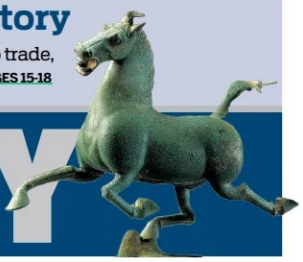
A fresh taste
City in Yunnan famous for tea is winning fans with its coffee
BUSINESS. PAGE 13

'Deals reached' on Black Sea shipping route
WORLD. PAGE 11

Passage to history
Hexi Corridor a key witness to trade, cultural bonds TALES &TRAILS. PAGES 15-18



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SPACE STATION PROVIDING UNIQUE ENVIRONMENT FOR RESEARCH FIRSTS

China has equipped Tiangong to seek multiple scientific, medical, other breakthroughs

By YAN DONGJIE
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indepth

With microgravity and cosmic radiation, the unique environment in space poses risks to human health and also vast opportunities for medical and scientific research breakthroughs, experts said.

This issue was highlighted recently when two NASA astronauts stranded aboard the International Space Station for nine months appeared haggard and thin upon their return to Earth.

Human activities such as movement and sleep are affected by such a lengthy period in space. The potential health issues astronauts face are ongoing challenges for long-term manned space missions that are being addressed by Chinese experts.

"Muscle atrophy is one of the significant physiological changes in a microgravity environment," said Li Yuying, an associate researcher at the Shanghai Institute of Nutrition and Health of the Chinese Academy of Sciences.

*See **Space station,** page 2*

PAGE TWO

Left: The Shenzhou XIX crew on board China's space station conduct an experiment on artificial photosynthesis for extraterrestrial survival. **Middle:** This screen image on Mar 21 shows Shenzhou XIX astronauts Cai Xuzhe (right) and Song Lingdong preparing for extravehicular activities inside the airlock cabin of China's space station. **Right:** Shenzhou XIX astronaut Wang Haoze works inside the station. PHOTOS BY XINHUA

Space station: Unveiling pioneering research

From page 1

Li said that understanding the mechanisms behind these changes and finding solutions to mitigate them can eventually contribute to medical fields affected by similar conditions on Earth.

China established its own space station system after the launch of the Tianhe core module in April 2021, followed by the Wentian and Mengtian laboratory modules in 2022, with multiple manned and cargo missions.

In November 2022, Li's research team sent mouse muscle cell samples to Tiangong, China's operational space station, via the Tianzhou 5 cargo spacecraft.

In the Wentian module's biotechnology experiment cabinet, they successfully cultured and differentiated muscle cells, discovering phenomena such as cell fusion and muscle fiber formation in microgravity for the first time. The team also identified the gene responsible for autophagy, the body's cell recycling system, under these conditions.

"We were the first to use a skeletal muscle cell autophagy fluorescence reporting system to analyze the effects of space microgravity on muscle cell autophagy. This led to discovering the mechanisms and potential molecular targets related to muscle atrophy in space," Li explained.

This research holds the prospect of improving astronaut health by regulating autophagy through specific drugs, dietary adjustments, or exercise.

"The findings could also be applied to patients with sarcopenia (loss of muscle mass) and those bedridden for extended periods on Earth, providing new solutions to combat muscle atrophy," she added.

Research platform

The unique conditions on the space station are invaluable for addressing important scientific and practical problems across various disciplines, said Gu Yidong, chief scientist at the China Manned Space Agency.

The Chinese space station will conduct over 1,000 research projects over the next 10 to 15 years, the Technology and Engineering Center for Space Utilization under the Chinese Academy of Sciences announced in January.

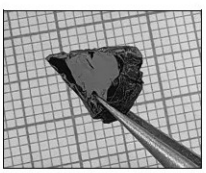
These efforts will include deepening research into basic biology, biotechnology and transformation, life ecology, and the origin of life, the center said.

Gu said the space station also offers a platform for breakthrough experiments in new space technologies.

"Nearly 100 academicians from the CAS and thousands of experts collaborated to plan the station's research projects, covering fields such as space life sciences, human studies, microgravity physical sciences, space astronomy and new space technologies," Gu stated.

The establishment of China's space station system, Gu said, "is the result of 30 years of hard work by multiple generations, representing a monumental stride in China's space endeavors and a historic opportunity for large-scale space science, technology, and application research.

"Space science paves the way for significant discoveries, new major scientific principles, and notable practical benefits."



A space-grown Indium Selenide semiconductor crystal sample.

Fully equipped

The space station is equipped with over 20 internal scientific experiment cabinets and three external experiment platforms. Major research tools, such as the two-meter aperture China Space Station Telescope, are under development, offering experimental platforms to scientists across various fields.

In addition to the research projects, the space station will "heavily promote scientific outreach and international cooperation", Gu said.

Scientists have already conducted pioneering experiments on the space station, such as obtaining new rice germplasm resources, differentiating embryonic stem cells into hematopoietic cells, and achieving the longest-running space aquatic ecosystem.

Since its inception, the space station has launched eight manned missions and seven cargo missions, hosted 21 astronauts and achieved a stable space living environment, according to a report released by China Manned Space Agency at the end of last year.

According to data from the CAS, over 180 science and application projects have been conducted on the space station, generating more than 265 terabytes of scientific data, over 150 patents, and several results have been transferred and applied.

Critical technologies

Researchers Liu Xuechao from the Shanghai Institute of Ceramics, and Jin Min from the Shanghai Dianji University, have made significant progress in research into new semiconductor materials through the space station's facilities.

"Semiconductor materials play an irreplaceable role in fields such as integrated circuits, communications, photovoltaics, and aerospace," Liu said.

