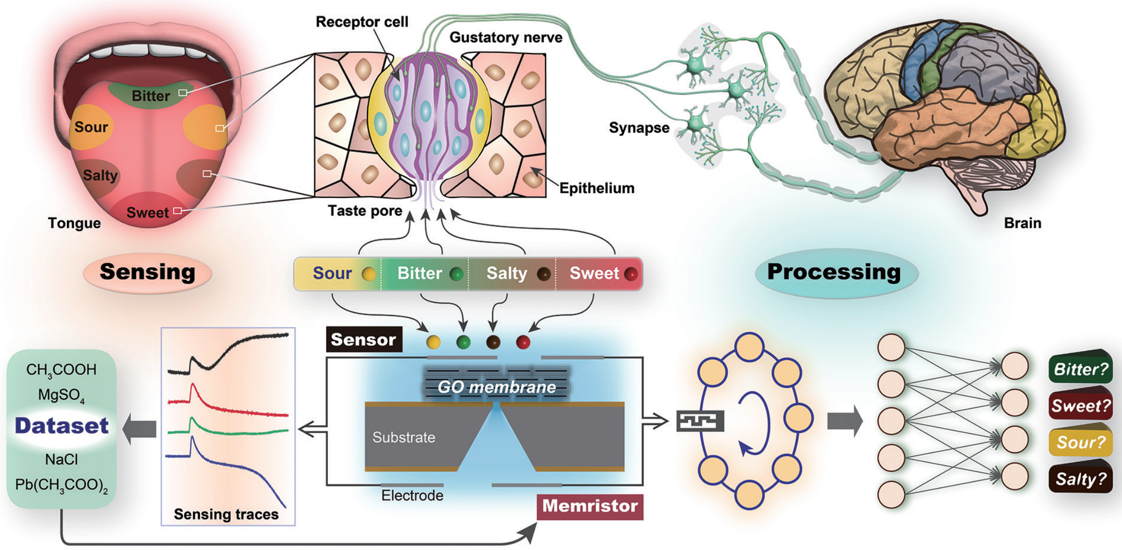




LiTA-HM schematic and imaging results. (Image by SIAT)

An Electronic Tongue That Tastes

Brain-inspired computer chips can already process visual, auditory, and tactile information, but they have struggled to detect chemicals in wet environments—the way human taste works. This limitation has prevented their uses in medical and environmental fields. As published in *PNAS* on July 7 (doi: 10.1073/pnas.2413060122), researchers from the National Center for Nanoscience and Technology (NCNST) of the Chinese Academy of Sciences developed an artificial taste system that overcomes this challenge. The team created a device using layered graphene oxide membranes that combines two functions in one—it acts as both a chemical



Schematic diagram: human *vs.* graphene oxide "tasting" system. (Image by NCNST) sensor and a learning system that mimics brain synapses.

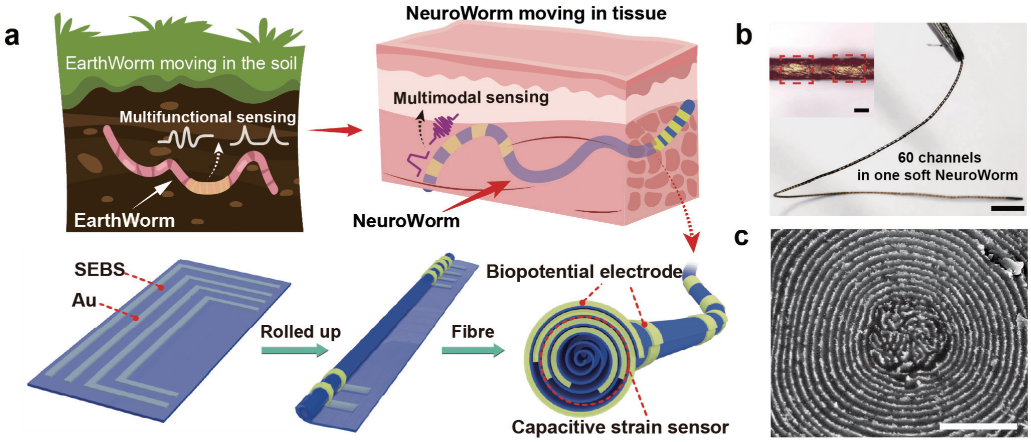
The key lies in how ions move through tiny channels in the graphene oxide. When ions temporarily get stuck through surface interactions, this creates a memory effect that enables both sensing and information processing. After training with artificial intelligence, the system could distinguish basic tastes like sour, bitter, salty, and sweet, as well as complex flavors such as coffee and cola, with over 90% accuracy. Unlike conventional systems where sensors and processors are separate—causing delays and wasting energy—this device computes where it senses, making it faster and more efficient.

