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Science and Art: Crossing Disciplinary Borders

Learn more

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Research Fronts 2021 released: 171 research fronts identified

[IMAGE: CASISD]

The Institutes of Science and Development of the Chinese Academy of Sciences (CASISD), the National Science Library of the Chinese Academy of Sciences (CAS), and Clarivate released a *Research Fronts 2021* report on December 8 at a joint forum in Beijing. The report identifies the hottest emerging scientific research areas, and is the eighth annual collaborative report of the three agencies.

With a new round of scientific and technological (S&T) revolution and flourishing industrial change, global S&T innovation has entered an unprecedentedly intensive and active period. A new generation of information technology represented by the Internet, big data and artificial intelligence has injected new momentum into economic and social development and is profoundly changing the development pattern of today's world.

"As the main force of national strategic S&T, CAS has always regarded fundamental research as its foundation. And S&T think tanks plays a vital role in how to scientifically understand changes, accurately adapt and actively seek changes in the major evolving situation," said Gao Hongjun, Vice President of CAS.

In order to accurately grasp the future S&T direction and focus, CAS has launched major S&T think tank research projects such as *Research and Judgment on China's Major S&T Breakthroughs that May Influence the Future Global Pattern,* widely organized research forces, prospectively analyzed China's major cutting-edge S&T breakthroughs on the basis of the global S&T frontier and national major needs, and served the strategic layout of national scientific and technological innovation, according to Gao.

Research Fronts 2021 identifies 171 research fronts, including 110 hot and 61 emerging fronts in 11 broad research areas in sciences and social sciences. Research Fronts are formed when clusters of highly cited papers are frequently cited together, reflecting a specific commonality in the research — involving perhaps experimental data, a method, a concept, or a hypothesis. Around one third of the Research Fronts identified this year were related to COVID-19. These include six among the top 10 Research Fronts in clinical medicine and three among the top 10 in biological sciences. The research being produced in these areas is instrumental to the fight against the disease and will have enormous impact on the world.

The 2021 report starts with 12,147 Research Fronts in Essential Science Indicators (ESI) provided by Clarivate from 2015 to 2020 and aims to discover which of them were most active or are developing most rapidly. Scientists at CASISD analyzed the 171 Research Fronts in great depth and interpreted them to highlight 31 key Research Fronts and two key Research Fronts groups.

"The research fronts are not mature disciplines, but the fronts of discovery. Through the scientific methods of 'Data + Methodological Tools + Comprehensive Analysis of Experts', we can find emerging or hot frontier fields in research. It shows an overall picture of the world's scientific development and reveals the contributions of research institutions and countries in science," said Pan Jiaofeng, President of CASISD.

There are two driving forces for scientific development: one is the internal contradictions of the S&T knowledge system that lead to cutting-edge revolutionary directions; the other is the major issues and demands of human society which constantly provide new impetus to scientific research, raise new questions and promote science development. "It is of great significance and value for our continuous release of *Research Fronts,*" said Pan.

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China's Space Technology Contributes to the Realization of the UN Sustainable Goals

China launches satellite for UN Sustainable Development Goals

China has launched a scientific satellite that will help nations meet the UN Sustainable Development Goals (SDGs). A Long March-6 carrier rocket sent it to orbit from the Taiyuan Satellite Launch Center on November 5.

Code-named "SDGSAT-1," it's the very first satellite on Earth to help realize the 17 goals in the "2030 Agenda for Sustainable Development" set by the UN in 2015 to stimulate action in solving social, economic and environmental problems faced by humanity and the planet.

Part of the Big Earth Data Science Engineering Project of the Chinese Academy of Sciences, the satellite is equipped with thermal infrared, glimmer and multispectral imagers to observe environmental changes on Earth linked to the coastal ecosystem and human activities like urbanization, habitation and energy consumption.

A Long March-6 carrier rocket carrying the "SDGSAT-1" satellite blasts off from the Taiyuan Satellite Launch Center, North China's Shanxi Province, November 5, 2021.
[IMAGE: ZHENG BIN/TAIYUAN SATELLITE LAUNCH CENTER]

Guo Huadong, chief scientist of SDGSAT-1 and director of the International Research Center of Big Data for Sustainable Development Goals (CBAS) said the satellite is part of an international plan for achieving the SDGs undertaken by all countries.

"The satellite will provide data support for the entire international community, especially developing countries in monitoring, evaluating and researching the interaction between humans and nature," Guo said.

"We hope to work with Chinese and international organizations and effectively gather and share data to help bridge the gap in unbalanced global sustainable development."

CBAS was established in September and has so far built up an initial SDG big data platform. It is one of the 24 partners on the online platform for the UN sustainable development technology promotion mechanism.

"Now, the satellite could work to meet six goals in the 17 SDGs. So, only one satellite is not enough and there will be more to serve for more goals and solve more problems. And we will unite relevant organizations in the world to form an observation union based in part on data of other satellite systems in the world," Guo said.

This launch was the 395th flight mission of the Long March rocket series.

