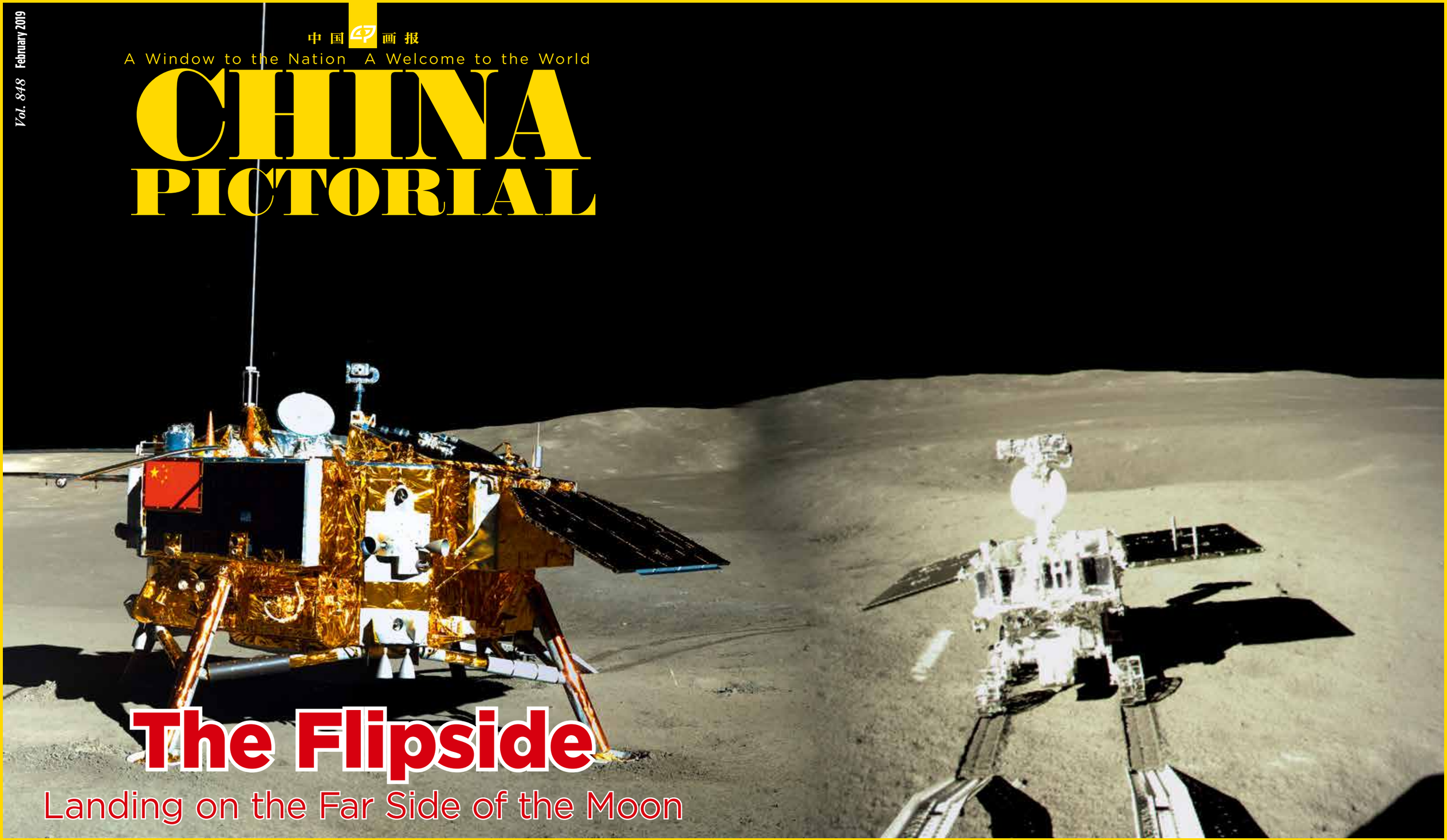
Vol. 848 February 2019

中国画报
A Window to the Nation A Welcome to the World

CHINA PICTORIAL



The Flipside

Landing on the Far Side of the Moon

邮发代号2-903 CN11-1429/Z

国内零售价： 10元
USA $5.10 UK £3.20
Australia $9.10 Europe €5.20
Canada $7.80 Turkey TL.10.00

ISSN 0009-4420

Left: A photo taken by the Yutu-2 rover on January 11, 2019 shows the Chang'e-4 lander. With the assistance of the Queqiao relay satellite, the Yutu-2 rover and the lander of the Chang'e-4 probe took photos of each other. courtesy of China National Space Administration

Right: The Yutu-2 rover. The rover left its first-ever "footprint" on the far side of the moon late on January 3, 2019. It had separated smoothly from the lander of the Chang'e-4 probe, which touched down on the South Pole-Aitken Basin on the far side of the moon earlier that day. courtesy of China National Space Administration and China's State Administration of Science, Technology and Industry for National Defence

CHANG'E-4

EXPLORE THE MOON

冷处偏佳 / 别有根芽

An illustration shows the lander of the Chang'e-4 probe being awakened by sunlight on January 30, 2019 after a long "sleep" during the first extremely cold night on the moon. The lander measured the temperatures on the surface of the moon during the lunar night. by Tan Hao

塞罕坝

牢记使命 艰苦创业 绿色发展

半个多世纪，三代人耕耘。
沙地变林海，荒原成绿洲。
寒来暑往，
塞罕坝机械林场的森林覆盖率
已达80%，
栽种树木按1米株距排开，
可绕地球赤道12圈。

Saihanba is a cold alpine area in northern Hebei Province bordering the Inner Mongolia Autonomous Region.
It was once a barren land but is now home to 75,000 hectares of forest, thanks to the labor of generations of forestry workers in the past 55 years.
Every year the forest purifies 137 million cubic meters of water and absorbs 747,000 tons of carbon dioxide.
The forest produces 12 billion yuan (around US$1.8 billion) of ecological value annually, according to the Chinese Academy of Forestry.

CHINA PICTORIAL

Feb 2019

Administrative Agency: China International Publishing Group
主管：中国外文出版发行事业局（中国国际出版集团）

Publisher: China Pictorial Publications
主办：人民画报社

Address: 33 Chegongzhuang Xilu, Haidian, Beijing 100048
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设计：利雅法盛

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Remittance to: Publishing and Distribution Department, China Pictorial
邮购收款人：人民画报社出版发行部

Legal Adviser: Yue Cheng
法律顾问：岳　成

Printing: Toppan Leefung Changcheng Printing (Beijing) Co., Ltd.
印刷：北京利丰雅高长城印刷有限公司

Overseas Distribution:
China International Book Trading Corporation (Guoji Shudian),
35 Chegongzhuang Xilu,
P.o. Box 399, Beijing 100044, China
Telephone: 86-10-68413849
Fax: 86-10-68412166
China Book Trading (Canada) Inc.
Telephone: 1-416-497-8096

出版日期 每月1日
国内刊号：CN11-1429/Z
国际刊号：ISSN0009-4420
京海工商广字第0121号

In China, subscriptions are available at any post office.

Subscription and distribution agency in Hong Kong, Macao, and Taiwan:
Hong Kong Peace Book Company, Ltd.
17/F., Paramount Building, 12 Ka Yip Street, Chai Wan, Hong Kong

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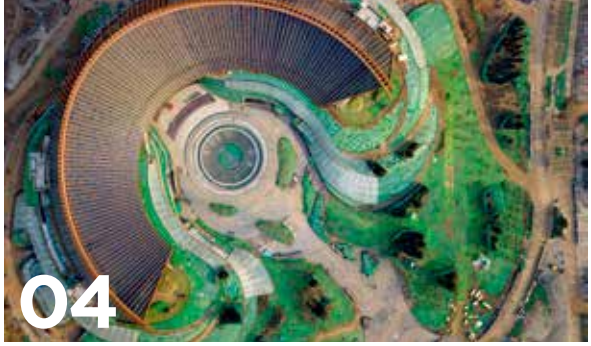
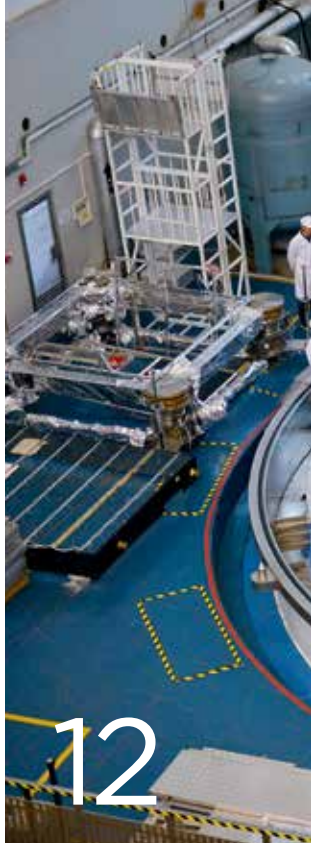




Features

by Xie Huanchi/Xinhua

Spotlight on Innovation

January 8, Beijing: President Xi Jinping (center) presents China's top science award to radar expert Liu Yongtan (right) and defense engineer Qian Qihu for their outstanding contributions to scientific and technological innovation. A total of 278 science projects and seven experts, including five foreigners, were recognized with the national science award this year.

by Zhang Chenlin/Xinhua

100-Day Countdown Starts

January 11, Beijing: The China Pavilion under construction ahead of the International Horticultural Exhibition 2019 Beijing in Yanqing District. January 19 marked the start of a 100-day countdown to the expo. More than 110 countries and international organizations have confirmed participation in the expo, making it the highest-attended in the global event's history. From April 29 to October 7, the 162-day expo will exhibit the latest achievements in floriculture and gardening.

VCG

Trump's Fast-food Feast

January 14, Washington, United States: The Clemson University football team is served fast food when they visit the White House to celebrate their national championship. The partial U.S. government shutdown left much of the White House staff furloughed because funding for parts of the White House operations lapsed. The shutdown over funding for President Donald Trump's border wall began on December 22, 2018. The U.S. federal government reopened on January 25 after President Trump signed a bill to fund the government for three weeks, ending the unprecedented 35-day-long shutdown.

Tesla Gigafactory

January 7, Shanghai: Tesla CEO Elon Musk speaks at the groundbreaking ceremony of the Tesla Shanghai Gigafactory as the U.S. electric carmaker became the first to benefit from a new policy allowing foreign carmakers to set up wholly owned subsidiaries in China. Production at the Shanghai plant will help Tesla significantly lower its cost and prices, giving it an edge in market competition.

VCG

by Qin Bin

Back to Class

January 13, Sanya, Hainan Province: Alibaba Chairman Jack Ma shares his insights on child development and education with the teachers during a session of the Jack Ma Rural Teacher Award Ceremony. The two-day event recognized 101 teachers and 20 headmasters for their outstanding service in some of China's most-impoverished and disadvantaged areas. Ma has awarded this prize to rural teachers every year in Sanya since 2015.

Homage to Yellow Emperor

December 31, 2018, Huangling County, Shaanxi Province: A grand ceremony to pay homage to Huangdi, or the Yellow Emperor, who is regarded as one of the common ancestors of the Chinese nation, is held at the Mausoleum of Huangdi. Many overseas Chinese representatives and community leaders from more than 50 countries around the world, as well as people from across China, welcomed the New Year of 2019 by honoring the figure together.

Shaanxi Pictorial

World Economy 2019
Hopes and Worries

Text by Yang Changyong

The current world economy is characterized by disjointed dynamics, widening gaps, increasing risks of slowdown and accelerated policy adjustments. Plagued by uncertainty and instability, the world economy is expected to maintain weak growth momentum.

The year 2018 marked the 10th anniversary of the breakout of global financial crisis and represented a turning point in world economic patterns towards major development, transformation and adjustment. Some significant events last year will exert far-reaching influence on world economic trends and the process of globalization in areas such as technology, infrastructure and regulation.

It is particularly noteworthy that the United States is luring or forcing global capital to flow into the country through a policy mix of "monetary policy normalization + protectionism + high standardization of rules" to strengthen the "unified front" of advanced economies based on new rules. Meanwhile, it is placing a dual pressure of "capital outflow + marginalization of rules" on developing countries. Overall, the present world economy is characterized by increasingly disjointed dynamics, widening gaps, increasing risks of slowdown and accelerated policy adjustments. Facing greater uncertainty and instability, the world economy is expected to maintain weak growth momentum at best.

Advanced economies including the United States suffered a decreased growth rate, which may drag down the world economy in 2019. Additionally, the impact of U.S. protectionism on its economy will further grow in 2019. The IMF forecasted that in 2019, the average growth rate of developed economies would be 2.1 percent, 0.3 percentage points lower than that of 2018, and specifically, the growth rate of the United States would be 2.5 percent, 0.4 percentage points down compared with the previous year.

At the same time, the risk of a downturn in the world economy might increase. For starters, the negative impact of U.S. protectionism will continue to grow. According to the IMF, after an evident drop in 2018, the growth rate of global cargo exports will fall further to 3.76 percent. The U.S. Federal Reserve continues to raise interest rates, which might push U.S. monetary policy into a tightening range. In December 2018, the U.S. Federal Open Market Committee predicted that the median federal funds rate for 2019 would reach 2.9 percent, exceeding the long-term neutral rate of 2.8 percent. This means that although the Federal Reserve raised interest rates and shrank the balance sheets, the federal funds rate was still below the long-term neutral rate in the past, which evidenced that monetary policy did not fundamentally change its relaxed situation. But once the federal funds rate goes higher than the long-term neutral rate, the U.S. monetary policy will step into a real tightening situation, giving way to qualitative change of its influence on global liquidity. Additionally, the possibility of large-scale financial risk in emerging economies may rise. With more developing countries suffering from currency devaluation and greater capital outflow, the financial risk in emerging markets is evolving from singular to systematic. A major financial market crash in a few countries may trigger problems in many emerging markets. This possibility should not be ignored.

Considering the slowdown of world economic growth, rising protectionism and unilateralism and faster evolution of global trading rules, China is facing complicated and serious challenges from an external environment undergoing profound changes. In 2019, China will coordinate stabilization of growth, promote reform, adjust structure, improve people's livelihoods, prevent risk and maintain economic growth at a reasonable range. It will further stabilize employment, finance, foreign trade, foreign capital and investment and boost market confidence as well as increase people's senses of gains, happiness and security. And the country will maintain the healthy growth of economy and the stability of society, laying a solid foundation for building a moderately prosperous society in all respects and preparing to welcome the 70th anniversary of the founding of the People's Republic of China.

The author is an associate research fellow at the Institute of Foreign Economics under the Chinese Academy of Macroeconomic Research.

Lessons from Forty Years of China-U.S. Ties

Text by Yuan Youwei

The China-U.S. relationship hasn't always been smooth, but it has consistently overcome disagreements to continue improving.

October 15, 2018: Chinese and American experts discuss China's economy and China-U.S. relations at a forum held at John F. Kennedy School of Government. by Wang Ying/Xinhua

On January 1, 1979, China and the United States formally established diplomatic ties at the ambassadorial level. After setbacks and improvements over 40 years, the depth and complexity of China-U.S. relations are greater than anyone could have imagined. Even former U.S. Secretary of State Henry Kissinger, who helped recover relations between the two countries, claimed that no one could imagine the depth of China-U.S. relations.

Over the past four decades, relations between the two countries have demonstrated three central characteristics: First, their bilateral relations haven't always been smooth, but improve while solving divergences. Second, when there is a need for strategic cooperation, the relationship is steady, but otherwise unstable. Third, during the periods when their relations are stable, outstanding divergences and contradictions still persist.

How have China-U.S. relations improved so much despite so many difficulties and setbacks? Many lessons can be learned from recent history that will be valuable for future interactions.