The researchers envision that this technology could help restore taste perception in patients who have lost it, enable autonomous machines to analyze their chemical environment, or monitor food and water safety. Future work aims to miniaturize the device for integration into standard computer chips while maintaining performance.

An Earthworm-inspired Brain Probe

Brain-computer interfaces rely on electrodes to record neural activity, but most existing electrodes remain fixed once implanted, limiting their sampling range and often triggering immune responses that degrade signal quality over time. As reported in a *Nature* paper (doi: 10.1038/s41586-025-09344-w) on September 17, researchers from the Shenzhen Institutes of Advanced Technology (SIAT), Chinese Academy of Sciences, and Donghua University have now developed NeuroWorm—a soft, movable fiber electrode that can navigate through tissues while continuously recording high-quality signals. The device marks a shift from static to dynamic neural interfaces.

Inspired by earthworm locomotion, the 200-micrometer-diameter fiber integrates up to 60 independent signal channels and features a magnetic tip that enables wireless steering via external magnetic fields. In rat experiments, researchers guided NeuroWorm through muscle fasciae via a minimally invasive incision, demonstrating smooth movement between tissue layers while capturing stable electromyographic signals from multiple positions over seven days. Long-term implantation in rat leg muscles for over 43 weeks showed continuous signal recording with minimal fibrotic encapsulation—less than 23 micrometers compared to 451 micrometers for conventional rigid electrodes. The team also navigated NeuroWorm through a rabbit's brain from the cortex to subcortical regions while maintaining stable signal quality throughout. By enabling noninvasive repositioning through magnetic guidance, NeuroWorm eliminates the need for repeated surgeries due to electrode drift or misplacement. Hence, NeuroWorm provides a platform for long-term, multisite neural monitoring with applications in brain-computer interfaces, smart prosthetics, epilepsy mapping, and chronic neurological disorder management.

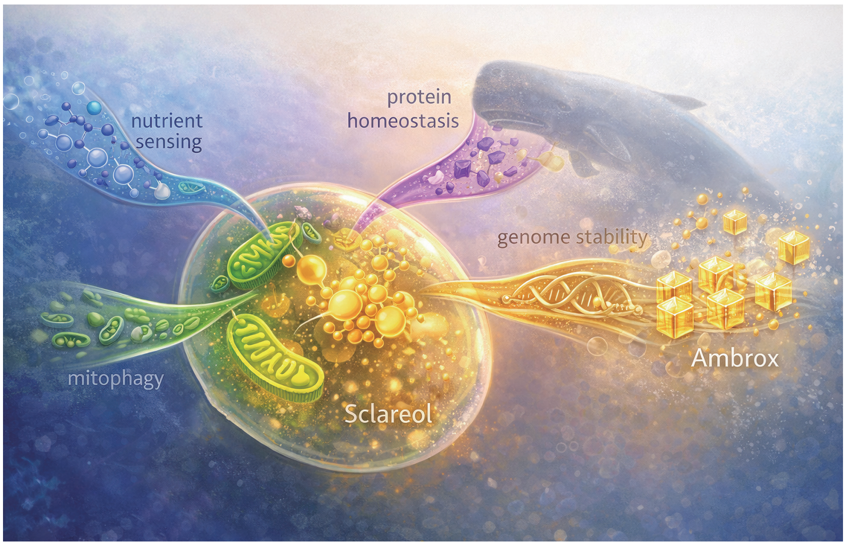


Design and fabrication strategy of NeuroWorm. (Image by SIAT)

Living Longer, Producing More

Yeast cells engineered for efficient chemical production face a critical challenge—they age and accumulate toxic metabolites during prolonged industrial fermentation, ultimately reducing productivity. A team at the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences has now shown that extending the cellular lifespan of yeasts dramatically enhances their biosynthetic capacity.

