Special | CAS Research Highlights 2023 in Retrospect

For your one-stop review of fundamental research at the Chinese Academy of Sciences (CAS) over the passing year, *BCAS* editors pick some promising candidates of annual stars (see page 200 for detail).

Glittering among them are some exciting discoveries in astronomy and astrophysics made using two high-profile, large-scale observational instruments, the Large High Altitude Air Shower Observatory (LHAASO) and the Five-hundred-meter Aperture Spherical radio Telescope (FAST). With the help from LHAASO, scientists captured the whole process of a gamma-ray burst, including the early onset of its afterglow; the data inspired discussions about the possible role of new physics. Using FAST, astronomers obtained evidence for nanohertz gravitational waves, consistent with Einstein's prediction.

Based on observations conducted with multiple Very Long Baseline Interferometry (VLBI) networks from the time span between 2000 to 2022, scientists detected the periodic precession of the relativistic jet bursting from the central supermassive black hole (SMBH) of galaxy M87, providing the first observational evidence for the spinning of the SMBH. (Credit: Yuzhu Cui *et al.*, 2023; Intouchable Lab@Operverse and Zhijiang Lab)

Subtle as it is, the technology of Very Long Baseline Interferometry (VLBI) holds an important position in astronomical observations for its dazzling angular resolution – the first "photo" of a black hole as taken by the Event Horizon Telescope, a VLBI network, can be the best footnote. The year 2023 saw another feat scored by this technique: the long-sought-after observational evidence for the spin of M87*, the central supermassive black hole of the galaxy named Messier 87 in the constellation of Virgo.

Studies in the field of quantum information and quantum physics are also scintillating. CAS scientists successfully built a system of genuine quantum entanglement with 51 qubits, shattering the former world record of 24 for the number of qubits in genuine entanglement for all kinds of quantum systems. Also, they succeeded in developing a prototype quantum computer with 255 detected photons, making it one million trillion times more powerful than the best supercomputer of traditional architecture nowadays when solving certain problems.

Nicknamed a "man-made Sun", controlled nuclear fusion has long been the focus of public attention. Magnetically confined nuclear fusion represents a promising pathway towards a practical solution to fusion energy. In the list, we pick the latest progress made at the Experimental Advanced Superconducting Tokamak (EAST), a superconducting reactor for such experiments.

The world of life sciences and human health is equally spectacular. From the constellation of important advances, two stand out: the characterization of a genetic locus in sorghum that renders this crop the ability to regulate its sensitivity to alkaline, salty soils; and the mapping of the entire cellular ecosystem of fetal human immune system. The former is expected to inspire genetic engineering for saline-alkaline tolerant crops, and the latter offers an atlas for navigation through the origins and roles of immune cells across human fetal development.

Highlights | The Dawn of Chimeric Non-Human Primates

As reported in the November 9 issue of *Cell*, researchers from the Chinese Academy of Sciences and partners have accomplished a remarkable feat: the birth of a chimeric monkey with substantial contribution from donor embryonic stem cells. This work not only showcases the feasibility of creating high-contribution chimeras in non-human primates but also opens new avenues for genetic engineering and disease research. Delve into this fascinating research for an insight into a future where medical breakthroughs are accelerated through chimeric models, turn to page 210.

The first live-birth chimeric monkey with high contribution of embryonic stem cells. (Credit: CAS)

Highlights | Teaching an Old Heart New Tricks

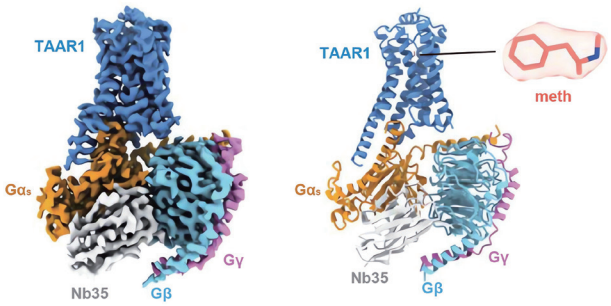
New research published October 2, in *Nature Aging* illuminates a natural molecular fountain of youth within our hearts. Scientists from the Chinese Academy of Sciences have identified the protein SIRT2 as a critical factor whose declining with age drives cardiac dysfunction. Remarkably, ramping up SIRT2 rejuvenated aged mouse hearts. These findings reveal new promise for combating cardiac aging, which brings hope that one day, we may defy the old adage you can't teach an old heart new tricks.

For more insights, see page 213.

Weaving a young and healthy heart with SIRT2. (Image by IOZ)

Highlights | Unlocking the Brain's Gateway to Methamphetamine Addiction

As reported in *Nature* on November 7, 2023, researchers from the Shanghai Institute of Materia Medica (SIMM) of the Chinese Academy of Sciences and their collaborators have discovered the precise molecular key enabling meth to hijack the brain's reward system, sparking intense highs underlying this dangerous addiction. Visualizing meth woven into its target receptor offers clues to jamming the gateway and treating this compulsive abuse. For finding out more, turn to page 215.