Source: CGTN

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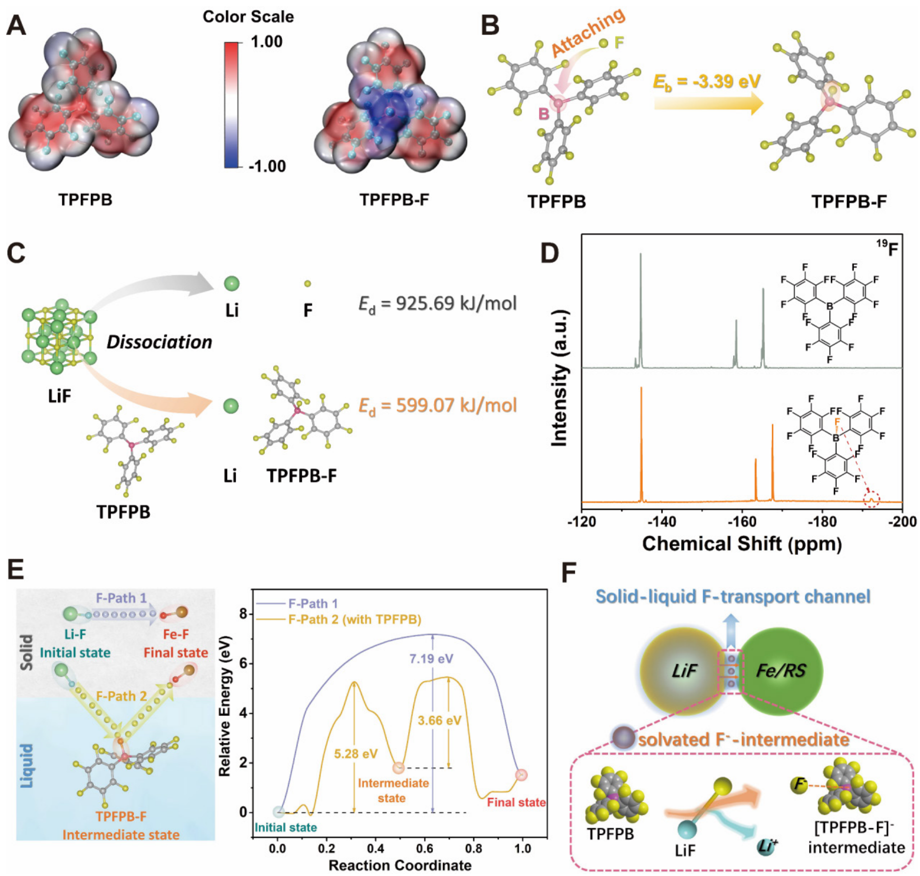
"This is an important report because its content guides us to look to the future of research. It also clarifies our vision of the way the world creates, protects and advances innovation," said Steen Lomholt-Thomsen, Chief Revenue Officer of Clarivate. "We are proud to see that this report has achieved increasing influence in the past years — not only in China but also in other parts of the world."

In conjunction with the *Research Fronts 2021 report*, the three agencies also published *2021 Research Fronts: Active Fields, Leading Countries*, which examines and compares national performance across the 171 Research Fronts. It reveals that the US remains the leading nation for research in 11 areas of sciences and social sciences, followed by China. The gap between the US and China has been reduced. The UK, Germany and Italy rank third, fourth and fifth respectively.

Source: Institutes of Science and Development, Chinese Academy of Sciences

New-type high-energy lithium-fluoride batteries developed



Characterization of solid-liquid F-transport channels enabled by the anion receptor of TPFPB
[IMAGE: SIC]

Lithium metal batteries based on Li metal anodes coupled with conversion-type cathodes have emerged to meet the demands of next-generation energy storage technology for large-scale application of powerful electromobility systems such as electric vehicles and all-electric aircraft.

Among conversion-type cathodes, iron trifluoride (FeF_3) is considered a promising candidate because it can offer an extremely high energy density of 1947 Wh/kg (based on a theoretical capacity of 712 mAh/g with a thermodynamic potential of ~2.73 V) via three electron transfer. Different from molecule cathodes (e.g., S_8 and O_2), FeF_3 can effectively mitigate the loss of cathode active species and the occurrence of anode side reactions caused by the difficulty of reaction-zone confinement.

However, the intrinsic solid-solid conversion of fluoride is sluggish during repeated splitting and re-bonding of metal-fluorine moieties. In particular for Li-driven fluoride conversion, heterogeneous precipitation and coverage of insulating lithium fluoride (LiF) on the whole electrode surface impedes the internal chemical reaction between active fluoride and lithium, causing large voltage hysteresis and low available capacity.

A research team led by Professor Li Chilin from the Shanghai Institute of Ceramics (SIC) of the Chinese Academy of Sciences has recently made progress in conversion-type lithium-fluoride batteries.