First, interactions between leaders of the two countries have played a key role. Leaders of both countries can view bilateral relations from a strategic and long-term prospective without being swayed by any specific incident. They have worked together to achieve long-term development of China-U.S. relations. Several years ago, when the two countries became more competitive with each other, President Xi Jinping and President Barack Obama innovated methods of communication. Through special informal talks such as the meeting at the Sunnylands estate and talks at Yingtai in Zhongnanhai and in the White House, Xi and Obama discussed a wide range of topics over a fairly long period of time. Good outcomes tend to come from discussions with a less serious tenor.

Second, the governments of the two countries can consider bilateral relations from a strategic prospective according to changes in the international situation, so that any single issue can't derail the entire relationship abruptly. As competition has become a bigger factor in China-U.S. relations, Chinese President Xi Jinping proposed building a new model of major-country relationship. When the United States launched a trade war against China, it was a severe blow to bilateral relations. On December 1, 2018, President Xi and President Trump held talks in Argentina, during which they reached consensus to propel the China-U.S. relationship based on coordination, cooperation and stability.

Third, trade is the cornerstone of China-U.S. relations. In contrast with relations between the United States and the former Soviet Union, China-U.S. trade relations are closely intertwined. Especially with the expansion of globalization, trade between China and the United States has become crucial for the entire world. Trump's trade war against China has caused a blow not only to China's economy, but also to the U.S. financial market, American farmers and the speed of global growth. All of these evidence the key role of trade in China-U.S. ties.

Last but not the least, the two sides have always sought to expand cooperation while controlling divergences. China and the United States are different in many aspects including ideology, social systems and culture, so it should be expected for bilateral relations to become contradictory and divergent at times. However, the two countries can always view their relationship from a strategic point of view. They are working to eliminate divergences, instead of ignoring them, to minimize misunderstandings. The two countries have strengthened cooperation at bilateral, regional and global levels.

The author is deputy director general of the Department of External Affairs at the China Center for International Economic Exchanges.

Crisis Meets Opportunity

The Next Step for Private Business in China

Text By Zhou Dewen

If Chinese private enterprises precisely adapt to changing market demand, actively adjust product mix and manage debt, a bright future awaits.

March 7, 2017: Workers test car performance on a production line of Geely Automobile in Ningbo City, Zhejiang Province. The Chinese automaker actively expanded international cooperation and sold more than 1.5 million cars in 2018, up by 20 percent year-on-year, despite a struggling domestic car market. VCG

Over the past decade, Chinese private companies have seen ups and downs. The global financial crisis in 2008 and the private-lending crisis in China in 2011 led to massive shutdowns. The country's supply-side structural reform, which kicked off in 2016 and lasts to this day, has weeded out many businesses that were using outdated technology, failing to add substantial value and lacking efficient production. Private enterprises that have endured the challenges to remain in operation have demonstrated substantial resilience.

China's private economy is composed quite differently compared to the past. Existing private companies are largely compliant with the government's policies on upgrading and improving industrial structure, riding the tide of national development plans such as "Made in China 2025." Hopefully these companies will continue to embrace government policies for a long time.

Although most private businesses in China are fine-tuned to meet demands for the country's long-term development and international industrial specialization, it is undeniable that some companies are suffering under increasingly intense market competition resulting from drastic changes in the international market and tightened financial policies at home.

Most major operational problems facing Chinese private enterprises fall into one of the two categories: inability to effectively meet consumer demand in the

market or a shortage of capital to sustain production and operations and seize a technological upgrade. The problems usually surface in the form of a debt crisis or a capital chain rupture when they become exacerbated.

How can Chinese private businesses seize new opportunities and kindle another boom amid enormous challenges at home and abroad? The following suggestions could help:

Cope with uncertainties caused by the prolonged China-U.S. trade conflict. China's private companies should actively adjust and optimize their product mix and, if possible, appropriately cut exports to the United States and prioritize orders from other markets to reduce dependence on the U.S. market and avoid the risk brought by China-U.S. trade conflict.

Control corporate debt. It is common for enterprises to operate with liabilities, but piling debt beyond ability always results in enormous pressure and risk. In this sense, private companies are not encouraged to expand their debt blindly for short-term orders or new projects without a sound evaluation to avoid risk of a capital chain rupture. Instead, the enterprises should operate within their financial capabilities and effectively control debt, so as to be better poised to seize future opportunities when they emerge.

Seek international opportunities. Cross-border acquisition costs have dropped thanks to the gloomy global economic outlook, which presents opportunities for private enterprises from China to acquire quality European and American companies. Advanced products and technology attained through acquisition can help the buyers gain competitiveness in the domestic market and meet demands for new products as domestic consumption upgrades. At the same time, cross-border acquisitions can benefit these companies by providing wider marketing channels to boost sales in overseas markets.

Facilitate a technological upgrade. When corporate resources allow, private enterprises should actively implement technological upgrade and improve their business structure through technological innovation. China's private companies have been encouraged to upgrade or rebuild operational and organizational processes to gain more competitiveness in domestic and overseas markets.

Adapt to technological waves. As science and technology advance day by day, complete industrial chains transform accordingly. Private enterprises should

December 27, 2018: A workshop of the Starlight printing company in Suzhou City, Jiangsu Province produces greeting cards to be exported to the United States and Europe. Over the past two years, the company has invested more than 30 million yuan (US$4.5 million) in technical innovation and intelligent facilities, aiming to make half of its production process automated by 2020. VCG

Stuffed toys produced in two factories in Laopo Village of Zaozhuang City, Shandong Province are exported to more than 20 countries and regions including Spain and the United States. This photo shows one of their workshops. VCG

April 18, 2017: A worker builds supporting sticks for newly planted *Lycium chinensis* seeds in a demonstration area for photovoltaic power stations in Yinchuan City, Ningxia Hui Autonomous Region. The area was funded by a local private enterprise to promote complementary agriculture to accompany solar power generation. VCG

follow technological progress related to their operations, reserve a pool of talent and technology, precisely identify market demand resulting from the consumption upgrade and provide products and services consistent with the latest trends at the right time.

Seize opportunities from urbanization. China's demographic structure has been transforming as increasing numbers of rural residents become urban residents. The growing population in cities and towns has certainly led to market expansion and upgrade. The new urban population is embracing drastic changes in living conditions. Traditionally, much of their means of livelihood were self-produced and self-consumed, but now the demand is met by the market. This process is bound to impact China's economic dynamics profoundly. Private businesses are most intimately aware of the changing demand in urban markets. And private companies will find new growth engines to promote long-term development if they manage to understand the huge underlying opportunities.

In confronting many challenges, Chinese private enterprises have demonstrated far more vigor and cemented more solid bases since the international financial crisis in 2008. The "new generation" of private entrepreneurs, born in the 1970s and 1980s, has now become the major force of business. Most of them are well-educated and armed with modern corporate managerial knowledge. Many studied overseas in the United States or Europe, sharply contrasting the older generation of Chinese private entrepreneurs who thrived with considerably less education. Furthermore, the younger entrepreneurs are the first generation to absorb the impact of new technologies such as the internet so they are more adaptive to new things. Their international vision helps them gain competition advantages.

Facing unfavorable conditions at home and abroad, private businesses in China are encountering difficulties of differing degrees yet great opportunities for development remain. If Chinese private enterprises carefully adapt to changing market demand, actively adjust product mix and manage debt, a bright future awaits.

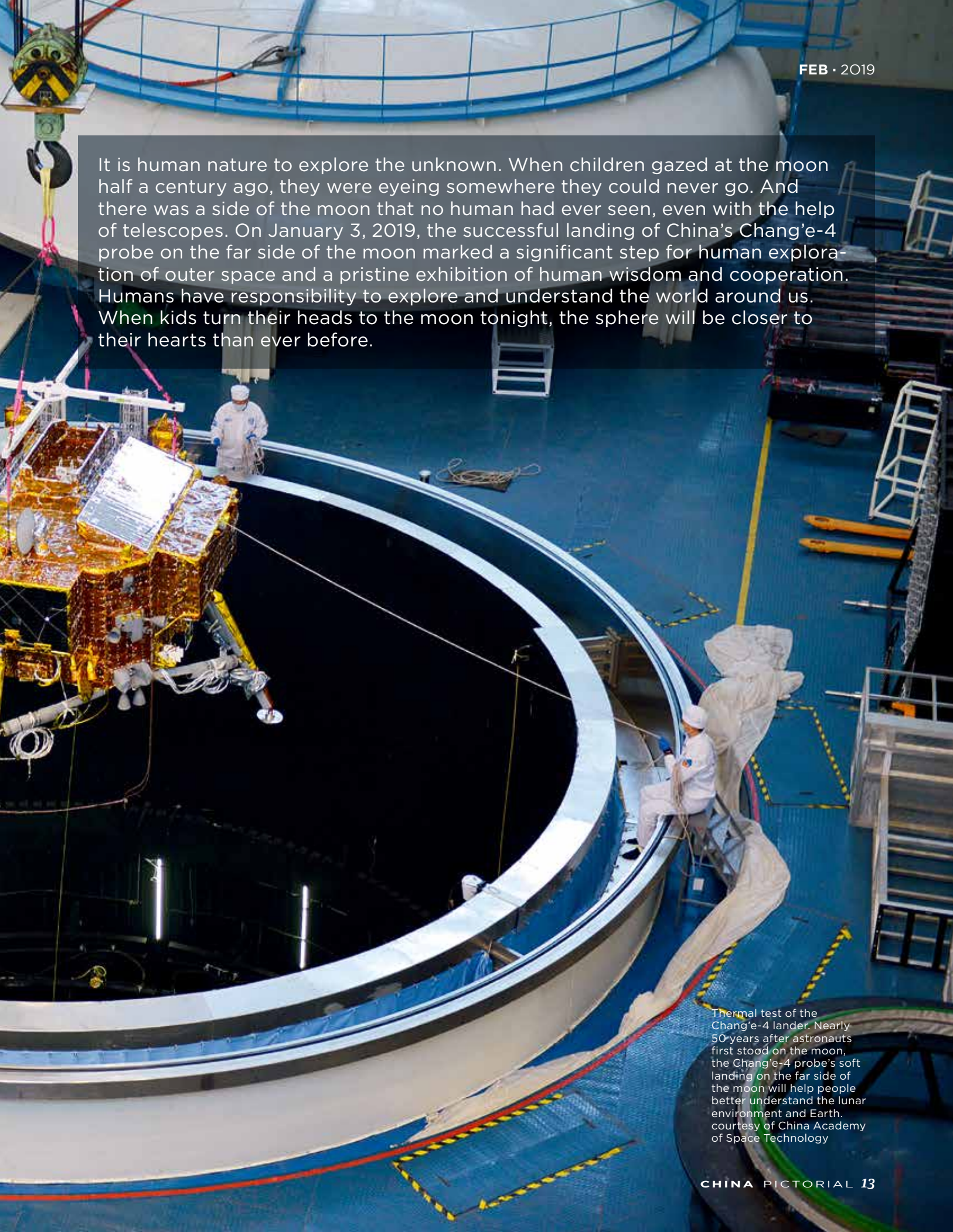
The author is vice director of the Economic Commission of the Central Committee of the China Association for Promoting Democracy (CAPD), one of China's non-Communist parties. He also serves as head of the Institute for China's Industry and Finance Integration Studies and chairman of the Federation of Private Investment Enterprises in Zhejiang.

The Flipside

—Landing on the Far Side of the Moon

Concept by *China Pictorial*

It is human nature to explore the unknown. When children gazed at the moon half a century ago, they were eyeing somewhere they could never go. And there was a side of the moon that no human had ever seen, even with the help of telescopes. On January 3, 2019, the successful landing of China's Chang'e-4 probe on the far side of the moon marked a significant step for human exploration of outer space and a pristine exhibition of human wisdom and cooperation. Humans have responsibility to explore and understand the world around us. When kids turn their heads to the moon tonight, the sphere will be closer to their hearts than ever before.



Thermal test of the Chang'e-4 lander. Nearly 50 years after astronauts first stood on the moon, the Chang'e-4 probe's soft landing on the far side of the moon will help people better understand the lunar environment and Earth. courtesy of China Academy of Space Technology

Chang'e-4 Lonely Landing

Edited by Zhao Yue

Chang'e-4, China's lunar probe, has completed the first soft landing on the far side of the moon. The touchdown represented one small step for a Chinese probe and one giant leap for mankind's space exploration.

Since ancient times, Chinese people have aspired to explore the moon. According to a fairy tale known throughout China, the moon is inhabited by Chang'e, a woman who drank an immortality elixir and ascended to heaven as a goddess. She is accompanied by the Jade Rabbit, who persistently grinds medicine in a mortar, and a 1,600-meter-tall laurel tree that can never be cut down.

In 2004, after more than a decade of research and planning, China's lunar exploration program was officially launched. Chinese scientists romantically named the program after the goddess of the moon and its lunar rover Yutu (Jade Rabbit), the pet of the goddess Chang'e. Since then, several Chang'e missions have been completed, evidencing an increasingly accelerated pace of Chinese exploration of the moon. Chang'e-1, Chang'e-2 and Chang'e-3 lunar probes were successfully launched in 2007, 2010 and 2013, respectively, all of which accomplished their missions. In December 2017, China announced plans to complete the Chang'e-4 mission through two launches in 2018: It would launch the Queqiao (Magpie Bridge) relay satellite in the first half of the year and the Chang'e-4 probe in the second half.

On May 21, 2018, a Long March 4C rocket carrying the Queqiao relay satellite blasted off from Xichang Satellite Launch Center in southwestern China's Sichuan Province.

A panoramic photo of the moon's far side taken by a camera installed on the top of the Chang'e-4 lander (azimuthal projection). courtesy of China National Space Administration

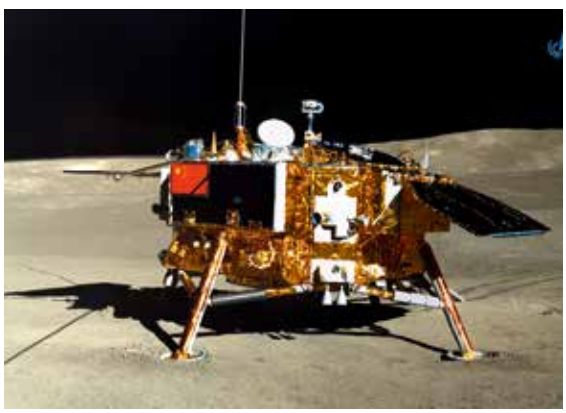
Technicians monitor the testing of electrical properties. courtesy of China Academy of Space Technology

After a series of complicated orbital maneuvers, Queqiao entered the L2 halo orbit about 65,000 kilometers from the moon. It became the first satellite to reach the location, with a mission to relay communication between the Chang'e-4 lunar probe and Earth.

On December 8, 2018, the Chang'e-4 probe was launched on its journey to the moon. On December 12, after 110 hours of flight, the probe entered an elliptical lunar polar orbit with a perilune of 100 kilometers, following a lunar orbit insertion burn. The lunar burn was a crucial orbital maneuver for the Chang'e-4 probe to reach the moon, through which the probe slowed down below escape velocity, enabling it to be pulled by the gravity of the moon and enter lunar orbit.

On December 30, 2018, after an orbital transfer, the Chang'e-4 probe entered a preset orbit to land on the far side of the moon. On the morning of January 3, 2019, the Chang'e-4 probe began its descent from an orbit 15 kilometers above the surface of the moon. At 100 meters up, the probe hovered above the surface to identify obstacles and measure the slopes on the surface. After navigating around obstacles, it selected a relatively flat area and descended vertically and slowly.