In a study published in *PNAS* (doi: 10.1073/pnas.2515324122) on November 10, researchers led by Dr. ZHOU Yongjin systematically engineered yeast longevity through four dimensions: nutrient sensing, mitophagy, protein stability, and genomic stability. By weakening nutrient-sensing pathways and enhancing mitophagy—the cellular process that removes damaged mitochondria, together with metabolic pathway optimization, the team achieved sclareol production of 25.9 grams per liter, the highest microbial production recorded for this valuable precursor for the synthesis of perfume Ambrox. Omics analysis revealed that lifespan extension automatically remodeled cellular metabolism, improving robustness during late-stage fermentation when cells typically decline. The longevity engineering strategy also boosted production of sesquiterpenes and phenolic acids, demonstrating broad applicability. This work establishes a connection between chronological lifespan and biosynthetic capacity—offering a generalizable strategy for sustainable biomanufacturing beyond conventional metabolic engineering.



Engineering yeast longevity boosts sustainable sclareol production, a valuable precursor for the synthesis of perfume Ambrox. Extending cell lifespan through four longevity pathways dramatically increased sclareol yields—without the cellular stress of traditional methods or harvesting from endangered whales. (Image generated by AI)

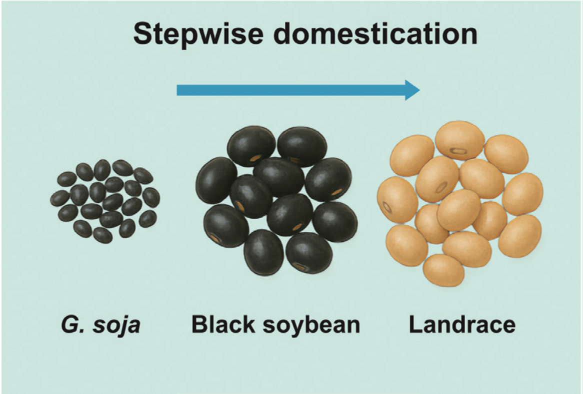
The Soybean's Missing Link

Soybeans are the world's most important source of plant protein and oil; yet how they evolved from wild vines has remained a mystery. Researchers have now found the missing piece—black soybeans served as the bridge between wild plants and today's yellow varieties.

A joint team led by Dr. TIAN Zhixi from Yazhouwan National Laboratory and the CAS Institute of Genetics and Developmental Biology analyzed DNA from 8,105 soybean samples to reveal a two-step domestication process, as reported in *Cell* (doi: 10.1016/j.cell.2025.09.007) on November 13. Approximately 5,000–6,000 years ago, farmers in two Chinese regions—the Huanghuai Plain and northwest China—first turned wild soybeans into black varieties. They selected for larger seeds, pods that held seeds until harvest, and predictable flowering. Later, farmers refined these black soybeans into yellow types better suited for cooking and storage.

The genetic analysis solved a modern problem. Soybean breeders have long struggled because increasing oil content typically decreases protein, and vice versa. The researchers identified a gene called *GmSWEET30a* whose specific version can boost both oil and protein simultaneously—potentially breaking this decades-long trade-off.

The study also revealed an unintended consequence of breeding. While creating yellow soybeans, breeders accidentally eliminated genes that provide resistance to crop-damaging pests. These valuable resistance genes still exist in older black soybeans, showing why preserving ancestral varieties matters.



Black soybeans served as the evolutionary bridge between wild *G. soja* and modern yellow varieties that now dominate global farms. (Adapted from Zhu et al., 2025)

The team created an online database that allows breeders to identify and recover useful traits lost during domestication. By combining ancient genetic diversity with modern techniques, scientists can now develop soybeans that are more nutritious, pest-resistant, and productive.