In view of the sluggish kinetics and poor reversibility of lithium-fluorine conversion reactions, they proposed a novel solid-liquid fluorine conversion mechanism enabled by a fluoride anion receptor of tris (pentafluorophenyl) borane (TPFPB) to promote the dissociation of inert lithium fluoride and provide a facile "fluorine transport channel" at multiphase interfaces via the formation of solvated F-intermediates. The construction of a solid-liquid channel could bypass tough solid-solid conversion and upgrade the fluoride conversion kinetics, achieving sustained cycling of conversion-type lithium-fluoride batteries with high capacity and energy efficiency.

The related result is published in *Science Advances* (2021, 7, eabj1491) under the title "Construction of solid-liquid fluorine transport channels to enable highly reversible conversion cathodes".

TPFPB has an electron-deficient boron center, which exhibits a strong attraction to electron-rich fluorine. TPFPB with F-binding affinity favorably promotes LiF splitting, and enables the F-state transformation from the solid LiF lattice to the solvated $[TPFPB\text{-}F]^-$ intermediate. For the Li-driven Fe-F conversion system, the dissolved F^- tends to react with the oxidized Fe species in the reconversion process. The construction of a solid-liquid fluorine channel not only improves

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the original rough solid-solid contact, but also kinetically promotes the F-sublattice conversion from Li-F to Fe-F structure, as indicated by the evidently reduced reaction energy barrier of the LiF-Fe system.

Additionally, the research team developed a thermal-induced self-oxygen penetration method for the structure optimization of fluoride cathodes. Two kinds of iron (oxy) fluoride composites (denoted as $FeO_{0.3}F_{1.7}$ and $FeO_{0.7}F_{1.3}$) were synthesized via sequential hydroxylation/dehydroxylation of hydrated iron fluoride under annealing treatment. The O doping in fluoride regulates the phase evolution pathway and introduces a stable second-generation parent phase of rock salt in the confined voltage region for conversion reaction.

Benefiting from the construction of facile round-trip F/Li-transport pathways and the optimization of fluoride structures, $FeO_{0.3}F_{1.7}$ and $FeO_{0.7}F_{1.3}$ cathodes enable a sustained conversion reaction with energy efficiency approaching 80 percent, high-capacity retention of 472 and 484 mAh/g after 100 cycles, and superior rate capability with reversible capacities of 271 and 320 mAh/g at 2 A/g. Their energy densities are achieved at 1100 Wh/kg for $FeO_{0.3}F_{1.7}$ and 700 Wh/kg for $FeO_{0.7}F_{1.3}$ under the power densities of 220 and 4300 W/kg, respectively. The key finding of solid-liquid fluorine channels provides an effective strategy to develop fluorine-conversion battery systems with high energy density.