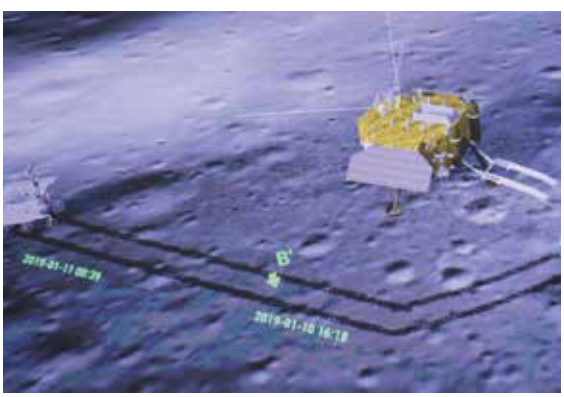
At 10:26 a.m., with the assistance of reverse thrusters and buffer equipment, the one-ton-plus probe successfully landed in the Von Karman Crater of the South Pole-Aitken Basin on the far side of the moon. At 11:40 a.m., the lander snapped the world's first close-up photo of the moon's far side and sent it back to Earth. At 3:07 p.m., Chinese scientists sent a command through the Queqiao relay satellite to have the Yutu-2 rover separate from the lander. At 10:22 p.m., the rover touched the lunar surface. Both the lander and the rover began their scientific work.



A photo taken by the Yutu-2 rover on January 11, 2019 shows the Chang'e-4 lander. courtesy of China National Space Administration

A photo taken by the Chang'e-4 lander on January 11, 2019 shows the Yutu-2 rover. courtesy of China National Space Administration

The first close-up image of the moon's far side taken by the Chang'e-4 probe. courtesy of China National Space Administration



The screen at the Beijing Aerospace Control Center shows the Chang'e-4 lander (right) and the Yutu-2 rover taking pictures of each other on January 11, 2019.
by Jin Liwang/Xinhua

An image captured by the Saudi camera aboard the Longjiang-2 microsatellite shows a portion of the northern hemisphere of the far side of the moon and the distant Earth. Xinhua

The Yutu-2 rover during a test. A robotic lunar rover developed as part of the Chang'e-4 mission, Yutu-2 is named after a legendary rabbit that lives on the moon as companion of moon goddess Chang'e. courtesy of China National Space Administration

On January 5, the Chang'e-4 probe tested its performance in high temperatures as the sun rose to its highest point over the landing site. The Yutu-2 rover entered standby mode to protect itself from temperatures reaching as high as 200 degrees Celsius. On January 10, the rover reawakened after a "midday nap" and resumed its operation.

On the afternoon of January 11, with support from the Queqiao relay satellite, the lander and the Yutu-2 rover took photos of each other on the far side of the moon, marking complete success of the first stage of China's Chang'e-4 lunar probe mission. Afterward, the Chang'e-4 probe entered a mode of scientific detection, with the lander conducting in-position detection and the rover conducting patrols.

The Chang'e-4 mission sets a new bar for China's lunar exploration program. The program consists of three stages: unmanned lunar probes, manned lunar landing, and construction of a moon base. The first stage also includes three steps: orbiting the moon, landing on the moon and bringing samples from the lunar surface back to Earth. So far, China has completed orbiting and landing on the moon. The Chang'e-5 probe will take off to bring samples on the surface of the moon back to Earth around 2020, laying groundwork for future manned lunar landings.

The Chang'e-4 landing on the far side of the moon was one small step for a Chinese probe, but one giant leap for human space exploration. The infinite possibilities presented by the boundless universe are inching closer.

A diagram of Chang'e-5 taking samples from the surface of the moon back to Earth around 2020. The Chang'e-5 lunar probe will be very complex, consisting of four parts: an orbiter, a returner, an ascender and a lander. courtesy of Shenzhou Media

Sketch Map for the Flight Track of Chang'e-4

Trajectory Correction

On December 9, 2018, Chang'e-4 made one trajectory correction before entering its designed orbit for landing. According the original plan, the probe would need three trajectory corrections. One-time trajectory correction could save incredible amounts of fuel for the probe, thus creating good conditions for its later performance and prolonging the lifespan of the device.

Separation of the Rocket and the Probe

On December 8, 2018, a Long March 3B rocket was launched from Xichang Satellite Launch Center in Sichuan Province, carrying the Chang'e-4 probe into Earth-moon transfer orbit. After a flight of about 1,133 seconds, the two separated.

Solar Wings

Solar wings unfolded to collect solar energy to power the Chang'e-4 probe.

Chang'e-4 Probe

The Chang'e-4 probe consists of a lander and a rover. Chang'e-4 was born as the backup to Chang'e-3. The first spacecraft to soft-land on the far side of the moon, Chang'e-4 focuses on carrying out comprehensive research on the moon's geology and resources to enrich studies about the celestial body.

Illustration designed by Xinhua News Agency

Information sourced from China National Space Administration

Scan for the Live Show of the Soft Landing of the Chang'e-4 Probe

Functional Diagram of the Chang'e-4 Lander, Yutu-2 Lunar Rover and Queqiao Relay Satellite

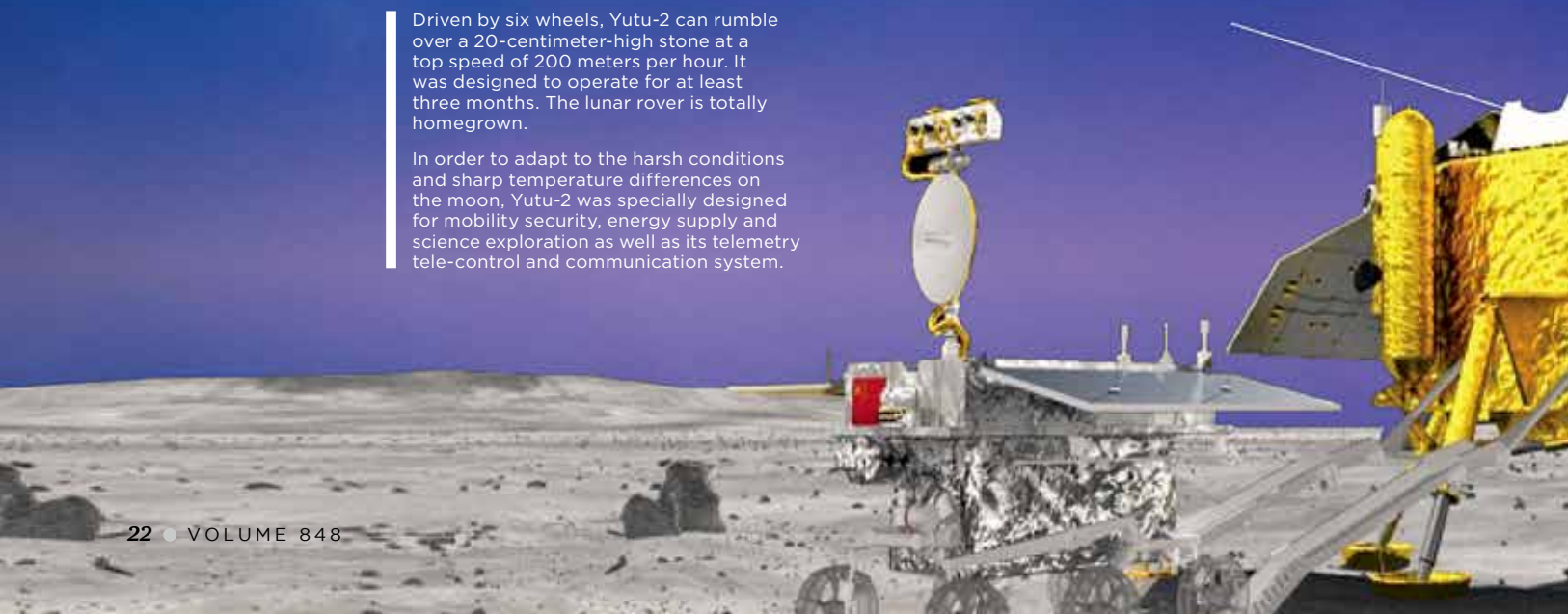
The Chang'e-4 mission includes a lander, the Yutu-2 lunar rover and the Queqiao relay satellite.

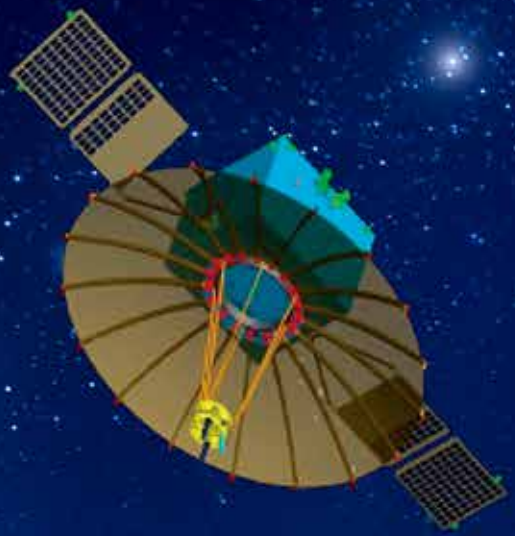
The Chang'e-4 lander and Yutu-2 lunar rover are collectively called Chang'e-4 probe. The probe flew about 400,000 kilometers and took 690 seconds to land on the moon.

Chinese scientists designed the probe to work during the moon's daytime and sleep at night. Like Earth, the moon also spins and has day and night. But a single day on the moon lasts the equivalent of 29.5 Earth days.

Driven by six wheels, Yutu-2 can rumble over a 20-centimeter-high stone at a top speed of 200 meters per hour. It was designed to operate for at least three months. The lunar rover is totally homegrown.

In order to adapt to the harsh conditions and sharp temperature differences on the moon, Yutu-2 was specially designed for mobility security, energy supply and science exploration as well as its telemetry tele-control and communication system.





Queqiao carries an umbrella-shaped antenna with a diameter of 4.2 meters, the largest communication antenna ever used in deep space exploration.

Queqiao operates at the halo orbit around the L2 point. In celestial mechanics, the Lagrangian points are the points near two large bodies in orbit where a smaller object will maintain its position relative to the large orbiting bodies. The first three of these points were derived by the Swiss mathematician Euler in 1767. French mathematician Lagrange proved two more in 1772.

The success of the Chang'e-4 mission can be attributed to efforts from many countries. Alongside payloads from Germany and Sweden on the probe, the Queqiao relay satellite was equipped with a Dutch low-frequency radio detector, and the isotope heat source jointly made by China and Russia can guarantee Chang'e-4 survives the cold nights. A deep space exploration station built by China in South America participated in the measurement and control task. In June 2018, the miniature imaging camera from Saudi Arabia on the Longjiang-2, a microsatellite developed by Harbin Institute of Technology in northeastern China's Heilongjiang Province, sent back many photos of the moon and Earth. Since the second half of 2018, NASA and China National Space Administration have negotiated several times on cooperative moon and deep space exploration.

The diagram is based on materials from VCG and Shenzhen Media.

To the Moon at Chinese Speed

—A Glance at China's Lunar Missions

Edited by Zhao Yue

1991
China's space experts proposed launching the country's own independent lunar exploration program.

1998
Chinese scientists started to plan, discuss and verify the feasibility of a lunar mission. They also began to tackle early-stage scientific and technological problems.

Chang'e-1 was China's first artificial lunar satellite, with a total weight of about 2,350 kilograms and a size of 2,000mm×1,720mm×2,200mm. The designed life of the satellite was one year. courtesy of Shenzhou Media

January 2004
China's lunar probe program, named Chang'e after the Chinese goddess of the moon, was formally launched. China's first unmanned lunar-orbiting satellite was named Chang'e-1. The country's ambitious moon project includes three phases: unmanned lunar exploration, sending humans to the moon, and establishing a moon base.

October 24, 2007
Chang'e-1 was launched from Xichang Satellite Launch Center. The same year, on November 7, after entering the lunar orbit, the satellite entered a 127-minute round polar circular orbit.

November 12, 2008
China released its first complete map of the moon's surface, produced from data collected by Chang'e-1.
The pioneer of China's lunar mission, Chang'e-1 orbited 200 kilometers above the moon for 16 months, carried out comprehensive scientific research and collected abundant data. In 2009, the satellite made a controlled crash on the lunar surface.

October 2008
The Chang'e-2 mission was approved by China's State Council.

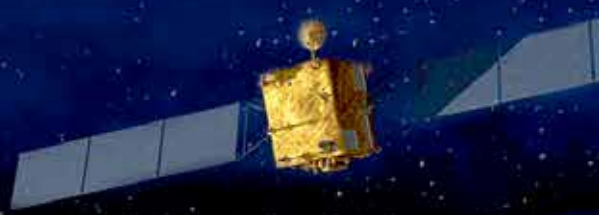
October 1, 2010
The Chang'e-2 satellite was successfully launched. After several orbital transfers, it finally arrived in a 118-minute round polar circular orbit and conducted research from 100 kilometers above the lunar surface.

June 9, 2011
The Chang'e-2 satellite left its lunar orbit for the Sun-Earth L2 point, 1.5 million kilometers from Earth, to conduct scientific experiments.

August 25, 2011
After a journey of 77 days, Chang'e-2 entered orbit around L2, the first time a satellite set off from the lunar orbit for remote outer space, making China the third after the United States and the European Space Agency to have reached this point.

February 6, 2012
China released a full lunar map produced by the Chang'e-2 satellite with a spatial resolution of seven meters that showed more details of the lunar surface than Chang'e-1.

By July 14, 2013
Chang'e-2, which was already a man-made asteroid in the solar system, had flown 50 million kilometers away from Earth.



Chang'e-2 was China's second lunar satellite and the backup for Chang'e-1. It was 130 kilograms heavier than Chang'e-1. The life of its propelling system was increased from three to six months. courtesy of Shenzhou Media

Chang'e-3 was China's first unmanned lunar probe to soft-land on the moon. It incorporated a robotic lander and a lunar rover. The net weight of the probe was 1,220 kilograms, of which the lander was a newly developed spacecraft platform with a weight of 1,080 kilograms and a designed life of 12 months. courtesy of Shenzhou Media

December 2, 2013
The Chang'e-3 probe was successfully launched. On December 14, after 12 days of flight, Chang'e-3, comprised of a lander and China's first moon rover called Yutu (Jade Rabbit), completed a soft landing on the Sinus Iridum, or the Bay of Rainbows, a plain of basaltic lava that forms a northwestern extension to the Mare Imbrium. Chang'e-3 has a mass of approximately 1,220 kilograms, and the rover is 140 kilograms, the lightest lunar rover ever.

February 18, 2016
After "sleeping" during the lunar night, the Chang'e-3 lander "woke up" for its 28th lunar day. The lander surpassed its designed life and performed exceptionally.

By December 14, 2016
The Chang'e-3 lander had worked admirably on the lunar surface for three years, a record length of time for a lander to work on the moon's surface.

May 21, 2018
China launched a relay satellite named Queqiao (Magpie Bridge) to set up a communication link between Earth and the moon's far side.

June 14, 2018
Queqiao entered a halo orbit around the L2 point of the Earth-Moon system, about 65,000 kilometers from the moon, becoming the world's first communication satellite operating in that orbit.

December 8, 2018
The Chang'e-4 probe was successfully launched. Consisting of a lander and a rover, Chang'e-4 was originally built as a backup for Chang'e-3, and its rover was named Yutu-2. The mission of Chang'e-4 is the follow-up to Chang'e-3.

January 3, 2019
The Chang'e-4 probe landed in the pre-determined Von Karman Crater in the South Pole-Aitken Basin, the first-ever soft landing on the far side of the moon. Around 3.6 billion years old, the Von Karman Crater is believed to be the oldest impact crater in the solar system and may contain water.

January 11, 2019
The Chang'e-4 lander and Yutu-2 rover took pictures of each other that were transmitted to the mission control station on Earth via the Queqiao relay satellite, marking complete success of the Chang'e-4 mission.

Around 2020
The Chang'e-5, China's first sample-return mission, is expected to bring at least two kilograms of lunar samples back to Earth.