Scientists reveal how methamphetamine activates its key target receptor TAAR1, a gateway receptor for trace amines, in the brain. (Credit: SIMM)

Highlights | Re-wiring the Brain

Scientists developed a novel gene therapy strategy for selectively reactivating the affected neural circuits in patients with Parkinson's disease. (Image by SIAT)

In a recent study published in *Cell*, scientists from the Shenzhen Institute of Advanced Technology (SIAT) of the Chinese Academy of Sciences developed a promising gene therapy that precisely targets and re-stimulates malfunctioning neurons underlying Parkinson's disease, safely reversing motor impairment in monkey models. Unlike current medications that simply boost dopamine level, this approach circumvents complications and demonstrates the power of directly fixing defective neural circuits. Showing strong potential for better therapies, it opens possibilities for using targeted neurological reprogramming, rather than chemical supplementation, to treat other brain disorders.

For further insights, please refer to page 217.

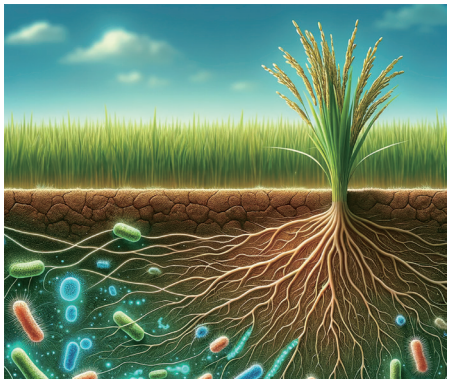
Highlights | Unraveling the Intricate Choreography of Brain Development

In a study published in *Cell* on December 12, a joint team led by scientists from the Institute of Zoology (IOZ) of the Chinese Academy of Sciences, Guangzhou Institutes of Biomedicine and Health, Peking University, and Tsinghua University created the most detailed map to date of the developing human brain, revealing the hidden choreography behind the genesis of our 86 billion brain cells. This breakthrough provides an unprecedented look at how distinct brain regions and cell types emerge and specialize over time. By mapping brain development at an unprecedented scale, this work represents a major leap forward for the field of spatial neuroscience and may pave the way for new therapies and treatments for neurological disorders.

For further insights, please refer to page 220.

Scientists seek to understand how the human brain's 86 billion neurons come to shape and function, a long-standing enigma. (Image created with DALL-E by YAN F.)

Highlights | Probiotics for Plants: Custom Microbes Boost Rice in Acidic Soils



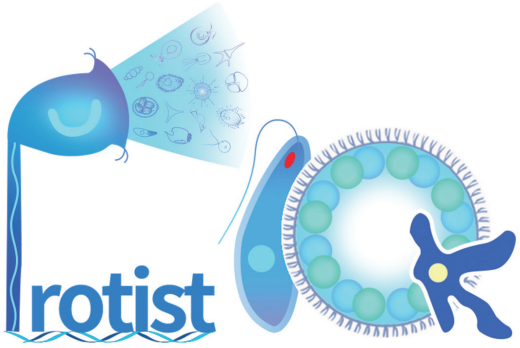
In a recent study reported in *Nature Food*, researchers from the Institute of Soil Science of the Chinese Academy of Sciences designed custom soil bacteria – a "probiotic for plants" – that enabled rice roots to thrive in acidic soils. The synthetic microbial community reduced aluminum toxicity, unlocked bound phosphorus, and guided rice roots upward to optimize nutrient capture. Field trials showed rice yields increased by over 25% in acidic soils with the microbiome boost versus rice grown alone. For further insight, turn to page 223.

Rice plants thrive in acidic soils when accompanied by specially chosen soil microbes. (Image created using DALL-E by YAN F.)

Highlights | Seeing the Unseen

A recent study published in *Nucleic Acids Research* unveils a trove of genomic data from protists – microscopic eukaryotes that play integral ecological roles across habitats. The involved project led by researchers from the Institute of Hydrobiology (IHB) of the Chinese Academy of Sciences significantly expands the representation of these understudied organisms, whose genetic intricacies remain a largely uncharted territory. With powerful tools now in hand, scientists worldwide can mine this unique compendium of knowledge to advance protist-centric research endeavors ranging from evolutionary biology to environmental science.

For further insights, please refer to page 225.



The logo for the Protist 10,000 Genomes (P10K) Project that aims to decipher the genomes of over 10,000 species across all major clades of protists, which are unicellular eukaryotic microorganisms that play crucial ecological roles. (Image by CAS)

ThinkTank | Safeguarding Food Security through Coordinating Management of Land and Water Resources with Environmental Governance

(Image by *Pixabay*)

China's drive for high-quality sustainable development hinges on maintaining adequate land and water resources and mitigating environmental degradation, while ensuring national food security. Here we present the recommendations from the Consultative Group of CAS Academic Divisions on the critical need to coordinate governance of water resources, land use, and environmental protection across all sectors and regions. A systemic approach is proposed to overcome fragmented policymaking and management silos that have undermined holistic ecological civilization goals.

To discover the key recommendations for aligning management of land and water resources and environmental governance to robustly uphold China's food security in the face of development pressures, please turn to page 227.