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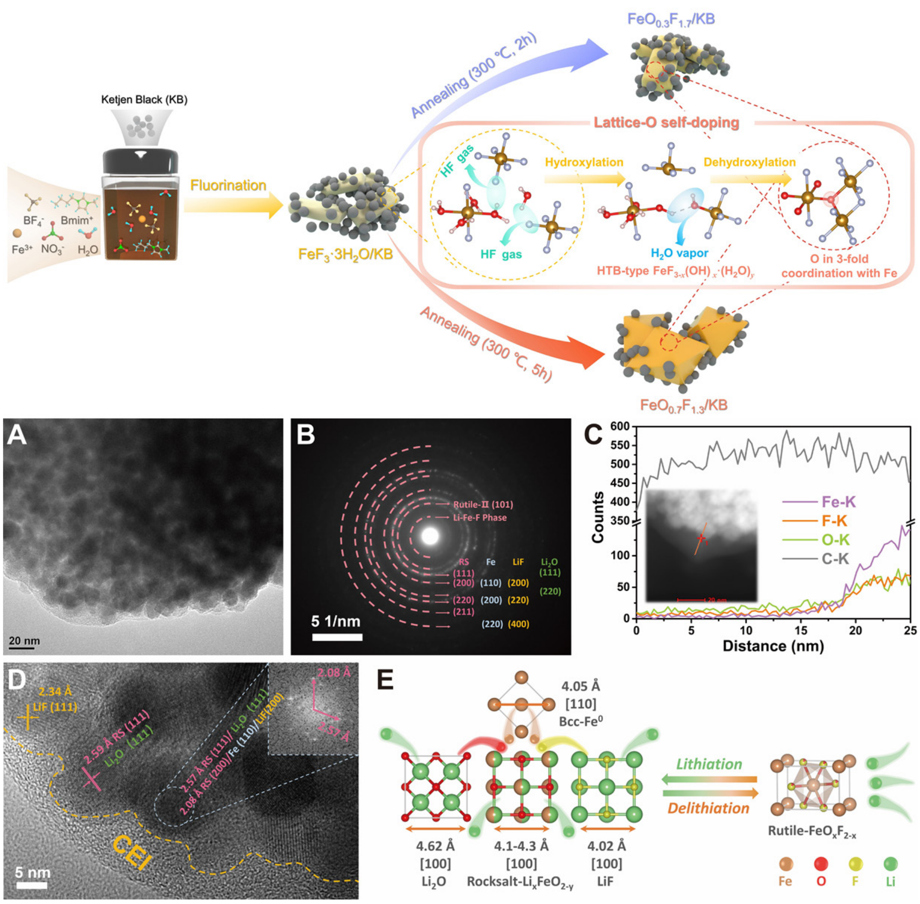
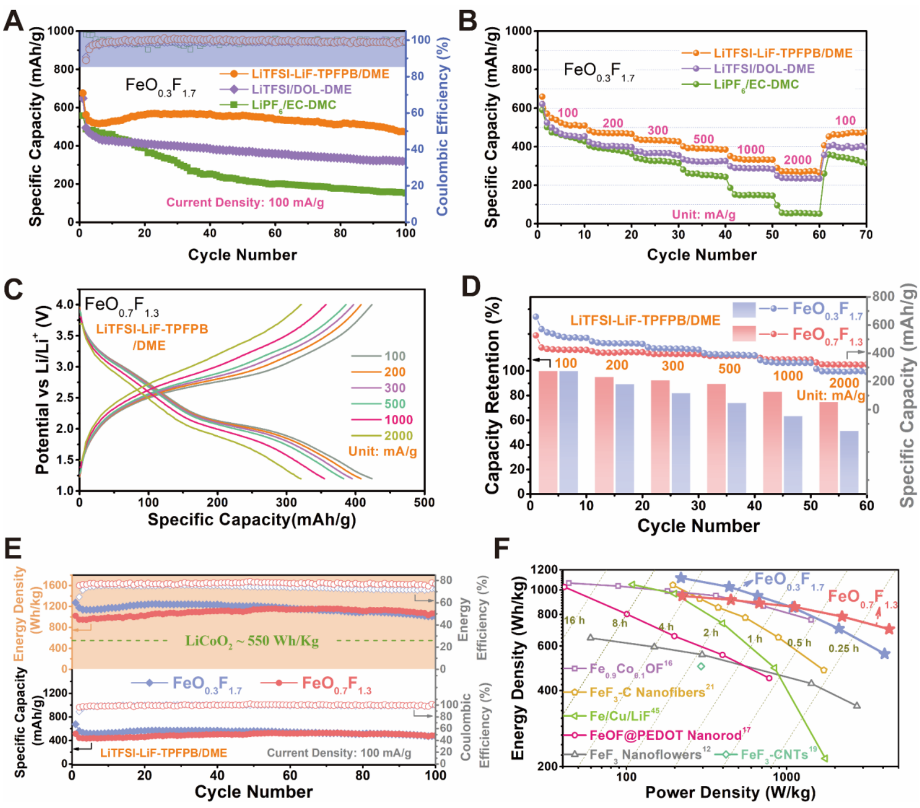
Shanghai Institute of Ceramics (SIC),
Chinese Academy of Sciences

Source: Shanghai Institute of Ceramics (SIC), Chinese Academy of Sciences



Schematic illustration of the preparation process of iron oxyfluorides via the thermal-induced self-oxygen penetration method and the phase conversion mechanism of iron oxyfluorides [IMAGE: SIC]



The effect of solid-liquid F-transport channels on promoting the electrochemical performance of $FeO_{0.3}F_{1.7}$ and $FeO_{0.7}F_{1.3}$ cathodes [IMAGE: SIC]

E3 ubiquitin ligase DSNP1 plays an essential role during rice meiosis

Synaptonemal complex (SC) assembly between paired homologous chromosomes plays a vital role in ensuring correct homologous recombination during meiosis. However, the mechanisms underlying the genetic regulation of SC assembly remain unclear.

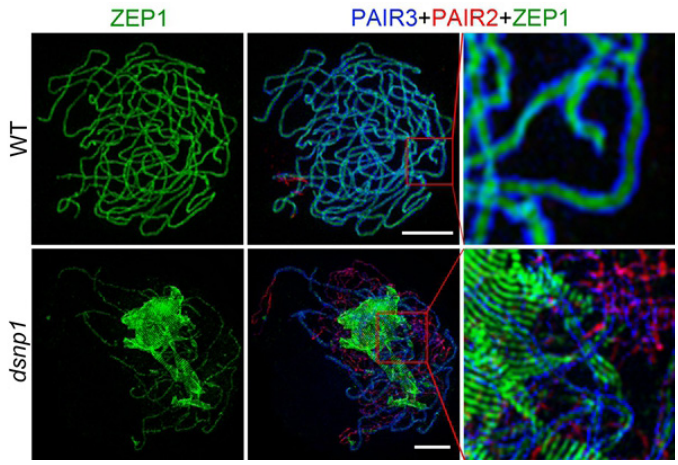
In a study published in *Cell Reports* (DOI:10.1016/j.celrep.2021.109941), a research group led by Professor Cheng Zhukuan from the Institute of Genetics and Developmental Biology of the Chinese Academy of Sciences, using a map-based cloning strategy, identified a novel RING finger E3 ubiquitin ligase encoding gene, DESYNAPSIS1 (DSNP1), participating in synapsis and homologous recombination.