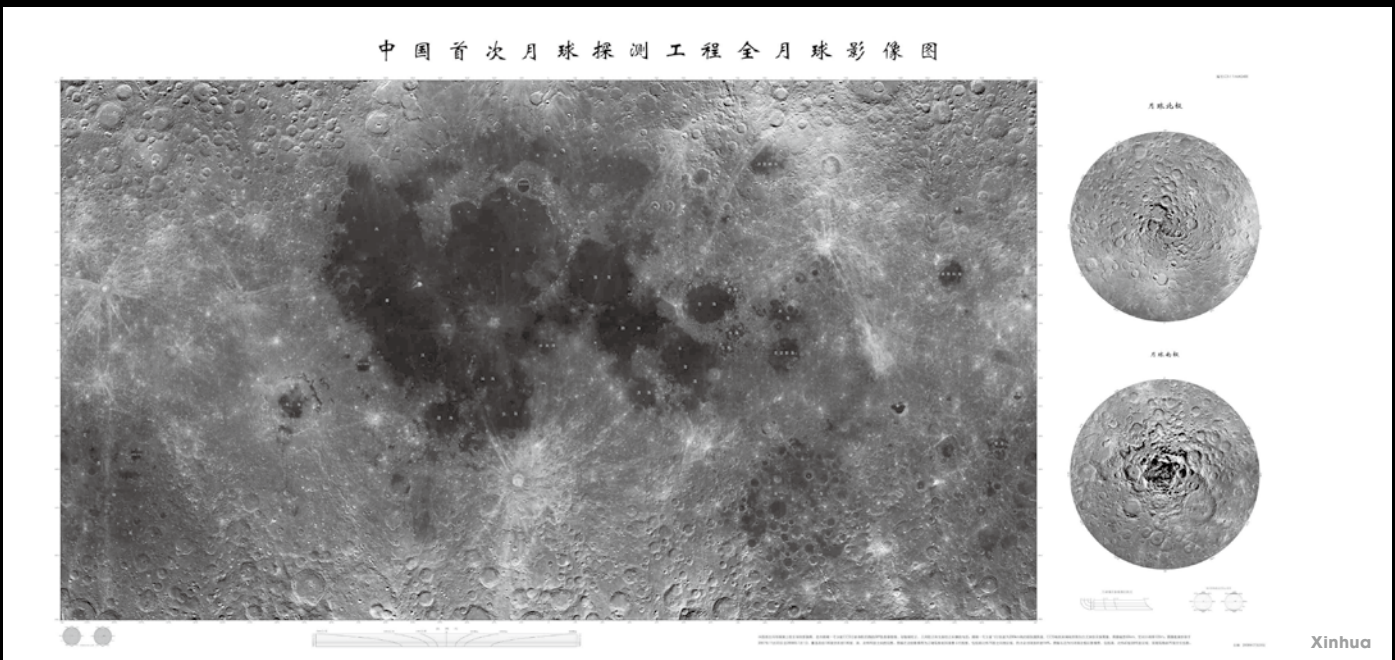
Sources:
China National Space Administration, Clep.org.cn, and Xinhua News Agency

Moon as Captured by Chang'e Probes

Edited by Zhao Yue

Moon Shot by Chang'e-1

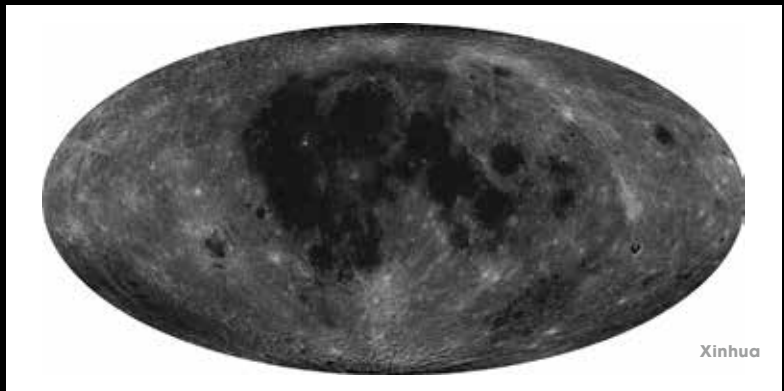
On November 12, 2008, China published the first picture of the entire moon that was pieced together from photos taken by the Chang'e-1 satellite. This was the world's most complete image of the moon ever published. The image of the lunar surface covered every corner of the mysterious moon: Chang'e-1 examined every inch of the moon and sent back complete data. This picture, processed from images shot by the satellite on Orbit 589, covers the area on the moon from 180 degrees east longitude to 180 degrees west longitude and between 90 degrees north latitude and 90 degrees south latitude.



Xinhua

Moon Shot by Chang'e-2

Mollweide projection of the entire moon. On February 6, 2012, China published an image of the whole moon with a resolution of seven meters. The Chang'e-2 probe adjusted its orbit several times and shot 746 images at this resolution, with total data of 800GB. Those pictures recorded the genuine landscape of the lunar surface. The resolution and quality of the images are the best in the world.



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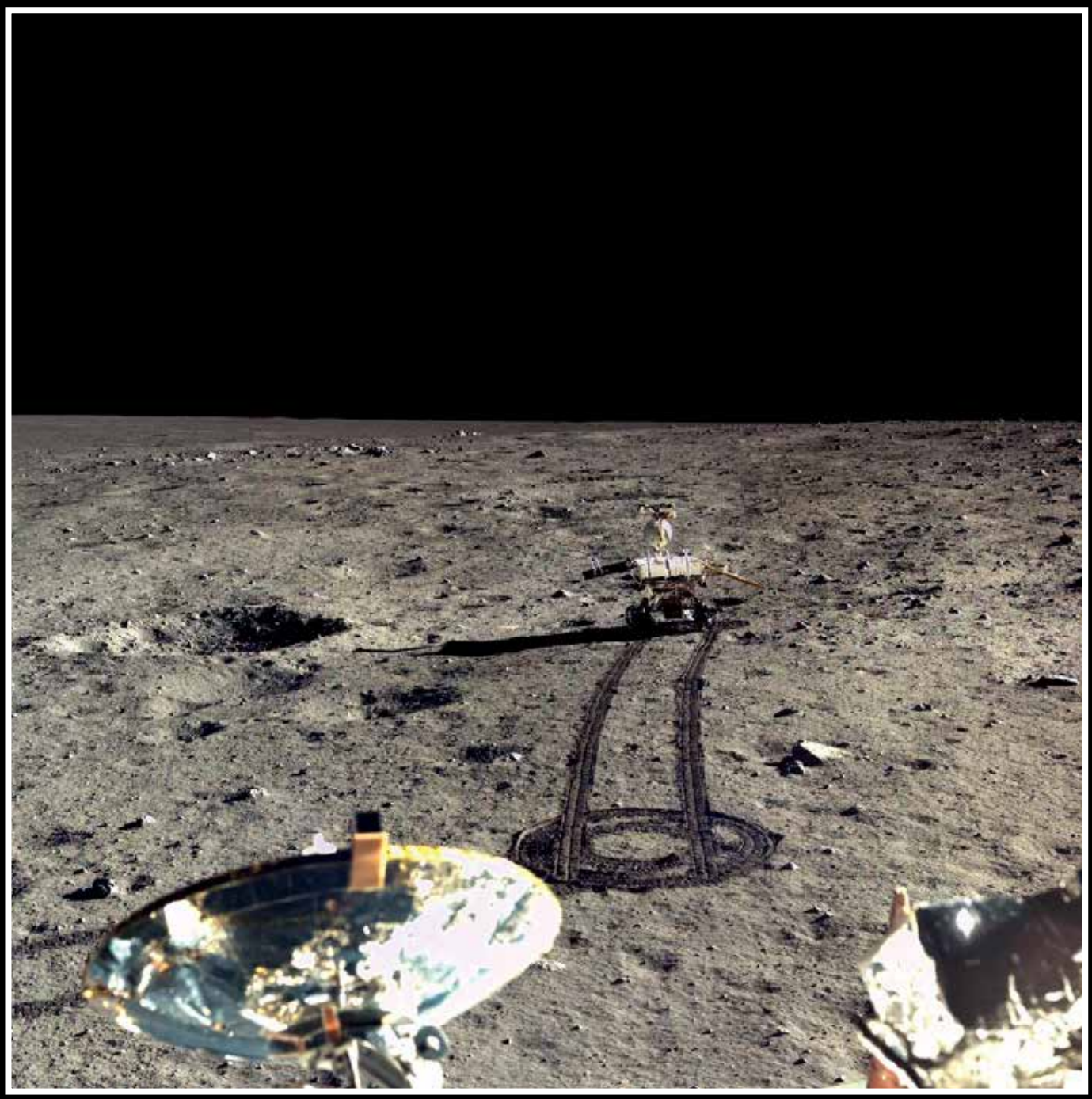


Xinhua

Moon Shot by Chang'e-3

A high-resolution picture of the lunar surface taken by Chang'e-3. On December 14, 2013, China's Chang'e-3 probe successfully completed a soft landing on the moon, which marked China becoming the third country after the United States and the former Soviet Union to successfully make a soft landing on an extraterrestrial celestial body. Chang'e-3 started working shortly thereafter. In April 2016, China released the world's highest-resolution colored picture of the moon shot by Chang'e-3 and the Yutu (Jade Rabbit) moon rover, presenting fresh material for the research of the moon globally. It was also the clearest picture of the moon in four decades since the Americans landed on the celestial body in 1969. The picture shows many details of the surface of the moon, ranging from the tracks of moon rover Yutu and rocks of all sizes to impact craters.

One in Ten Million

—Exclusive Interview with Ye Peijian, Chief Scientist with China's Lunar Exploration Program

Interviewed by Wen Zhihong, Hu Zhoumeng and Li Zhuoxi
Text by Hu Zhoumeng

"After living for more than 70 years, I have seen many ups and downs. But I feel excited now because I am so proud. Humans will finally land a spacecraft on the moon's far side, and Chang'e-4 is ready."

Every time before a satellite launch, Ye Peijian feels the pride swell. "Everybody in the country will know we succeed when the satellite goes into space."

Ye has been devoted to China's lunar probing for two decades. In 2001, he accepted the role of the chief scientist of the Chang'e-1 project and led his team to trailblaze the Chinese path to the moon. From the demonstration of lunar exploration plans to team organization and relevant design and research and then to the implementation of the lunar-probing missions, Ye has witnessed every thrilling moment of the Chang'e project and knows all about the hardship behind the success. Currently, he serves as chief scientist of deep space exploration at the China Academy of Space Technology (CAST). As a consultant to chief designer and chief commander of the Chang'e probe project, Ye continues to steer China's journey of lunar exploration.

Just two days before the launch of the Chang'e-4 probe, Ye said at a motivational conference: "After living for more than 70 years, I have seen many ups and downs. But I feel excited now because I am so proud. Humans will finally land a spacecraft on the moon's far side, and Chang'e-4 is ready. I have had such great luck. Among the 7.5 billion people on Earth, the core team of the Chang'e-4 project consists of only a few hundred. This opportunity is only one in ten million. And we got it."

***China Pictorial* (CP): Were there any setbacks in the three-year feasibility study of China's lunar exploration program conducted from 2001 to 2004? What foundation did the discussion lay for the program?**

Ye Peijian: It was quite a complicated process. Due to limited funding, we had to achieve scientific goals and progress in space technology with a limited number of launches. So, we planned to complete all unmanned lunar probe processes in three steps—orbiting, landing and returning. There was no divergence in the design of the three-step plan, but there was disagreement on how to perform the first step. Several options were presented, and the CAST's plan was ultimately chosen for two main reasons. First, we could not adopt too many new technologies concerning risk control so we mainly inherited the technologies of two previous satellites, Dongfanghong-3 and China Earth Resource Satellite-2. Second, China is a latecomer in lunar exploration, so we needed some innovative ways to accelerate the project and ensure it continues moving even after completion. In all, we achieved quite a good balance of inheritance and innovation.

One critical lesson China has learned from both manned spaceflights and lunar exploration program is the importance of sound top-level design. Throughout the three steps for our lunar probes, we will stick to the plan and keep the

team stable. We have all adopted this philosophy: When working on one step, we consider how to utilize the technology used in the former step as well as how to serve the next step. This ensures we continue striding forward no matter how hard it is.

CP: After the Chang'e-1 project was first launched in 2004, it took your team three years to finish building the Chang'e-1 satellite. What was the biggest challenge of that period?

Ye: When I accepted the role of the chief designer of Chang'e-1, I was shouldering enormous responsibility because I also served as the chief designer and commander of another satellite, China Earth Resources Satellite-2, China's first transmission satellite for Earth observation.

Chang'e-1 was China's first lunar-probing satellite, and we confronted many unprecedented technical challenges that were sources of hardship and pressure. For instance, how did the satellite approach the moon without getting sucked to its surface by gravity? We could not experiment on Earth to answer this question. And how should we tackle communications with the moon nearly 400,000 kilometers away from Earth? Moon-based positioning requires ultraviolet radiation sensors but there was none in China at that time, so we had to start research on it from scratch. An Earth satellite requires two-body positioning while a moon satellite requires three-body positioning including Earth, the sun and the moon, so its antenna must spin. How could we make it happen? The temperature gap along the moon orbit can exceed 300 degrees Celsius, so how could the satellite survive both extremes while circling the moon? There were many more questions. Ultimately we summarized seven key technical problems and solved them one by one.

Ye Peijian is chief scientist of deep space exploration at the China Academy of Space Technology. He is a consultant to the chief designer and chief commander of the Chang'e probe project. by Chen Jian

CP: What was your tensest moment working on the lunar exploration program?

Ye: I kept thinking that we deserved to succeed after all the efforts we made. If we didn't succeed, there might have been something we missed. Our work on the Chang'e project has been meticulous. You should see the hundreds of malfunction emergency response plans we made for the Chang'e-4 mission. We took everything we could imagine into consideration and drilled procedures, even including who makes decisions when problems emerge and how to report to authorities. However, there is no guarantee for success in any scientific experiment.

I have witnessed the launch of each Chang'e spacecraft personally. As a key member, I always stay calm so nobody else panics. If I appear anxious, people may expect huge trouble. The best scenario for flight control experts is when they're drinking coffee and chatting, with nothing else left to do.

CP: How do you monitor the progress of the lunar exploration program and prevent potential risk?

Ye: Despite the success of Chang'e-1, opposition to the launch of Chang'e-2 was strong. But should Chang'e-1 be China's one-off lunar exploration? A backup satellite had already been completed, and there was little reason not to launch it to accumulate more experience for the future. Chang'e-2 successfully reached the Earth-Sun L2 point, which is 1.5 million kilometers from Earth, and achieved a flyby of the asteroid 4179 Toutatis. Before the latest lunar mission, some objected to the idea of Chang'e-4 landing on the moon's far side. As long as China's lunar exploration continues, the far side was always going to remain key to innovation. If the chance emerges, why skip it and spend more time and money in the future to do the same thing? Chang'e-4 faced many challenges as it worked to land on the far side of the moon. Communications problems became a major issue, so we launched a relay satellite. The geographic environment of the far side of the moon is quite complicated, so landing required multiple sensors to determine the surrounding landform, something we also successfully accomplished.

CP: The Chang'e-4 mission included international cooperation on its scientific payloads, which were supplied by four international partners. What is your opinion on the collaboration?

Ye: Only a limited number of visits have been made to the moon, and scientists all over the world jump at the opportunity to conduct research there. International cooperation contributes to mankind, demonstrating China's inclusiveness and openness. Some international lunar exploration projects exclude China, but we aren't looking to exclude anyone. All countries are welcome to participate in our space station construction and our lunar exploration. American scientists have suggested extending the operational time of Queqiao (Magpie Bridge), China's lunar relay satellite,

> "The best scenario for flight control experts is when they're drinking coffee and chatting, with nothing else left to do."