Dogs and Humans—Ancient Migration Partners

Dogs have accompanied humans for thousands of years, but the precise nature of this relationship during major prehistoric migrations has remained unclear. A genomic study published in *Science* (doi: 10.1126/science.adu2836) on November 13 reveals that dogs were integral migration partners rather than mere companions—their movements across Eastern Eurasia closely mirrored human population shifts over the past 10,000 years.

Researchers led by Prof. WANG Guodong from the Kunming Institute of Zoology of the Chinese Academy of Sciences analyzed 73 ancient dog genomes from archaeological sites spanning Siberia to Northwest China. The team discovered that multiple domestic dog populations—including ancient Eurasian steppe dogs and ancient northern East Asian dogs—experienced admixture and replacement events during the Holocene. When compared with ancient human genomic datasets, these canine population changes coincided remarkably with documented human migrations involving Ancient Paleo-Siberians, Eastern hunter-gatherers, and Steppe pastoralists.

The findings demonstrate that dogs were not passive followers but essential components of human migratory waves. Their dispersal patterns reflect both shared journeys with specific human groups and independent exchanges between communities, particularly among hunter-gatherer societies in northern latitudes. This comparative ancient genomics approach establishes a framework for understanding domestication dynamics and offers new perspectives on how domesticated species shaped—and were shaped by—human civilization across millennia.

Han Dynasty stone relief "Dog Training Scene" excavated from Changzhongdian, Deng County, Henan Province, north-central China, depicting the close relationship between dogs and humans. (Image by courtesy of online sources)

Mangrove Trees also Release Climate-Warming Methane

Mangrove ecosystems are celebrated as powerful carbon sinks, absorbing and storing atmospheric CO_2 more efficiently than most terrestrial forests. However, they also release methane—a greenhouse gas far more potent than carbon dioxide. A study published in *Nature Geoscience* (doi: 10.1038/s41561-025-01848-4) on November 14 reveals that mangrove tree stems represent a previously overlooked pathway of methane emissions, partially reducing the climate benefits of these coastal ecosystems.

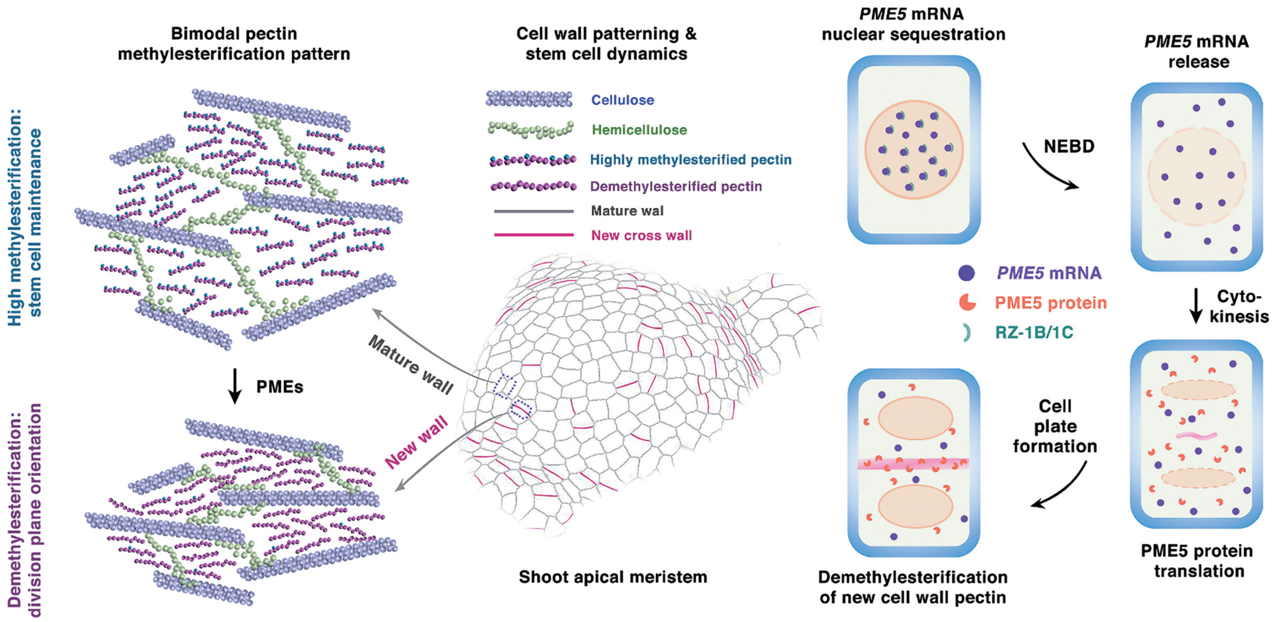
Researchers from the South China Botanical Garden of the Chinese Academy of Sciences conducted a global-scale assessment combining long-term field monitoring across multiple Chinese mangrove sites, worldwide literature data, and machine learning models. Their analysis showed that methane produced by anaerobic microbes in waterlogged mangrove soils travels upward through specialized aerenchyma tissues in tree stems and escapes into the atmosphere. Field measurements confirmed that emissions are highest near the stem base and decrease with height.