In the *dsnp1* mutant, aberrant SC-like polycomplexes with ZEP1 as a skeleton, such as in wild-type late leptotene meiocytes, formed independently of homologous chromosomes at prophase I. And MG132 treated wild-type meiocytes showed aggregation of ZEP1 proteins similar to those observed in *dsnp1*, suggesting a significant role of the DSNP1-mediated proteasome pathway in degrading aberrant SC-like polycomplexes.

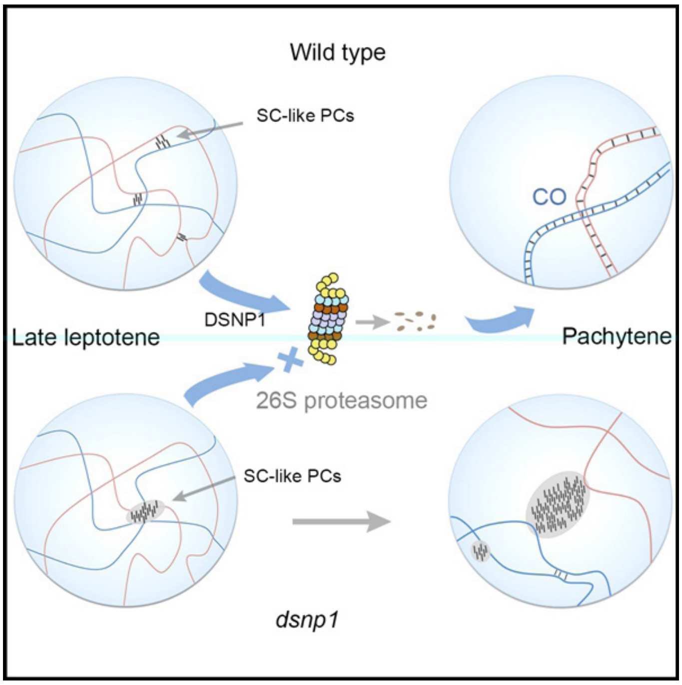
Moreover, recombination factors including HEI10, MER3, and ZIP43 were trapped in ZEP1 polycomplexes, leading to a decreased foci of these recombination factors on meiotic chromosomes and a dramatic reduction in the number of crossovers (COs) in *dsnp1*.

Interestingly, the introduction of ZEP1 mutation in a *dsnp1* background could to a great extent restore the localization of ZMM proteins on meiotic chromosomes and the formation of COs.

These findings indicate that the stabilization of canonical tripartite SC structures along paired homologous chromosomes and further formation of COs are regulated by the component of the Ubiquitin-proteasome pathway, DSNP1. This study provides new insights into the mechanisms of the meiotic process.



Super-resolution structured illumination microscopy analysis of SC assembly [IMAGE: IGDB]



An E3 ubiquitin ligase DSNP1 plays an essential role during rice meiosis. [IMAGE: IGDB]

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Institute of Genetics and Developmental Biology (IGDB), Chinese Academy of Sciences

Source: Institute of Genetics and Developmental Biology (IGDB), Chinese Academy of Sciences

How fatty liver disease turns into liver cancer

A research team from the Hefei Institutes of Physical Science (HFIPS) of the Chinese Academy of Sciences has reported their discovery that a metabolic regulation mechanism may play a role in transformation of non-alcoholic steatohepatitis into malignant liver tumors.

The study team led by Yang Wulin spent more than two years on this work that was published in the *International Journal of Biological Sciences.*

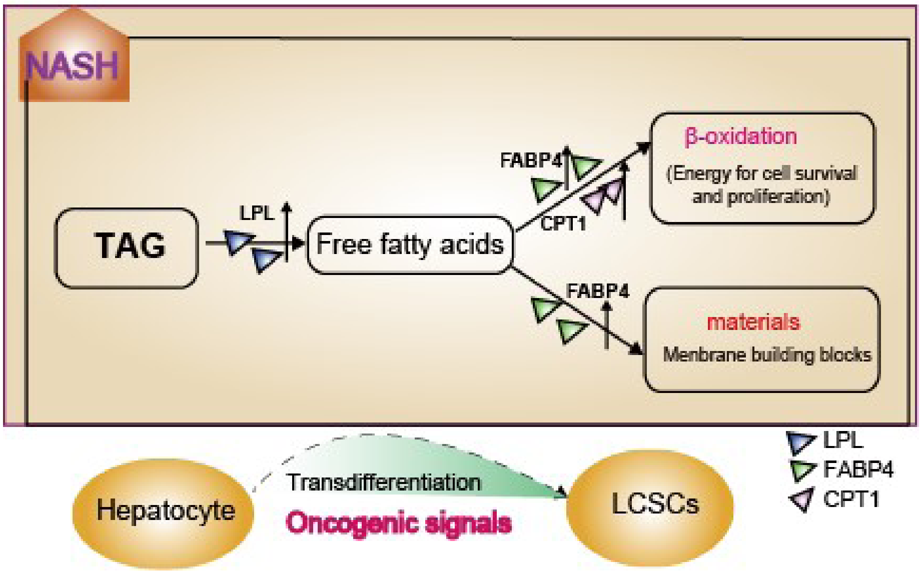
Fatty liver, just as its name suggests, is a common disease marked by an excessive accumulation of fat in liver cells.