Ye Peijian explains China's lunar probe to students at Hangzhou Chongwen Experimental School in Hangzhou City, Zhejiang Province. courtesy of China Academy of Space Technology

Workers test the Chang'e-4 lunar probe at an assembly center. The probe has become the first-ever spacecraft to make a successful landing on the far side of the moon. courtesy of China Academy of Space Technology

to five years. They hope to use the satellite, and we also welcome that.

CP: What is the value of exploring the moon?

Ye: Was the moon part of Earth? Or did it come into being simultaneously with Earth? There are still no promising clues. Research of the moon can enhance our understanding on the formation of the universe. Better understanding of the moon can facilitate the renovation and exploration of Earth. There is also a wealth of resources on the moon. For example, Helium-3 from the moon can be used to generate nuclear power. Its supply of Helium-3 is enough for 10,000 years of human use. It is a kind of clean energy. The difficulty is how to exploit it on the moon and take it back to Earth. It may seem hard now, but what about in a century or two? It is not available now, but it is not necessarily unavailable in the future.

CP: What do you think of the ability and momentum of China's deep space exploration compared to other countries?

Ye: Moon exploration has regained popularity in the 21st century. But we cannot expect China to make remarkable achievements overnight. Our efforts have paid off, but in general we are still lagging behind the global forerunners in this field.

We aim to take samples from the moon back to Earth this year. We are also conducting research on sending astronauts to the moon and planning to visit the South and North Poles of the moon. In the foreseeable future, we will be in a leading position in lunar exploration. According to our plan, the Mars-1 probe will be launched in 2020. It will not only orbit Mars, but also land and rove on the Red Planet. If the plan succeeds, China will be a step ahead on exploring Mars. We also plan to explore asteroids and reach Jupiter by the 100th anniversary of the founding of the People's Republic of China. Only when those steps are completed will China take a leading position in deep space exploration.

A Scientist's Dream

—Exclusive Interview with Zhang He, Executive Director of the Chang'e-4 Probe Project at the China Academy of Space Technology

Interviewed by Li Zhuoxi **Text by** Wen Zhihong

Just before the Chang'e-4 probe was set to land, Ye Peijian, a consultant to chief commander and chief designer of the Chang'e project, approached Zhang He, executive director of the project, to ask whether she was nervous. "A little," admitted Zhang. "Don't worry," Ye said. "Relax."

After the "long" 10 minutes during which the probe slowed and landed on the moon, Zhang let out a sigh of relief and turned back to hold hands with Ye and cried with happiness.

Chang'e-4 was originally a backup for Chang'e-3. Back then, a big debate took place to determine whether Chang'e-4 would land on the near side or the far side of the moon. Some questioned why other countries had not gone to the far side. Others asked why China should go and what it would mean.

Zhang He, executive director of the Chang'e-4 probe project at the China Academy of Space Technology, granted an exclusive interview to *China Pictorial* (CP). According to her, exploring the far side of the moon has always been a dream for scientists around the world. The images sent by the probe presented a very different picture of the moon's far side from what humans had imagined. Furthermore, a comparison of the exploration results from the near side and the far side could kindle many scientific discoveries which will be of great significance for scientists and engineers worldwide.

CP: From launch to landing, when were you most nervous? What do you think was the most crucial factor for the success of Chang'e-4?

Zhang He: Three moments tugged at my heartstrings. The first was the launch of the rocket. It mattered whether the probe could enter into the correct orbit and whether the solar panels could unfold to collect power. The second was space braking. When approaching the moon, if Chang'e-4 didn't slow down, it would have missed the moon and drifted into space. So, both its speed and position had to be controlled accurately. Otherwise, it wouldn't orbit the moon. The last but the most nerve-racking moment was the slow lowering and landing process. Contrasting Chang'e-3, Chang'e-4 relies heavily on the Queqiao relay satellite for communications, resulting in a two to three-minute delay. This eliminated any chance to change directions. So the whole process could not be amended or reversed.

Each leg of Chang'e-4 has a moon-touching switch. When we saw the four switches were off, along

with the image sent back by the camera, we knew the probe finally landed on the moon. The subsequent challenge was the automatic spread of the solar wings. After this step, we believed we had avoided the most dangerous problems and felt relieved.

Rather bumpy compared to the near side, the moon's far side is full of craters. So unlike Chang'e-3, we adjusted the powered lowering strategy and made many modifications to control software. Chang'e-3 descended obliquely when landing on the moon. But Chang'e-4 first moved horizontally while slowing down and then arrived six kilometers above its designed landing point. Finally, it descended to the landing point almost vertically in order to avoid possible obstruction.

The workstation on the ground could see the landing of Chang'e-3 with a very short-time delay. The communications for Chang'e-4 had a longer delay and we couldn't respond to potential malfunctions in real time. So we granted Chang'e-4 some automatic functions to allow it to judge whether the engine was on and whether the sensors worked.

Since 2001, Zhang He has joined the demonstration team of China's Chang'e probe project. This time, she serves as the executive director of the Chang'e-4 probe project. by Chen Jian

Assembling the rover. courtesy of China Academy of Space Technology

CP: What are the possible problems and challenges during the scientific investigation of the Chang'e-4 lander and the Yutu-2 rover on the far side of the moon? What are the biggest breakthroughs that will be made?

Zhang: Because the evolution history of the far side and near side of the moon is quite different, we hope the Chang'e-4 probe can make new discoveries in the analysis of surface material on the far side of the moon, which mainly relies on the infrared spectrometer loaded on the rover of Chang'e-4 to analyze the composition of the lunar soil. Chang'e-3 also carried such a device.

On the last lunar day, the infrared spectrometer was turned on and will continue to work this month. The Yutu-2 lunar rover is equipped with an electromagnetic radar like that on Chang'e-3. It works by sending out electromagnetic pulses that travel through lunar soil and bounce off objects below to collect information about the layered structure of the lunar crust. We hope that Yutu-2 can go further.

The most difficult part is the low-frequency radio astronomical observation, which is a new payload of Chang'e-4 aiming to observe the low-frequency radio signals from the universe, the sun and other celestial bodies. The difficult factor is that our probe itself also emits a lot of low-frequency electromagnetic signals.

According to data we have already collected, a lot of work has to be done to further eliminate noise and truly separate the low-frequency radio signals from the universe, especially from the sun.

CP: What scientific payloads is the Chang'e-4 probe equipped with? What were the selection criteria for those? What is the significant international cooperation between China and other countries and international organizations?

Zhang: The lander and rover are equipped with four scientific payloads each. For instance, the rover carries a panoramic camera to take pictures for scientific research, and a neutral atom detector developed by Sweden to analyze what neutral atoms exist on the moon. The lander has a neutron radiation detector developed by Germany to test the neutron environment of the moon and discover whether there is water or ice on the moon and an infrared imaging spectrometer to obtain images of the moon's surface.

China's State Administration of Science, Technology and Industry for National Defence has collected payloads globally. But because of the limits on weight, the Chang'e-4 probe is equipped with only four international payloads. The Queqiao (Magpie Bridge) relay satellite carries a low-frequency radio astronomical instrument developed by the Netherlands.

CP: What is the biggest difference between Chang'e-3 and Chang'e-4?

Zhang: The two probes look similar, but they are quite different.

Firstly, because the navigation control strategy of the Chang'e-4 landing is different from that of Chang'e-3, navigation sensors, laser range sensors and microwave velocity sensors are specially modified for the far side of the moon.

The second difference is the collection of data about the temperature of the moon night, which Chang'e-3 did not achieve. What's the temperature of the moon at night? The U.S. Apollo mission on the near side of the moon obtained related data and the country has reported in other materials that the temperature of lunar soil is as low as minus 180 degrees Celsius, but China does not have its own data.

Chang'e-4 uses technological breakthroughs to solve the problem of continuous power supply to the moon night temperature acquisition device. The lander is able to reach the lunar soil by laying out many measuring points to obtain the temperature of the lunar soil and other data.

CP: What are the challenges ahead for China's lunar probe project and deep space exploration?

Zhang: The work on the Chang'e-5 lunar probe is ongoing—it is expected to bring lunar samples back to Earth. China's lunar exploration team has basically amassed the knowledge about regular procedures to explore an extraterrestrial body, including "orbiting, landing, roving, and returning."

Despite having probed the moon over 100 times, human beings possess very limited knowledge about it. Scientific questions waiting to be clearly answered include: How did the moon come into being? Is there water on the moon? What is under the lunar crust? We plan to land a spacecraft at the moon's poles in the fourth phase of China's lunar exploration program. The primary challenge is presented by the more rugged landform at the poles and permanently shadowed areas where landers can't escape once they fall in. Chang'e-3 landed in an optional area of a few hundred square kilometers, and Chang'e-4 landed in an optional area of a few square kilometers. But landing at the moon's poles requires the lander to find a proper spot within an area of one square kilometer or even smaller, which increases the difficulty.

The lunar poles are also extremely cold because of low sun angles and there is no energy and light in the permanently shadowed areas, which creates new barriers for heat supply and energy sustainment of the probe.

We are also looking to explore more materials deep in the lunar soil, which requires lunar probe robots to be more capable of working independently at deep digging, flying and task planning. And China hopes to complete building a scientific station for long-term operation on the moon by 2030.

As for deep space exploration, alongside a manned moon landing, China also plans to explore Mars, Jupiter, asteroids and even the edges of the solar system. To achieve these goals, we need to tackle enormous technological challenges concerning orbit design, automated navigation, power system, communication for measurement and control, and energy. Each step in deep space exploration requires a great technological breakthrough.

CP: What was the biggest challenge in your personal growth from 2001 when you first joined the lunar probe project to today as you serve as executive director of the Chang'e-4 probe project?

Zhang: Taking part in the lunar probe project and aerospace work has given me more courage to face challenges, and I became more competent in solving problems. In my early days on the Chang'e project, I once took part in an engine test. The squeaking of the engine became extremely loud at certain parts, which made me nervous. My colleagues comforted me by saying, "Take some time and you will get used to it." Another time in a mechanics experiment, I heard increasing sound as the whole satellite resonated on a different frequency band. When the tremendous noise surrounded me, I could not have felt more nervous and worried that something went wrong with the project. This was a hard exercise on my mental endurance. After enduring more exercises like this, I tend to believe that any problem can be solved no matter how difficult it is.

I have been obsessed with gazing at the stars since I was a kid, and I took many photos of starry nights and celestial bodies. I always dream of going further and seeing more extraterrestrial celestial bodies. So, I feel extremely lucky to work in deep space exploration and be a member of China's lunar probe team.

CP: Contact with aliens has been frequently discussed. What do you think of the mysterious signals from the universe? Do you believe in extraterrestrial life?

Zhang: I believe that humans are not the only intelligent beings in the universe and that there may be creatures more intelligent than us. We can't see them now but we may run into them some day.

Human beings should be cautious about aliens. In the beginning of the encounter, I suppose aliens will also "wait and see." I hope human beings and aliens meet without hostility and live in harmony together in the universe.

Light on the "Dark Side" of the Moon

Text by Pang Zhihao

Thanks to the Chang'e-4 probe conducting detailed exploration of the far side of the moon, humans are expected to unravel more scientific mysteries.

On January 11, 2019, the Chang'e-4 lander and Yutu-2 rover took pictures of each other with the support of the Queqiao (Magpie Bridge) relay satellite, marking overwhelming success of China's Chang'e-4 mission. China's lunar program has already reaped remarkable achievements. Chang'e-4 is the first probe from Earth to soft-land on, rove and explore the far side of the moon. In the coming years, China's lunar program will continue to develop quickly. By around 2020, the Chang'e-5, China's first sample return mission, will bring lunar samples back to Earth. After that, subsequent missions of China's lunar program such as Chang'e-6 and Chang'e-7 will be launched in succession.

China's lunar exploration program was formally launched in early 2004. Compared to the United States and some European countries, China's lunar program started late. Why do humans spend so much on lunar exploration? In general, moon exploration is tremendously significant for scientific, technological, and economic fields as it promotes social development and influences future life.

For example, with almost zero atmospheric and geological activities on the moon, rocks are kept in pristine condition. Studying moon rocks is like studying samples from Earth some four billion years ago. Research of the moon helps provide more early information about Earth and enables people to better understand the origin and evolution of life, Earth, the solar system and even the whole universe. Since the moon has no global magnetic field, its geological structure is extremely stable, and because the moon's far side is free from radio signal interference from Earth, it is an ideal place to set up large observatories and other scientific research bases.

Exploring the moon is a complicated systematic project. Lunar missions can promote and facilitate the development of basic scientific research and high-tech realms including cosmology, space astronomy and space physics. Furthermore, since the moon is home to abundant natural resources, lunar missions can set a foundation for future usage of moon resources.

It is easy to grasp the great significance of lunar missions. According to *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* by the United Nations Committee on the Peaceful Uses of Outer Space, the moon and its natural resources are the common heritage of mankind. However, the countries that develop the celestial body first will certainly benefit first. Consequently, increasing numbers of countries are actively working on lunar programs. India, Israel, and Japan all have plans to launch lunar probes in 2019.

China now leads the world's second-tier lunar exploration group composed of Europe, Japan and India. China has reached a lunar orbit, landed and roved on the moon and

conducted both general surveys from afar and detailed regional investigations at a close range. It is worth mentioning that Chang'e-4's soft landing on the far side of the moon has left a major impact on the world.

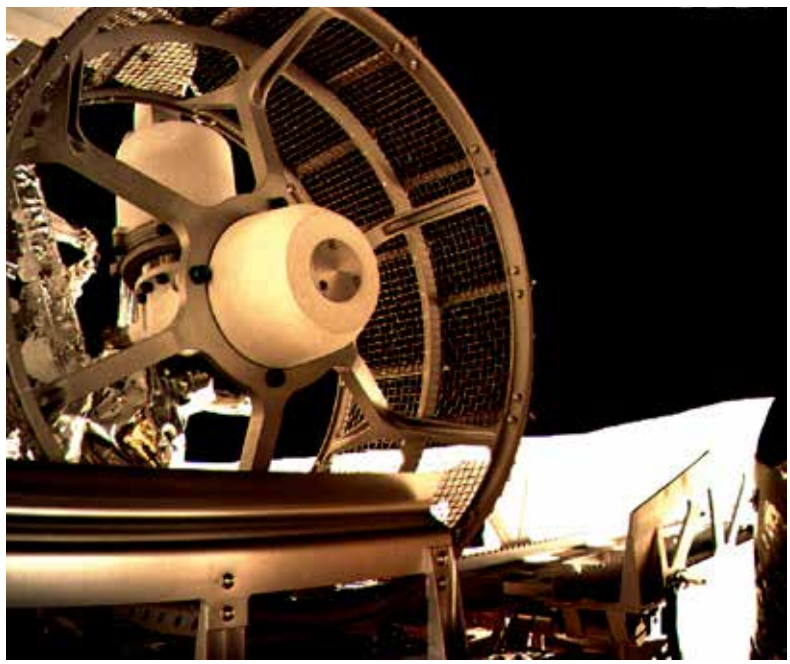
The far side of the moon, which always faces away from Earth, starkly contrasts the near side of the moon that we see almost every night. In general, the moon surface is composed of two geological forms: lunar maria (Latin for "seas") and terrae (Latin for "earth"). Compared to maria, terrae are older and preserve more of the original appearance of the moon. The far side of the moon has a battered, densely cratered appearance with few maria. Conducting research and investigations of the morphology, substance composition, soil and shallow structure of the moon's far side will help people learn more about the moon's early evolution and holds important value for the research on the early history of Earth.

Since the moon rotates on its axis at the same rate that it orbits Earth, only the near side of the moon is visible from Earth. Thus, for astronomical researchers, the far side of the moon is ideally quiet. The far side of the moon is shielded from electromagnetic interference from Earth where low-frequency radio waves less than 10MHz can be monitored, so it's an ideal place to research the origin of stars and nebula evolution. Major astronomical breakthroughs are expected to emerge from there.