Mangrove roots in waterlogged soil—where anaerobic microbes produce methane that travels up through tree stems into the atmosphere. (Graphic: Pixabay)

The team estimates that mangrove tree stems globally release approximately 730.6 gigagrams of methane annually—offsetting roughly 16.9% of the carbon buried in mangrove sediments each year. When soil methane emissions are included, total methane losses could offset up to 27.5% of mangroves' blue carbon sequestration. These findings suggest that current climate mitigation assessments based solely on sediment carbon burial without consideration of methane emission may overestimate the benefits of mangrove restoration projects. However, even when considering the methane emissions, the mangroves are still a more powerful carbon sink than most terrestrial ecosystems.

Soft Walls, Precise Divisions

Plants continuously generate new organs throughout their lives—a feat orchestrated by stem cells tucked within growing tips. But how do these cells know precisely when and where to divide? The answer lies in the walls surrounding them. Researchers led by Dr. YANG Weibing from the Center for Excellence in Molecular Plant Sciences of the Chinese Academy of Sciences have discovered that cell wall stiffness acts as a molecular guide, directing stem cell division with remarkable precision. The study was published in *Science* (doi: 10.1126/science.ady4102) on



Proposed model for the regulation of plant stem cell dynamics by precise pectin modification. Mature cell walls retain highly methylesterified pectin for structural support, while newly forming division walls are enriched in de-methylesterified pectin that guides division plane orientation. This spatial pattern is achieved by locking *PME5* mRNA inside the nucleus until cell division releases it to soften pectin precisely where new walls form. (Graphic: Dr. YANG Weibing's group)

December 4, 2025.