There are two categories of fatty liver disease; non-alcoholic fatty liver disease (NAFLD) is the one the team explored. Gradually becoming the main type of fatty liver disease, the non-alcoholic variety may progress stage by stage, eventually reaching the key stage of non-alcoholic steatohepatitis, usually called NASH, which may then turn into liver cancer.

The team was curious about that last development. They planned to conduct a study to reveal the mechanism of how non-alcoholic steatohepatitis progresses to liver cancer.

Their work began with a mouse model that mimics the development of human fatty liver disease and enables study of changes in gene expression information that occur at various stages in the progression of NAFLD.

In each stage of the disease, they conducted deeper analysis on gene differential expressions and gene set variations, finding that carcinogenic signals were extensively activated during NASH. They also found that fatty acid metabolism was specifically regulated and increased by the LPL/FABP4/CPT1 signal axis. The two may work together to promote tumor-initiating cell formation and begin malignant transformation.



Model diagram: In the NASH stage, a variety of oncogenic signals and the fatty acid metabolism signal axis are activated in concert, which is conducive to the formation of tumor stem cells and malignant transformation. [IMAGE: LIU YU]

Based on these analyses, the team conducted further laboratory studies, which showed that inhibition of the LPL/FABP4/CPT1 signaling axis effectively inhibited liver tumor growth in vivo.

In addition, in vitro cell experiments also confirmed that targeted inhibition of the metabolic axis significantly reduced the self-renewal and proliferation capacity of liver cancer stem cells.

The team believes that inhibition of the fatty acid metabolic signaling axis may prevent NAFLD from transforming into liver cancer, shedding new light on prevention of NASH-related liver cancer.

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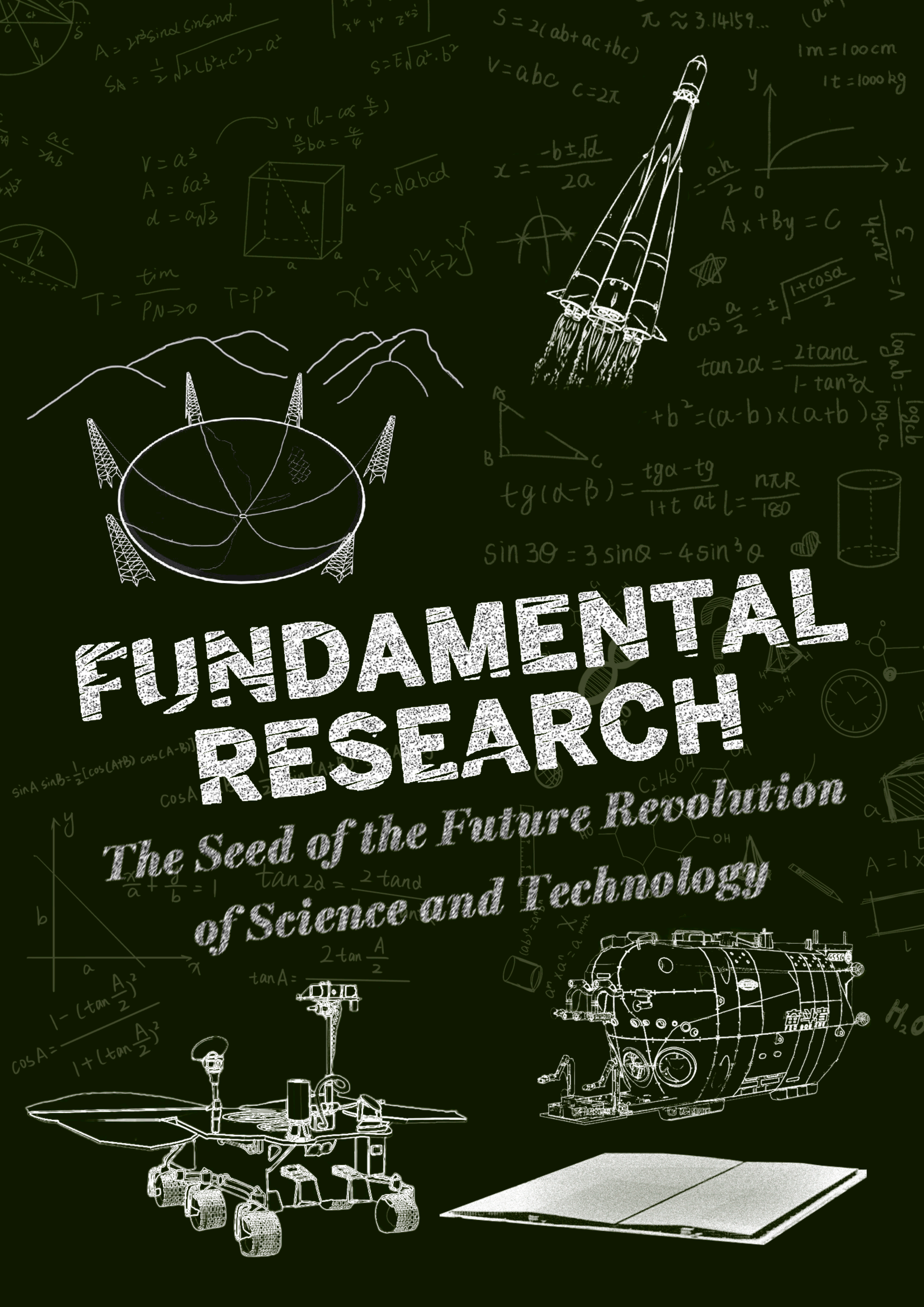
Hefei Institutes of Physical Science (HFIPS),
Chinese Academy of Sciences