However, because people can never "see" the far side of the moon from Earth, probes have a difficult time establishing radio communication with Earth from there. This factor has presented a persistent difficulty hindering a landing on this part of the moon. Although more than 100 probes and orbiters have been launched to the moon by various countries since the 1950s, never before had a probe landed on its far side. Furthermore, the exceptionally complicated landforms on the far side of the moon pose great challenges for soft landing, roving and researching in this area.

China dived headfirst into solving this worldwide problem. On June 14, 2018, China launched the Queqiao relay satellite into a halo orbit around the Earth-Moon L2 point. In this orbit, the relay satellite serves as a mirror facing both Earth and the moon's far side at the same time, which enables a communication link to Chang'e-4 after it landed. Since Chang'e-4 was planned to land in a rugged environment, the probe was designed to achieve a high-degree landing precision. To avoid "cliffs" on the moon surface, Chang'e-4 is equipped with strong abilities in automatic navigation and obstacles avoidance. It was able to find a comparatively flat place independently before performing a nearly vertical landing.

The Chang'e-4 mission is a first for both a human probe visiting the moon's far side and a communication satellite operating at the L2 point of the Earth-Moon system. It has provided scientists with a new work platform on the moon's far side and produced abundant original scientific research data. The mission serves as a critical step for humans to uncover the mysteries of the moon's far side. Scientists expect that after the Chang'e-4 probe conducts detailed exploration on the far side of the moon, the long-standing scientific mystery of the spike in impact rate 3.9 billion years ago on both the moon and Earth can be solved.



A wheel of the Yutu-2 rover. Compared to its predecessor Yutu-1, Yutu-2 faces more challenges because its landing area, the Aitken Basin, is the largest, deepest and oldest crater on the moon. Xinhua/China National Space Administration

The author is chief science popularization expert on space exploration technology at the China Association for Science and Technology and a former researcher with the China Academy of Space Technology.

A worker pastes the national flag of China on the Chang'e-4 probe. courtesy of China Academy of Space Technology

Chang'e-4 Mission

The Far Side of Technology

Text by Huang Zhicheng

China is poised to play a greater role in deepening human understanding of the moon and our universe.

On January 3, 2019, China's Chang'e-4 lunar probe completed a soft landing on the far side of the moon before carrying out a series of scientific tests.

The pioneering landing marked an unprecedented step for space exploration and a major innovation of space exploration technologies, evidencing the innovation capacity of China's space program. The same day, NASA Administrator Jim Bridenstine tweeted: "Congratulations to China's Chang'e-4 team for what appears to be a successful landing on the far side of the moon. This is a first for humanity and an impressive accomplishment!"

Because the moon is tidally locked—a single rotation of its axis takes the same amount of time as a single orbit around Earth—its far side is always facing away from Earth. Consequently, we can only see the near side of the moon from Earth.

On October 7, 1959, the Soviet Union's Luna 3 probe transmitted the first images of the far side of the moon. In 1968, as the U.S. manned spacecraft Apollo 8 orbited the

moon, astronauts aboard saw the far side with their own eyes for the first time. By the end of 2018, countries around the world had launched more than 100 lunar probes, including over 60 lunar landers, but none achieved a soft landing on the far side of the moon as China's Chang'e-4 probe did.

In general, the far side and near side of the moon contrast each other sharply. The crust on the far side is thicker than that on the near side, and the two sides also differ in terms of material composition, topography and age of rocks. Scientists have yet to reach consensus on explaining such differences. Finding an answer to this unsolved question is meaningful for humans to understand the moon and even the universe.

Discoveries related to the far side of the moon are conducive to advancing moon-based scientific research. The far side of the moon is free of disturbances caused by Earth's radio waves, making it the best place for radio astronomical observations. Low-frequency moon-based radio astronomical observations can help mankind better probe the detailed evolution of the moon and study the origin of celestial bodies and the universe. Surveys on the lunar surface environment are conducive to the research of particle radiation and solar wind.

The moon is abundant in mineral and energy resources. One purpose of mankind's lunar exploration is to utilize its resources. In recent years, countries including the United States have consecutively formulated plans to survey and research resources on the far side of the moon. Through scientific surveys of the landing zone, the Chang'e-4 probe provided valuable first-hand information for the exploration and utilization of lunar resources.

The unprecedented landing of the Chang'e-4 probe on the far side of the moon overcame three major technological challenges: First, soft landing in a zone with complex topographical conditions. Compared to the comparatively flat landing zone for Chang'e-3, the South Pole-Aitken Basin where Chang'e-4 landed features rugged terrains with large and dense impact craters, which meant stricter requirements for selection of the landing location and accuracy of landing maneuvers. The second challenge was control communication. Radio signals from Earth cannot directly reach the far side of the moon because it always faces away from Earth. Therefore, communication between Chang'e-4 and Earth requires assistance of the relay satellite Queqiao (Magpie Bridge) that hovers in the L2 halo orbit. The relay satellite features an umbrella-like antenna nearly five meters in diameter when extended. It is the largest diameter for a communication antenna on a deep-space probe in human history. The third challenge was designing automated roving technology specifically for the far side of the moon. Due to a lengthy history of meteorite impacts, the far side of the moon has a rougher environment than the near side. Chinese scientists designed eight modes for the rover, including sensing, moving, detecting, recharging, safe, sleep, lunar day switching to lunar night, and lunar night switching to lunar day, to adapt to different working environments and conditions. The technological breakthroughs achieved by Chang'e-4 laid groundwork for future lunar exploration as well as the exploration of other planets in the solar system such as Mars.

The Chang'e-4 mission involved extensive international cooperation which resulted in a model for international collaboration in space exploration. The payloads on the Chang'e-4 probe include a neutron radiation detector developed by Germany and a neutral atom detector developed by Sweden. Moreover, a low-frequency explorer developed by the Netherlands was installed on the relay satellite Queqiao. Those international payloads, coupled with those independently developed by China, have already carried out various scientific tests on the far side of the moon.

After the Chang'e-4 mission, China will launch the Chang'e-5 unmanned probe to accomplish a series of tasks including bringing lunar samples back to Earth. A new wave of global lunar exploration is about to happen, and China is poised to play a greater role in deepening human understanding of the moon and the universe.

The author is a senior researcher with Techxcope, a technological consulting agency.

Chang'e-4 In Context

Text by John M. Logsdon

Discussions between Chinese and U.S. space leaders, should they occur, would certainly be flavored by the overall state of China-U.S. relations. It may well be that those interests are best served by limiting the degree of cooperation and pursuing largely separate and competing paths. But there is also the possibility that expanded China-U.S. space cooperation could be at the leading edge of a more harmonious relationship between the two powerful countries and their allies.

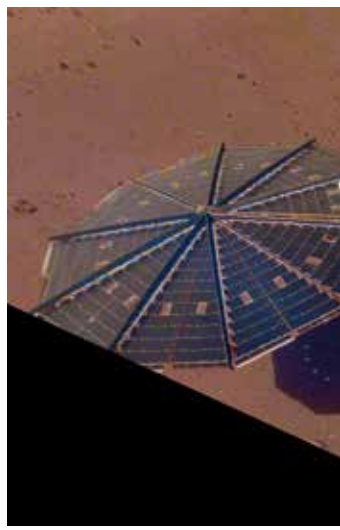
The January 2 landing of the Chang'e-4 spacecraft on the far side of the moon and the subsequent operations of both the lander and the Yutu-2 rover were very impressive technical achievements. China should be rightfully proud of accomplishing this new step in its well-planned lunar exploration program following the successes of the Chang'e-1 moon orbiter in 2007, the Chang'e-2 orbiter in 2010 and the Chang'e-3 lunar lander and rover in 2013. But to characterize the mission as critical in determining whether the future of space exploration, resource development, and colonization will be dominated by China, as was suggested in a January 10 essay published by the influential *Washington Post*, greatly exaggerates Chang'e-4's significance. The character of future space exploration activities is indeed an important and unsettled issue, but it is not likely to be decided by one relatively modest robotic mission.

December 3, 2014: An H-IIA rocket carrying Hayabusa 2 space probe blasts off from the launch pad at the Tanegashima Space Center on the Japanese southwestern island of Tanegashima. VCG

It is useful to put Chang'e-4 in context. One widespread reaction to China's success was surprise—surprise that China, not some other spacefaring countries, and particularly not the United States, was the first to land on the side of the moon facing away from Earth. That reaction evidences that the general public and media have not been paying attention to China's progress in developing comprehensive space capabilities. Over the past four decades, China has become the third country able to send humans to space, has carried out a variety of space application missions to benefit Chinese society, has created significant national security space capabilities, and has conducted a series of space science missions. The existence and plans for the Chinese lunar exploration program have been public knowledge for over 15 years.

It is true that Chang'e-4 was a relatively late addition to the program made possible because the success of Chang'e-3 on the first landing attempt freed up its backup lander and rover, which could then be modified for the far-side mission. The most impressive technological achievement associated with Chang'e-4 may be placing the Queqiao (Magpie Bridge) relay satellite needed to carry out the landing at the Earth-Moon L2 point. Once there was a path for relaying commands and other information between Earth and Chang'e-4, there was not much difference technologically between landing on the moon's Earth-facing side and its far side.

In the same time frame as the Chinese moon landing "only" 250,000 miles from Earth, NASA's New Horizons spacecraft was sending back images of the Kuiper Belt object Ultima Thule from four billion miles away. Its InSight spacecraft began science operations after its November 26 landing, and its Osiris-Rex spacecraft went into orbit around the asteroid Bennu to prepare to seize a sample



December 6, 2018: NASA InSight's first full selfie on Mars. It displays the lander's solar panels and deck. On top of the deck are its science instruments, weather sensor booms and UHF antenna. IC

of that celestial body for return to Earth in 2023. Japan's Hayabusa-2 spacecraft is circling another asteroid, Ryugu, in preparation for an early 2019 landing and sample return. Other nations in addition to China are doing impressive things in space.

The goal of the Chinese lunar exploration program since its inception has been to lay the foundation for eventual Chinese human missions to the moon. The program's logo is a lunar crescent with two human footsteps at its center. In the wake of the success of Chang'e-4, China has formalized its robotic lunar exploration plans for the decade of the 2020s. A long-planned lunar sample return mission is scheduled for a December 2019 launch, followed by a series of missions focused on eventual development of a scientific base near the moon's South Pole, on either the near or far side. Chang'e-4 is the first of several missions to identify the best site and technological requirements for such an outpost. For several years, China has included human missions to the moon "after 2030" in its long-range plans, and there is no reason to doubt that intent.

The United States is also planning to send humans to the moon and has set out a series of potential robotic missions as precursors. The current U.S. space policy states that "the United States will lead the return of humans to the moon for long-term exploration and utilization" and directs NASA to "lead an innovative and sustainable program of exploration with commercial and international partners." NASA is developing the hardware and preparing to carry out that directive. It remains to be seen if the current and subsequent administrations and Congresses have the political will to provide sustained support for the U.S. space exploration. China's form of government gives it an advantage in implementing efforts taking place over a number of years, but U.S. policy over the past 15 years has focused on resuming deep-space exploration. So there is a reasonable prospect for support.

Which is more likely in coming years: two competing programs of lunar exploration and eventual exploitation, one led by China, the other by the United States, or a globally-coordinated effort, with those two leading countries pursuing a complementary mixture of cooperation and competition? Current U.S. law, which makes close consultation between U.S. and Chinese space leaders practically impossible, presents a short-term obstacle to addressing that crucial question. But that law originated in a Republican-controlled House of Representatives. Now that the Democrats are in the majority, it could be modified to allow NASA and Chinese space leadership to engage in top-level discussions.

Those discussions, should they occur, would certainly be colored by the overall state of China-U.S. political, security and economic relationships. Both China and the United States would have to decide on how future large-scale space activities relate to their core national interests. It may be that those interests are best served by limiting the degree of cooperation and pursuing largely separate and competing paths. But there is also the possibility that expanded China-U.S. space cooperation could be at the leading edge of a more harmonious relationship between the two powerful countries and their allies. The success of Chang'e-4 is in these indeed significant, serving as a reminder to all that the fundamental issue of the future China-U.S. space relationship needs to be addressed.

The author is Professor Emeritus at George Washington University. He has been on the university's faculty since 1970 and founded its Space Policy Institute in 1987. He is a prolific author with focus on presidential space policy decisions.

Beyond the Far Side

Text by Vasudevan Mukunth

China's goal of achieving development from a lunar orbiter to a moon outpost in three decades is remarkably fast.

China has always advocated for the peaceful use of outer space. It adopted its current Constitution in 1982 and ratified the UN Outer Space Treaty (OST) in 1983. And since 1985, it has been working together with the United States and Britain, among other countries, to develop space technologies.

Today, it is an elite spacefaring nation with an operational heavy-lift launch vehicle, a space station and crewed spaceflight programs, a functional collaboration with a dozen world-class universities around the country and a flourishing private space sector. China also has a space science division but it isn't quite as expansive or full-fledged as its space technologies counterpart.

When the country's Chang'e-4 mission deployed a rover on the far side of the moon on January 3, 2019, observers were surprised. The Chinese space agency aims to build an "outpost" on the moon's South Pole. As futuristic as that sounds, Chang'e-4's success was a reminder that China might just achieve that goal by the 2030s, with the complicated mission profile attesting to the country's capabilities.

Since the first Chang'e mission in 2007, China has sent two orbiters, two landers and two rovers and is expected to undertake two sample-return missions by 2021. Three decades from orbiter to outpost is remarkably fast.

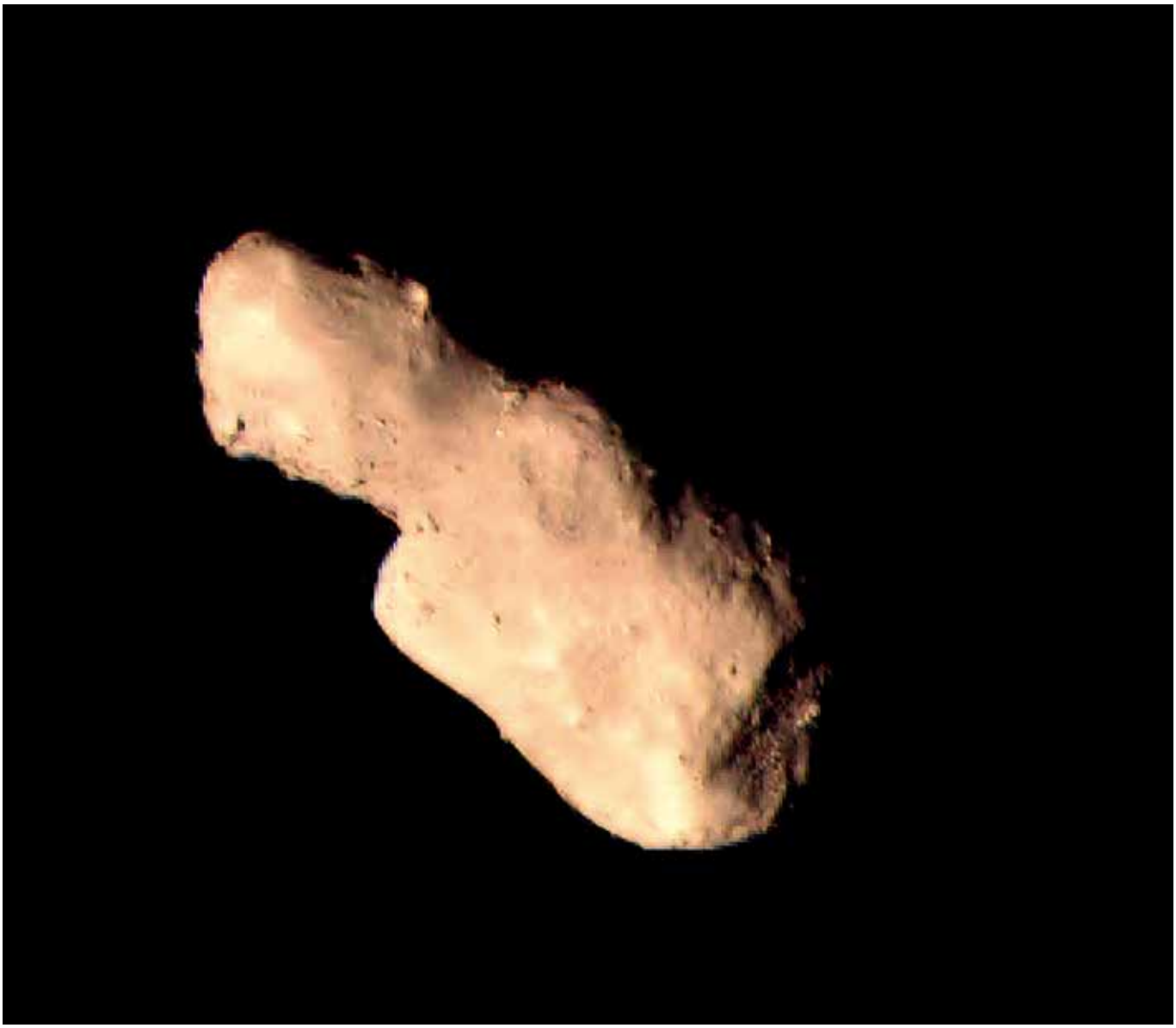
At the same time, China's cislunar and lunar missions can't be written off entirely as pilots to greater non-lunar endeavors. The moon is not simply a springboard. Although crewed lunar missions ceased to be of interest in the 1990s, the natural satellite has been reborn as a "superpower destination."