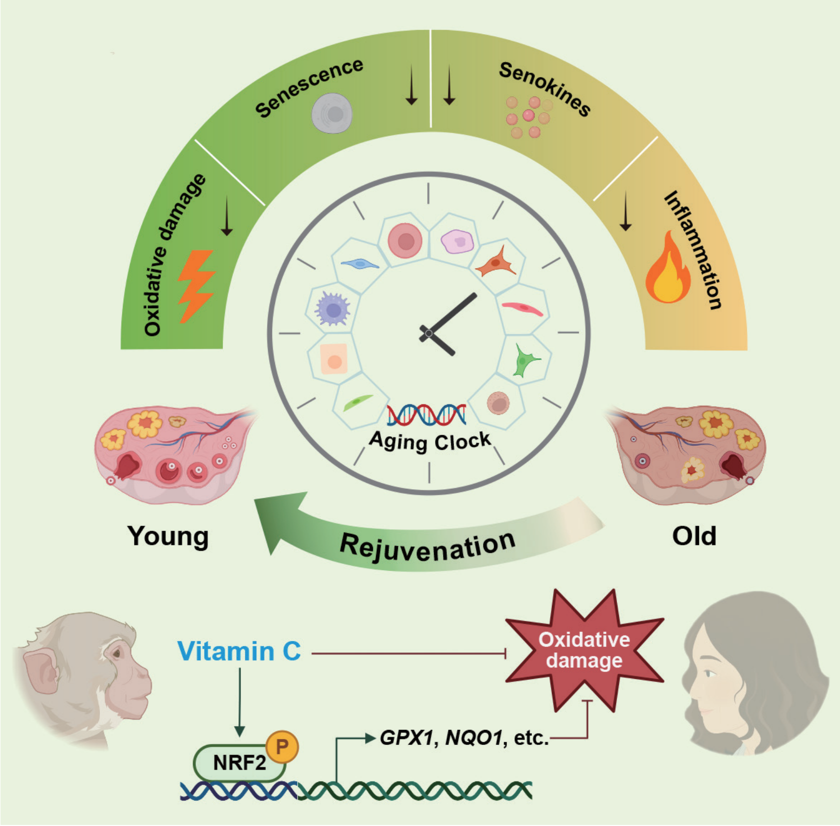
The team found a striking pattern in the shoot apical meristem—the plant's stem cell hub. Old, mature cell walls remain stiff like structural beams, while newly formed walls between dividing cells start soft and flexible. This stiffness difference comes from a simple chemical modification to pectin, a gel-like wall component. Stiff walls have highly methylesterified pectin, while soft new walls have de-methylesterified pectin. The softening is controlled by an enzyme called PME5, but the plant employs a clever safeguard: It locks the instruction manual for this enzyme—the *PME5* messenger RNA—inside the nucleus. As the cell divides and the nucleus briefly disassembles, the mRNA escapes to produce PME5 exactly where the new wall forms. This ensures that PME5 softens only the new division plane, allowing it to orient correctly within the stiff mother cell. When PME5 is not working, the division plane lacks the necessary "softness/flexibility". This leads to misoriented divisions (slanted or crooked walls) because the new wall cannot adjust its position correctly within the stiff mother cell.

When the researchers disrupted this mechanism by letting *PME5* mRNA escape prematurely, the results were dramatic—disorganized cell divisions, reduced stem cell activity, and stunted plants with malformed fruits. This nuclear sequestration strategy is not unique to PME5 but is used by several related enzymes. The team found this bimodal wall pattern in corn, soybean, and tomato, suggesting it is a fundamental principle of plant growth. Since key crop traits like tiller number and seed count depend on stem cell activity, understanding this cell wall code could enable scientists to engineer crops with improved architecture and higher yields.

Vitamin C Fights Primate Ovarian Aging

Ovarian aging profoundly impacts female reproductive health, driven primarily by key factors like oxidative stress. Non-human primates (monkeys) serve as vital models because they, like humans, can not synthesize their own Vitamin C (VC). Researchers, including those from the Institute of Zoology, Chinese Academy of Sciences, and the China National Center for Bioinformation and Beijing Institute of Genomics, Chinese Academy of Sciences, investigated the use of oral VC supplementation to mitigate this biological decline.

In a significant 3.3-year longitudinal study conducted on aged cynomolgus macaques, oral VC was found to delay ovarian aging. The treatment diminished crucial aging markers, including follicular depletion and widespread oxidative stress. Molecular analysis using a single-cell transcriptomic clock revealed substantial rejuvenation: VC lowered the biological age of ovarian somatic cells by 5.66 years and oocytes by 1.35 years. This geroprotective effect is mediated, at least in part, by activating the NRF2 pathway—an intrinsic cellular antioxidant defense mechanism that subsequently alleviates inflammation and cellular senescence. Published in *Cell Stem Cell* (doi: 10.1016/j.stem.2025.09.008) on November 6, these findings support VC as a translatable nutritional strategy for combating reproductive aging.



New study reveals that oral vitamin C supplementation delays ovarian aging in non-human primates, attenuating key aging hallmarks and rejuvenating the ovarian cellular and molecular profiles. (Graphic: Jing et al., 2025)