Source: Institute of Health and Medical Technology,
Hefei Institutes of Physical Science (HFIPS),
Chinese Academy of Sciences


FUNDAMENTAL RESEARCH
The Seed of the Future Revolution of Science and Technology

Celebrating 30 years of international collaboration

An international partnership between Scotland and China, forged to fight biodiversity loss, is celebrating its 30th anniversary.

For many decades, scientists from the Royal Botanic Garden Edinburgh (RBGE) and the Kunming Institute of Botany (KIB) of the Chinese Academy of Sciences (CAS), have been working together to understand, record and conserve plant diversity, a relationship which was put on a formal footing by a twinning agreement in 1991.

Professor Pete Hollingsworth, Director of Science at RBGE said "At a time when the natural world is under extreme pressure and 40 percent of plant species are under threat, this kind of international collaboration has never been more important."

"By combining the resources and expertise of both institutes, we have been able to achieve much more than would have been possible on our own, and I look forward to working ever more closely with colleagues in the years ahead."

Professor Li Dezhu at KIB emphasized that "The twinning between KIB and RBGE has been a great success, from the updating of English and Chinese flora to the conservation of wild species in Southwest China and the Himalayas, as well as from staff exchanges to student training.

"As the primary producers of the ecosystems on Earth, plants are central to many nature-based solutions, particularly in the face of climate change. Working together we can provide more such solutions."

RBGE's relationship with China began in the early 20th century when iconic species such as rhododendrons were collected then grown back in Scotland. Now, RBGE's collection of Chinese plants — reputedly the largest outside of China — attracts international researchers, including Chinese botanists, and demonstrates the amazing diversity of flora in the country.

Today, the collaboration with the Kunming Institute of Botany includes science, horticulture and education, and spans studies at scales ranging from studying biodiversity from space using satellite imagery to understanding biodiversity through the optics of DNA.

The Lijiang Alpine Botanic Garden and the Jade Dragon Field Station on Jade Dragon Snow Mountain (or Yulong Xueshan) in China's Yunnan Province were opened 20 years ago in 2001 and designated as the UK and China's first joint scientific laboratory in 2005. They provide a base from where horticulturists and scientists from Edinburgh and China can study the diverse flora of China.

MoU signing ceremony in 1991 [IMAGE: KIB]

Cutting-edge DNA-barcoding work, led by Professor Hollingsworth and Professor Li, is helping researchers to differentiate between plant species more accurately, the first step in recording and conserving species under threat of extinction.

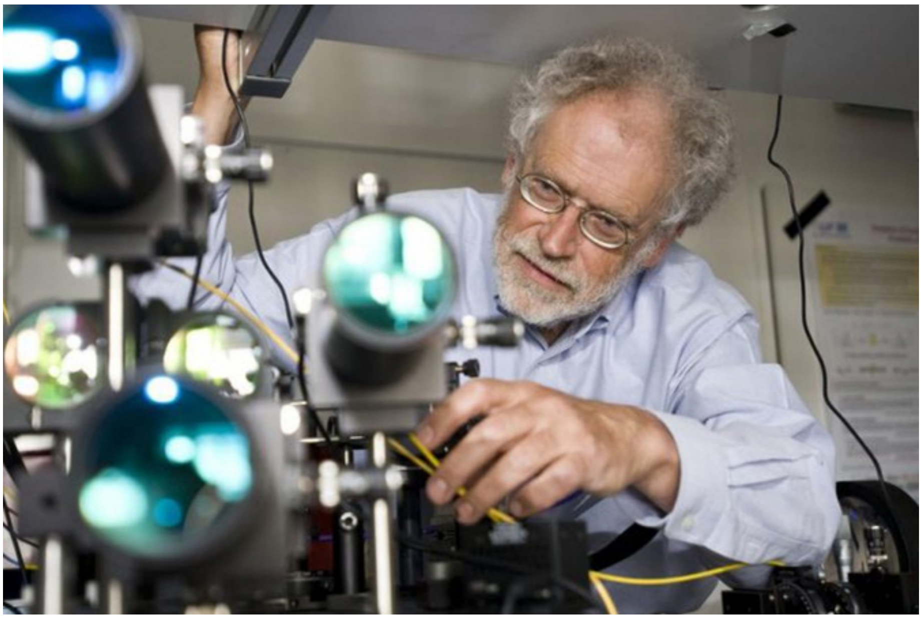
Ground-breaking work carried out by RBGE's Dr. Antje Ahrends and KIB's Professor Xu Jianchu uses remote sensing and satellite technology to quantify and assess the rate of deforestation for the sake of rubber plantations and the success of afforestation programs.