Last November, NASA announced the selection of nine companies to "deliver services to the lunar surface," starting as soon as 2019. Although the organization's chief called it the first step to "feed forward to Mars," it still involves long-term scientific explorations of the celestial body itself.

India is another country interested in the moon, and its trajectory to the celestial body and beyond is very similar to China's. In fact, Chandrayaan-2 will land on the moon at a spot close to where Chang'e-4 did, exploring a similar region with similar instruments. Both countries have also announced a similar suite of interplanetary missions and have built or are building capabilities that will allow them to launch both very heavy and very light satellites, send humans to space and ultimately to the moon, and reach Mars in the not-so-distant future.

In fact, it is possible that India is paying more attention to space diplomacy only because China. India has accelerated its human space flight program after many years of dismissing its value largely due to the possibility of a Chinese space station in low-Earth orbit by 2024.

However, one area holds hope for cooperation because more than half of all countries that have independently developed spaceflight are from Asia and at least seven other countries around the world are keen on returning to the moon. If India, China and Japan join hands, they can effectively lead a



An image of the asteroid Toutatis taken by the Chang'e-2 probe during its flyby in 2012. courtesy of Shenzhou Media

conglomerate of 15 nations that could set the terms of the world's return to the moon.

Since NASA shut down its Space Shuttle program in the 1990s, it hasn't had the ability to launch astronauts to space, let alone to the moon. It has navigated the situation of using Russian rockets to access the International Space Station. In fact, its choices passively set up a gatekeeping situation.

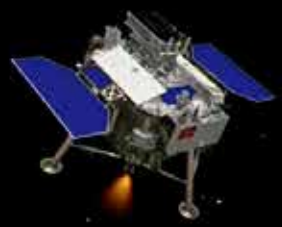
The OST is still in effect but has become dated. It doesn't provide clear answers on who can own off-world resources and how their trade should be managed. In this framework, China has an opportunity to be the country that paves a road for India and Japan to participate.

This is to be expected. Space exploration has a long way to go until it is completely democratic, thanks mostly to the extreme costs and technological maturity it demands. Until then, China—as much as India, the United States or Russia—will seek to extend its diplomacy where its rovers go and build spatio-economic leverage in the new world order.

The author is the science editor of *The Wire*, a leading online news publication in India.

Rapid Fire Quiz
Chang'e and Yutu

Concept by Wen Zhihong **Quiz designed by** Li Yiqi **Edited by** Li Zhuoxi



From the first visit by Luna-1 in 1959 to the soft landing of Chang'e-4 in 2019, lunar exploration has spanned 60 years, yet unknown realms still wait to be discovered. Let's see what Jia Yang, deputy chief designer of the Chang'e-4 probe and chief designer of the Yutu lunar rover, has to say about Chang'e and Yutu.

Chang'e-4 was originally built as a backup for Chang'e-3. Why did the spacecraft head for the far side of the moon alone instead of "uniting" with its predecessor?

It's true that multiple routes were mapped out for Chang'e-4 including a second exploration near the landing site of Chang'e-3. But we ultimately decided to land the spacecraft on the far side of the moon. The reason behind the decision was simple: Although man had explored the moon several times, landing on the moon's far side represented an unprecedented feat.

If there is no evidence of aliens or extraterrestrial spacecraft on the far side of the moon, what exactly is there?

The moon is an ancient celestial body. It was active three billion years ago, but now the body is still. Landing on the far side of the moon provides us clues about its evolution, which greatly contributes to the study of the early history of the moon and Earth.

A lunar night apparently lasts for two weeks. During the period, are the Chang'e-4 lander and the Yutu-2 lunar rover sleeping in the darkness?

Without solar energy during the lunar night, both the lander and the rover lose power and "fall asleep." During those frigid hours, internal instruments emit heat which helps them survive the night.

Instead of using caterpillar tracks, why was Yutu-2 designed as a six-wheeled rover? If Yutu-2 tips over, can it get up by itself?

Yutu-2's "feet" were indeed an important design feature that was discussed at length. We gave up on the plan for caterpillar tracks because they proved less maintainable. For instance, if a small stone gets stuck in the track, the rover would be stuck. In contrast, wheels are reliable and resource-saving. If Yutu-2 tips over, it cannot stand up again. The solar panels on the back of the lunar rover are fragile and will crack or become contaminated with dirt if it falls down, which

Jia Yang, deputy chief designer of the Chang'e-4 probe and a designer of China's Yutu lunar rover. by Chen Jian

would render it completely useless. So, our focus was to keep it standing and prevent it from falling.

With the help of the Queqiao relay satellite, is it possible to broadcast live from the surface of the moon's far side?
In theory, it is possible, but current communications links cannot meet the requirements for live video streaming.

How long will Yutu-2 work on the moon? How far can it go?
Its designed life expectancy is about three months. We certainly hope that Yutu-2 will journey further than its predecessor.

Will Yutu-2's tracks stay on the moon forever?
That depends on the definition of "forever." The marks will remain for at least hundreds of thousands of years.

What can the lunar rover send back to Earth from the far side of the moon?
Yutu-2 carried several scientific payloads to study the geophysics of the landing zone including soil stratification, soil temperature, mineral elements and other things.

How far apart are China's two Yutu lunar rovers on the moon? Is it possible for them to meet? Will more Yutu rovers be sent to the moon?
The two Yutu lunar rovers are respectively on the near side and far side of the moon, the furthest possible distance from each other. It is likely that they will never meet. In the future, I hope there will be more Yutu rovers on the moon and on other celestial bodies as well.

What is your opinion on extraterrestrial civilizations?
The universe is vast, and human beings are probably not alone. But contact between two civilizations may still be distant. Current human technology cannot establish communication with extremely far places.

An illustration shows Chang'e-3 awaiting Chang'e-4's arrival on the moon. by Tan Hao

Gu Fangzhou
Sugarcoating Vaccines

Text by Li Zhuoxi

On January 2, 2019, Chinese virologist Gu Fangzhou passed away at the age of 92. Not until his passing did many come to appreciate the "father of sugar pills" in China.

Gu Fangzhou, a renowned Chinese virologist and former president of Peking Union Medical College, who passed away on January 2, 2019. He protected the health of generations of Chinese people with the sugarcoated polio vaccine he invented. Xinhua

Most Chinese people born after the 1960s share a similar memory: When they were young, they were given a small white sugar pill that melted instantly on their tongue. In the days when food, clothing and commodities were scarce, this "candy" lingered as a sweet memory in the minds of many children. This seemingly insignificant sugarcoated pill has saved the lives of countless Chinese children and completely eliminated polio in China.

On January 2, 2019, virology expert Gu Fangzhou passed away in Beijing at the age of 92. Not until his passing did many come to appreciate China's "father of sugar pills."

Difficult Times

A highly infectious viral disease, polio is most likely to affect children. Many infected with the disease suffer from life-long disabilities even after they recover. Many had limbs amputated, others became paralyzed and countless lives were lost to the virus. In the 1950s, fear of polio was rooted deep in the hearts of Chinese.

In 1955, a disastrous polio outbreak in Nantong, eastern China's Jiangsu Province affected 1,680 people. The epidemic resulted

in 466 deaths, and polio spread to neighboring areas. Appalled by the massive number of casualties, the government designated Gu Fangzhou, who had just returned from a scientific expedition to the Soviet Union, to develop a vaccine.

The same year, Gu and his research team traveled to the mountainous areas of Yunnan Province in southwestern China to prepare a polio vaccine production base with the goal of developing and producing 4.5 million doses. The production base was situated on Yu'an Mountain in Kunming, which lacked roads, water and electricity at the time. It took only nine months for researchers to build shelters and transport the equipment themselves, and soon a vaccine production base was functioning on the barren hills.

"We had nowhere to live up there," Gu recalled. "We had to set up our own base and work everything out by ourselves. There wasn't enough food. It was a very difficult period."

In early 1960, China successfully developed a polio vaccine. The vaccine, however, could not be used immediately without clinical trials. After passing product quality tests, they also had to pass the crucial final step of human trials. More specifically, the vaccine had to be tested on preschool-aged children. Gu took the bold step of administering an oral vaccine to his one-month-old son. Moved by his determination, his colleagues followed suit and administered the vaccine to their own children which provided strong support for preliminary evaluation of the safety and efficacy of the vaccine.

The team's actions also ideally brought attention to the vaccine. Word spread, and soon clinical tests of 4.5 million people in Beijing, Tianjin, Shanghai, Qingdao and Shenyang evidenced that the incidence rate of polio dropped significantly. The first attempt at polio vaccine research and development proved successful.

December 5, 2006: The polio vaccine (oral sugar pills) at the Yichang Center for Disease Control and Prevention, Hubei Province. IC

Scientist and Strategist

Developing a basic polio vaccine was still not enough for Gu. The second phase, in his eyes, was providing full immunity. To ensure public immunity, a masterplan had to be drawn.

Vaccines can be classified as attenuated or inactivated vaccines. At that time, existing polio vaccines developed in the United States and the Soviet Union generally used injectable inactivated vaccines. Experts held different views: Some argued that inactivated vaccines were safer and that attenuated vaccines could recover virulence in feces after leaving the human body; others stressed that the attenuated vaccine could be distributed in the environment after being discharged from the body to become a natural vaccine that helped human form an immunity barrier that inactivated vaccines could not.

As the debate raged on, Gu determined that an inactivated vaccine was not suitable for China's local conditions. First, inactivated vaccines are costly. Back then, hundreds of millions of children were eagerly awaiting the vaccine, and the government could not afford the costs. Second, injecting children would have required a huge trained epidemic prevention team that China lacked at that time. Above all, although inactivated vaccines can reduce the incidence of the disease, their power to control the epidemic was inadequate. Multiple doses were required, and if antibodies in the blood did not survive long enough, the virus could still cause an epidemic. This situation was confirmed by studies in the United States, Canada and other countries.

Gu Fangzhou, holding a thick stack of research papers, considered his options, and ultimately decided to recommend that the state give up the inactivated vaccine program in favor of attenuated vaccines.

After mass production, the next problem was delivering the vaccine to every child. This also required a refined strategy.

American children could go to health clinics for injections, but this method would not work for China's children at the time. Children living in remote areas such as the Qinghai-Tibet Plateau, the barren areas of Xinjiang Uygur Autonomous Region

May 19, 1987: Children in Yunnan Province taking sugarcoated polio vaccine for free. The live polio vaccine produced by the Institute of Medical Biology under the Chinese Academy of Medical Sciences located in Yunnan Province has accounted for three-quarters of the national output. Xinhua

March 2, 2006: At the Kid Castle Kindergarten in Urumqi, 2.5-year-old Wei Sining is taking a sugar pill. VCG

and the deep mountains of Guizhou Province were most in need of the vaccine. A minor mistake could have led to a relapse. At that time, there was no cold chain service in China. Gu had to figure out how to transport the vaccine across the country while preserving its effectiveness. His solution was sugarcoated pills. Liquid vaccines were invented first but transportation of those vaccines was found to be difficult. After the invention of sugar pills, epidemic prevention personnel could preserve the sugar pills in thermos bottles with ice cubes to ensure the effectiveness of the live vaccines.

Thanks to such innovative strategies, the candy vaccine was embraced in every corner of China. The sugarcoated polio vaccine was available in China's rural areas by 1965, reducing the disease's incidence rate exponentially. In 1978, China began to implement a nationwide immunization program and incidence continued to plummet.

In 2000, the World Health Organization certified China "polio-free." The immunization strategy that Gu Fangzhou embraced for four decades wiped out the disease in China, for good.

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The Most Effective Treatment

—Ideals of E.R. Doctor Guo Shubin

Text by Wen Zhihong **Photographs by** Chen Jian

"Late one night, a pregnant woman who had been in cardiac arrest for more than 20 minutes came in," recalls Guo Shubin. "We immediately began to perform the cesarean section operation while trying our best to save her. Even though her heart still wasn't beating, and the newborn had no heartbeat either, we couldn't give up. After another 20 minutes, the baby suddenly burst out crying, and the mother's heart magically started beating again."

Such breathtaking stories happen almost every day in the emergency department of Beijing Chaoyang Hospital. Guo Shubin, director of the emergency department, considers his division a world apart from other departments. "Dying people coming back to life and families devastated by the loss of one or more members are everyday scenes," says Guo. "For many, this is the last hope to hang on to life."

Leave No Patient Behind

Guo has been working as an emergency physician for quite some time. Before he transferred to Beijing Chaoyang Hospital in 2015, he had been working in the emergency department of Peking Union Medical College Hospital for 13 years, where he excelled in comprehensive departmental management and innovation. When he first arrived at Beijing Chaoyang Hospital, the department's biggest problem in his mind was that emergency resources were being severely taken up by other departments.

"Emergency and non-emergency cases were often mixed together," he explains. "As many as 30 percent or more of patients coming to the emergency department only needed simple treatment or were suffering from geriatric or chronic diseases. Those who really needed emergency treatment were often waiting in line."

This phenomenon is not unique to Beijing Chaoyang Hospital. Compared to emergency systems in developed countries such as the United States and some European countries, the most prominent feature of emergency departments and even the entire medical system in China is the large population base. Statistics from China's National Health Commission show that from January to November 2018, a total of 7.54 billion people received treatment in the country's medical and health institutions, of which 2.76 billion were treated in public hospitals, accounting for 36 percent of the total patients treated. The volume of emergency patients exceeded 120 million as early as 2013.

In many countries, more than 90 percent of patients make their first visits to primary hospitals. However, the situation is different in China because Chinese people have an obvious preference for higher-level hospitals with better-trained medical staff and more advanced equipment. Especially in big cities like Beijing, Class A hospitals like Beijing Chaoyang Hospital, the highest-ranked hospitals in China, are overcrowded throughout the year. Emergency department corridors filled with beds are a common scene.