"Space semiconductor crystal growth has been a major focus worldwide. Space station research supports the breakthrough of critical technologies on Earth."

The performance and structure of semiconductor materials are closely linked to their environment and manufacturing conditions, Liu said. Earth's gravity causes convection, sedimentation and wall effects during material preparation, impacting nucleation, thermal mass transport, and microstructures while masking secondary effects.

Professor Jin's team discovered that Indium Selenide (InSe), a flexible semiconductor material that can bend, twist, and compress without breaking, is suitable for flexible thermoelectric devices.

"InSe semiconductor crystals not only possess excellent physical properties typical of traditional semiconductors, but can also undergo plastic deformation and mechanical processing like metals. This provides a new path for designing and applying next-gen electronic devices," Liu explained.

He added that InSe also shows vast potential for use in photovoltaics, optoelectronic devices, and photodetectors.

After 70 hours in the high-temperature materials science cabinet, Liu's team obtained a complete semiconductor crystal sample. Upon returning to Earth in June 2023, they found the material had swelled under microgravity, indicating potential expansions.

The space-grown samples exhibited significantly lower density defects compared with ground-based samples, with almost zero defects in areas not in contact with container walls.

"This breakthrough expands development opportunities substantially, promising improved transistor performance," Liu said. "Our future studies will build on this sample, aiming for commercial production of this semiconductor material soon."

Researchers examine space station experiment samples brought back by the Shenzhou XVIII spacecraft at the Technology and Engineering Center for Space Utilization under the Chinese Academy of Sciences in Beijing on Nov 4. TECHNOLOGY AND ENGINEERING CENTER FOR SPACE UTILIZATION / VIA XINHUA

Zebrafish, grain experiments answer cosmic questions

By YAN DONGJIE

On China's space station orbiting 400 kilometers above Earth, scientists are conducting a series of astounding laboratory experiments.

From zebrafish that lay eggs to rice that completes an entire life cycle, to fruit flies performing acrobatics, these fascinating space research projects are providing crucial clues for humanity in exploring the mysteries of life.

In April last year, four zebrafish measuring about three centimeters were brought aboard the Chinese Space Station by the Shenzhou XVIII crew.

In the "Tiangong Aquarium" ecosystem, four grams of hornwort, a fast-growing aquatic plant that can oxygenate water, were added. Over 43 days in orbit, the zebrafish not only swam freely but also naturally spawned in the space environment, according to the Chinese Academy of Sciences.

This marked the first time China had established a self-sustaining aquatic ecosystem in space, with a closed loop of carbon dioxide exhaled by the fish and oxygen released by the plants. The 43 days also surpassed the previous record of 30 days set by the International Space Station's aquatic system, said researcher Wang Gaohong from the Institute of Hydrobiology under the CAS.

"These three-centimeter-long fish are crucial for verifying vertebrate survival capabilities in space," he said.

"Zebrafish were chosen not only because their genome shares over 70 percent similarity with humans, but also due to their rapid reproduction rate," Wang explained.

Scientists are studying the effects of microgravity on vertebrate bones and muscles through the swimming posture and movement trajectories of the fish.

The second phase of the experiment, set to start this year, will be expanded to consist of six zebrafish and six grams of hornwort.

Scientists plan to later dissect the fish samples on Earth to focus on the effects of microgravity on protein metabolism. These experiments are essential not only for astronauts' health, but also for potentially developing new treatments for osteoporosis on Earth, Wang said.

In the plant cultivation cabinet of the *Wentian* module, rice research completed a 120-day life cycle and achieved the first cultivation of space-regenerated rice.

Since the experiment began in 2022, scientists have overcome challenges like pollination and grain filling in microgravity. Space-grown rice exhibits unique characteristics — more upright leaves and fewer grains per spike, yet the grains are fuller, said Wang Lihua, a researcher at the CAS Center for Excellence in Molecular Plant Sciences.

Excitingly, the space rice seeds have successfully propagated to a third generation on Earth, proving that cosmic radiation has not affected their genetic stability.

The research team is exploring cutting and regrowing techniques beyond traditional planting methods — harvesting the first batch and allowing the stubble to regrow.

Remarkably, space-regrown rice produces new spikes in only 45 days, reducing the cycle by one-third compared to on Earth. This "one sowing, multiple harvests" approach can increase space planting efficiency by half, offering a new perspective on food production for future lunar bases.

By comparing gene data from space and Earth, scientists have identified over 20 molecular switches regulating flowering.

"It's like equipping plants with a biological clock regulator, enabling us to potentially design space rice that delays flowering to continuously produce more food during long-term missions," Wang explained.

Furthermore, in granular vibration experiments, researcher Hou Meiying from the Institute of Physics under the CAS observed movement that defies conventional knowledge. When a container with mixed grains vibrates under microgravity, larger grains sink instead of rising, a phenomenon named the anti-Brazil nut effect.

This discovery explains the unexpected sinking incidents lunar rovers encounter on the moon's surface and provides crucial data for designing future extraterrestrial exploration vehicles, CAS scientists said.

In November, fruit flies aboard the space station had already reproduced three generations in space. These tiny insects exhibited unique "space dance" behaviors in the weightless environment — floating and tumbling instead of crawling or flying, completing courtship and mating activities, the scientists said.

By analyzing over four terabytes of surveillance video, Chinese scientists are using artificial intelligence to decode the adaptive mechanisms behind these behavioral changes, said researcher Li Yan from the CAS.

Over the next decade, more than 1,000 research projects, including space breeding of mice and the synthesis of cosmic materials, will take place.

"Each piece of data we accumulate now is paving the way for humanity to step out of Earth's cradle," said CAS researcher Zhang Wei.