A joint horticultural training program provides a rare opportunity for horticultural staff in both Edinburgh and Kunming to discuss and learn new skills from each other.

COP26, held in Glasgow in November 2021, focused global attention on the climate emergency. In April 2022, global attention will move to COP15 in Kunming and focus on the closely related and equally urgent challenge of the biodiversity crisis. The joint work of RBGE and KIB on biodiversity characterization and conservation is fully aligned to the aims of COP15, and joint events will celebrate the partnership and share biodiversity knowledge. They will include a planned conference and training course on the use of genetic technologies to understand biodiversity, and a workshop on biodiversity and environmental change to celebrate the 20th anniversary of the opening of the Jade Dragon Field Station.

Source: Royal Botanic Garden Edinburgh

Anton Zeilinger: building a teleportation bridge between China and Austria



Dr. Anton Zeilinger has been Einstein Chair Professor of the University of Science and Technology of China (USTC) since 2016. An esteemed physicist, he is the president of the Austrian Academy of Sciences, and a foreign academician of the Chinese Academy of Sciences (CAS) and of the US National Academy of Sciences (NAS). He is a pioneer and trailblazer in quantum physics and quantum information. Dr. Zeilinger has received numerous international prizes and awards for his outstanding contributions to the foundations of quantum physics, including the Wolf Prize in Physics, the International Quantum Communication Award, the inaugural Isaac Newton Medal, the Descartes Prize, and the Micius Quantum Prize.

In 2017, a research team led by Dr. Zeilinger took part in the intercontinental quantum communication experiment based on the Micius Quantum Experiment Science Satellite (QUESS) as a trusted relay. They constructed a secure and stable quantum communication spanning 4,600 km between Beijing and Vienna for the first time in history. This achievement was selected as a "Highlight of the Year" in 2018 in physics by the American Physical Society (APS). In 2019, he cooperated with professors from the USTC to build the first teleportation of a high-dimensional quantum system in the world, which was widely recognized by global academia.

Dr. Zeilinger has long been engaged in talent cultivation and international scientific research cooperation between China and Austria. He devotes great efforts to the development and future of young scholars, including a group of outstanding young Chinese scientists. Dr. Zeilinger has helped them make prominent contributions to the related scientific fields and co-published more than 60 papers in prestigious international peer-reviewed journals.

Dr. Zeilinger has given multiple lectures on quantum frontiers at the Forum of Great Minds and the "Micius Salon" at USTC. His talks have encouraged students to devote themselves to quantum scientific research. He promotes China-Austria international academic collaboration, and strengthens the international academic exchanges of young researchers from both countries. He has been working closely with the Chinese Academy of Sciences (CAS) since 1983, organizing the Conference of the World Academy of Sciences that was attended by Bai Chunli, then president of CAS, and other academicians. His actions have greatly promoted cooperation and exchange between Chinese scientific researchers and the world.

His outstanding contributions to international cooperation between China and other countries earned him the 2020 Chinese Government Friendship Award.

The ceremony of the Friendship Award for 2020 and 2021 was held at the Great Hall of the People on September 30. Chinese Premier Li Keqiang met all the 100 foreign experts who won the 2020 and 2021 Friendship Award, including Dr. Zeilinger, congratulated them on their achievements and highly praised their contributions to promoting Sino-foreign cooperation and talent cultivation in China.

The Friendship Award is the highest award given by the Chinese government to commend foreign experts who have made prominent contributions to China modernization. It recognizes about 50 winners every year. The 100 foreign experts who won the 2020 and 2021 award come from 32 countries. Almost 1,800 foreign experts have won the award since its inception in 1991, including six from USTC.

Source: Chinese Academy of Sciences

ISSAS marks World Soil Day

The Institute of Soil Science of the Chinese Academy of Sciences (ISSAS) recently held a group of activities with the Soil Science Society of China and the Soil Science Society of Jiangsu Province to welcome this year's World Soil Day (WSD).

The ISSAS publicized knowledge about soil through lectures and fun experiments, aiming to raise public awareness about soil protection and inspire people's interest in science.

A minor planet was named after the institute on December 5, which was one of the most important celebrations of this year's WSD, and received widespread attention from peers at home and abroad.

In December 2013, the UN General Assembly designated December 5, 2014 as the first World Soil Day. This year's WSD theme was "Halt soil salinization, boost soil productivity".

Source: Chinese Academy of Sciences