Guo's primary reform goal was to ensure emergency resources were truly allocated to patients with emergent and severe conditions or those stricken with difficult diseases. "We should never lose a patient who can be saved," stresses Guo. To improve the efficiency of emergency treatment and resource allocation, Guo has been attaching importance to "regional" cooperation of medical resources, which means integrating resources throughout all levels of hospitals within the same area and improving the efficiency of medical referrals between hospitals at various levels based on different medical situations of patients. From May 2016,

Guo Shubin, director of the emergency department of Beijing Chaoyang Hospital. For the past three years, after his reform on process optimization, emergency resources previously occupied by other departments have been released. More efforts have been diverted to severe and complicated cases, with the treatment order and environment being further improved.

Guo began to work on the establishment of a joint out-of-hospital medical treatment system to transfer patients who were out of immediate danger but suffering from combined organic diseases or multi-system disorders. "Patients in the new system can receive medical treatment of the same quality at hospitals of the same levels, and the resources of the emergency department are no longer sapped," explains Guo. Since the number of beds in the emergency department is limited, the vast majority must be saved for patients who need immediate and intensive care.

Another critical step for Guo's reform was closed-off management for emergency rooms and observation rooms. In a small office, a doctor surrounded by a dozen patients and their families is quite a common scene in Chinese hospitals. "For doctors, this kind of situation is quite noisy and makes it hard to focus," says Guo. "We closed off the emergency rooms and observation rooms to reduce distractions and interference during our work."

Guo launched a grading diagnosis and treatment system in his department in February 2017. Patients were classified by international standards for different treatment. First- and second-grade patients in a life-threatening situation would receive active treatment in five minutes, and third- and fourth-grade patients would receive treatment within 15 minutes and two hours, respectively.

The improved process for emergency treatment not only released previously occupied medical resources, but also guaranteed the quality of rescue, improved clinical operations and environment and greatly enhanced medical, social and economic benefits.

Internet Plus Medicine

Guo often compares emergency physicians to "special forces" in the military. They must have quick reaction capabilities, wide-ranging medical skills and the ability to identify dangerous and even fatal symptoms immediately. They must be able to work under great pressure, handle complex matters and communicate effectively with patients and their families. Contrasting their foreign counterparts, Chinese doctors often participate in the entire process of rescuing patients, so their comprehensive skills are often better.

Guo majored in gastroenterology from undergraduate to postdoctoral studies as a medical student. However, since graduation, he has been working as an emergency physician for nearly two decades. Because of his many years in the emergency department, Guo has developed a profound understanding of the general situation. Just as he launched the drive to reform his department, Beijing started its landmark reform to separate drug sales from medical treatment at public hospitals. A highlight of the municipal reform was using the medical reimbursement and medical service fees as leverage to divert patients to different levels of hospitals to increase the workload of community hospitals and other medical institutions at grassroots levels while freeing up higher-level

January 18, 2019: A patient with emergent conditions is sent to Beijing Chaoyang Hospital. In the emergency department of the hospital, guidance information for various medical services is clearly displayed for all visitors entering the area from different entrances.

An open consulting room of internal medicine in Beijing Chaoyang Hospital. Surgery and internal medicine are the two departments which receive the largest number of emergent cases. Open consulting rooms facilitate doctors in keeping an eye on their patients and attending to them in time.

All beds in emergency rooms and observation rooms in Beijing Chaoyang Hospital are equipped with vital signs monitors, ensuring that doctors can observe patients' conditions.

hospitals to concentrate on treating difficult and complicated cases. By the end of 2017, less than a year after the reform was carried out in the capital, the volume of patients visiting Class A hospitals for emergency treatment fell by 12 percent.

Guo's reform of Beijing Chaoyang Hospital's emergency department conformed to the general trend of graded treatment and the establishment of medical unions in China. "The emergency department is the first place in a hospital to treat emergent and severe cases," says Guo. "The current direction of China's medical reform is to divert patients with common diseases to community hospitals and those with emergent, severe and serious illnesses to bigger and higher-level hospitals. So, although the total number of emergency cases in Class A hospitals has dropped, the volume of difficult and complicated cases as well as emergent and severe cases has increased." Today, the emergency department of Beijing Chaoyang Hospital receives 260,000 patients every year, and the proportion of patients with emergent and severe diseases far exceeds that of many other hospitals.

Now in the emergency department of Beijing Chaoyang Hospital, guidance information for various medical services is clearly showed to all visitors entering the area from different entrances. The whole

treatment procedure, from registration to check-up, is displayed at electronic screens. Doctors attending ward rounds carry mobile devices to receive triage information and no longer need to sort through thick stacks of paper medical records. All beds in emergency rooms and observation rooms are equipped with vital signs monitors. And a large liquid crystal display is installed in every emergency room to ensure that doctors can keep an eye on patients' conditions and attend to them in time.

At the end of 2018, the Chinese Academy of Medical Sciences issued a ranking of hospitals' emergency medicine scientific and technological influence. The breadth and depth of hospitals' scientific and technological activities were evaluated on three aspects: scientific and technological output, academic influence, and scientific and technological conditions. The emergency department of Beijing Chaoyang Hospital ranked second on the list, only behind West China Hospital of Sichuan University.

But Guo's vision is even broader. Beginning in 2018, he promoted the establishment of a remote clinical diagnosis and treatment center in his hospital, with an aim to integrate thousands of hospitals in China into a system to share remote medical teaching and treatment processes. Against a backdrop of the fast development of both the internet and artificial intelligence in China, Guo hopes that more hospitals at grassroots levels can share experience with large hospitals to push the country's medical system to become fairer.

Guo believes that in the near future, virtual reality devices or a pair of Google glasses could help young doctors at community hospitals in China watch professors and senior doctors from Beijing's Class A hospitals attend ward rounds or discuss complicated cases in real time.

Science Popularization

Guo holds quite a few social titles alongside being director of the emergency department of Beijing Chaoyang Hospital. The titles he values most include member of the Science Popularization Committee under the Chinese Medical Association and head of the Medical Science Popularization Society under the Chinese Medical Doctor Association.

Guo recalls the scene when a senior patient with severe cerebral infarction was sent to the emergency department. The patient was still conscious when he arrived, but soon lost consciousness. His family couldn't accept that his conditions worsened after he arrived at the hospital and accused the hospital of malpractice. A doctor-patient dispute was about to ensue.

"I came to the room, spent several minutes quickly analyzing the patient's condition and explained the whole situation to his family," recounts Guo. "Much of the general public doesn't quite understand that plenty of conditions are not diseases as much as results of the irreversible aging process. When some people reach a certain age, some diseases may become unavoidable."

Guo thinks it important to provide ordinary people with as much medical science knowledge as possible to help avoid preventable diseases and ensure every condition is treated correctly. Such a trend would be greatly significant for the development of medical science popularization, which aligns with the future direction and strategy of China's medical reform.

Two years ago, the Chinese Union for Medical Science Popularization was established thanks in part to Guo's efforts. Guo was elected its chairman. Statistics released at the launch ceremony were thought-provoking: Compared to developed Western countries, the general public in China doesn't have adequate knowledge of medical science. A 2015 survey by China Association for Science and Technology showed that only 6.2 percent of Chinese people were equipped with adequate scientific knowledge. People's knowledge about health and capabilities to rescue others in emergencies were also insufficient.

"Statistics show that investing one dollar in medical science popularization generates an 'income' of seven dollars," asserts Guo. "Investing more can also drop the incidence rates for some diseases. Patients equipped with enough medical knowledge will find the right help, reducing both their expenses and pain. All of society will benefit from medical science popularization."

Guo often participates in the health programs hosted by well-known Chinese media, spreading health knowledge to the public and promoting social awareness on health and healthy lifestyles. He also promoted the Chinese Union for Medical Science Popularization to bring various organizations together, to inspire medical professionals to spread science knowledge and to work with mainstream Chinese social media platforms to build a large stage for health science popularization.

Guo believes there are three types of "good doctors." The first possesses fine medical skills and saves abundant people. The second has strong management capabilities, so they save even more people by leading excellent medical teams. The third was born with a heart for public good. They employ various means to popularize medical knowledge, which could benefit the most people. To Guo, the third type is the charm and the top tier of medicine.

No-Waste Games

Text by Zi Mei **Photographs courtesy of** Novaloop with Friends of Nature

Thanks to zero-waste games and events, public awareness about environmental protection and garbage sorting is on the rise.

Against a backdrop of green mountains and clear water, the Fuxian Lake Marathon commenced. Contrasting traditional marathons, this event called for zero-waste running and 118 runners volunteered to use non-disposable cups, becoming the torchbearers of the zero-waste campaign.

Waste from Races

An event like the Beijing Marathon with about 30,000 participants would require 500,000 paper cups along with other disposable items such as plastic bottles, sponges and food packaging. Japanese scholars estimate that the Tokyo Marathon, usually involving about 50,000 persons in total (including athletes, working staff and audience), would produce waste and carbon emission equal to the volume discharged by 300,000 persons in a day. So, large-scale races cause extra burden on urban garbage disposal systems which have already been facing great challenges.

During the Fuxian Lake Marathon, a runner holds a non-disposable cup while pointing to his zero-waste volunteer badge.

A single marathon event produces more wastes, and such events are becoming more frequent. In 2017, China held 1,202 marathons involving over 4.98 million participants. In 2011, the two figures were only 22 and 400,000, respectively. According to a plan for developing the marathon industry issued by China's General Administration of Sport, marathon events held in China are expected to reach 1,900 by 2020 and attract 10 million runners. It will not be hard to achieve this goal based on the current growth rate. The frequency of outdoor concerts, carnivals and other cultural activities is also rising annually. Traditional and emerging tourist cities turn to sports and cultural events to promote the local economy. Without any measures, the waste from those events would pose a great threat to the environment.

Green Marathons

Wu Xiao is a fan of marathons as well as a "green" runner. When he realized how much waste was

A recycling station is set up for sorted garbage with volunteers providing a guide for the audience.

created by the events, he decided to do something. In 2016, he and several other volunteers tried zero-waste practice in several marathons and other races. "We felt great," Wu recalled. "Both the runners and organizers recognized the idea. Players didn't sacrifice their running experience for environmental protection and sponsors believed the idea elevated their brand value. At that time, I began to believe it was promising to promote zero-waste practice in games and events."

"Zero-waste" does not mean no garbage at all, although that is the eventual goal of zero-waste practitioners. They propose the three Rs—reduce, reuse and recycle, focusing on rubbish reduction, non-disposable usage and waste recycling.

Later, Wu joined the Friends

of Nature, an environmental NGO, to set up Novaloop, a team specially engaged in promoting zero-waste games and providing related services. Already, they have served more than 30 large-scale games and events. The Fuxian Lake Marathon is one of them. To better protect Fuxian Lake, one of the most important national drinkable water sources, the organizer of the marathon hired Wu's team to oversee the game's environmental protection work.

"Upon receiving the organizing committee's invitation, we were ecstatic that they had such awareness," exclaimed Wu. "During our preparations, we are surprised by the participants' enthusiasm. When we were still brainstorming how to recruit enough runner-volunteers to 'give up disposable paper cups,' the 118 needed volunteers signed up in less than half an hour."

In addition to reducing paper cups, the team recycled the majority of used cups and sent them to a waste paper treatment plant. At the starting and finishing lines, 30 volunteers managed 54 dustbins for different categories of waste and helped collect and sort garbage on the spot. Guided by volunteers, participants learned how to sort garbage including left-over food, bottles, paper cups and other waste.

"Maybe such a campaign only does a little for real-time environmental protection," admitted Li Penghui, head of the Publicity Base of the Publicity and Education Center under China's Ministry of Ecology and Environment. "But it does a lot to change people's habits."

Volunteers have always played an important role in zero-waste games and events, which are gaining popularity in China.

At the end of the MTA Festival, the audience spontaneously picks up trash that was created not only by themselves but also by others.

Cleanest Music Festival

Japan's Fuji Rock Festival is known as "the cleanest festival in the world." Gao Xiaosong, a famous Chinese musician, recalled his experience at the event: After the festival ended at midnight, 100,000 spectators left the venue, each holding a garbage bag. And then all of them lined up to throw the garbage in their bags into six different types of dumpsters, which lasted until 2 a.m.

On May 18 of last year, the 2018 MTA (Music, Technology and Art) Festival opened. Wu Xiao's team, along with some volunteers from Japan, endeavored to make it the cleanest in China. In addition to reducing and sorting garbage, a stall was set up to display how waste can be changed into valuable things such as T-shirts with recycled plastic bottles as raw material. Environmental slogans and posters adapted from lyrics familiar to music fans could also be found at the concert.

"Garbage sorting has been going on for 20 years in Japan—household waste is also sorted. But China hasn't done it yet. This is a big difference," noted Kanta Hani, founder of iPledge, a Japanese environmental

At the MTA Festival, environmental slogans and posters adapted from lyrics familiar to music fans can be found to encourage them to practice zero-waste.

protection agency that serves the "zero-waste" Fuji Rock Festival. "Fuji Rock began the zero-waste practice in 1998. After just three years of efforts, it became 'the cleanest music festival' in the world. I think the MTA Festival still needs at least three to five years to reach the goal."

Wu Xiao, chief planner of the zero-waste campaign for the MTA Festival, noted that despite the gap, the improvement in Chinese people's awareness of environmental protection is obvious. "At the end of the festival, music fans began picking up garbage that was created not only by themselves but also by others. I was really moved."

Alongside the efforts of the public and NGOs, governments at all levels in China are encouraging zero-waste games and events. The environmental protection department of the organizing committee of Beijing 2022 Winter Olympics has entrusted Wu's Novaloop to collect experience from past events.

"As case studies, experience gleaned from past events including the MTA Festival will go into reports to be submitted to the organizing committee as part of an effort to provide references for the environmental protection work of Beijing 2022 Winter Olympics," explained Wu. "With the original aspiration for a green life, we encourage each organizer to make even tiny progress. We don't expect a great leap and just hope our participation can contribute a little bit to China's environmental progress."

Hebi

Big Ideas from a Small City

Text by Zhou Xin

The stunning transformation of a small city in central China has attracted many foreign students from emerging markets.

With little water in its bed in chilly December, a 500-year-old canal crosses in front of the rebuilt gate of the ancient county of Xunxian in Hebi City, central China's Henan Province. The canal is part of the Beijing-Hangzhou Grand Canal, which once fueled the prosperity of the county hundreds of years ago. And it is now part of an amazing transformation of the county in a different age.

Not long ago, Xunxian County, home to a 2,000-year-old town, welcomed a group of 52 international students from 30 developing countries including Laos, Egypt and Sudan. These students from the Emerging Markets Institute of Beijing Normal University visited for a glimpse of the brilliant transformation of the county as well as the city of Hebi, to which it is affiliated.

An Ancient Town and Foreign Visitors

Residents of Xunxian County didn't have much experience meeting foreigners. When the foreign visitors entered through the front gate of the town, crowds formed to witness the spectacle, some even recording video of the event with their phones. Some foreign students blurted "*ni hao*" (hello) to the curious crowd. Surprised and excited, the locals quickly replied with the same. Some even dared say in English, "Nice to meet you too," but quickly turned away with a shy smile. Despite encouragement to greet the foreign friends, a small local child opted to hide behind his grandma.

The rebuilt ancient town was intended to be a tourist attraction. The structure of traditional residences, the offices from the past and ancient ways of Chinese life are interesting for foreigners. Chittanavong Bounnam from Laos deemed it a good cultural site. "I really like the culture here," he grinned. "Those people here seem to have rarely met any foreigners before. Perhaps they should advertise more to attract more foreigners."

Following the lead of this group of foreign guests, perhaps more and more foreigners will venture to the ancient town.

Kassa Abraha Amare from Ethiopia is greatly intrigued by Chinese culture. In such a hotbed of ancient Chinese culture, he

The Qihe National Wetland Park with its beautiful natural environment in Hebi City, Henan Province, in August 2017. The province has made great efforts to promote poverty alleviation and seek prosperity by developing ecotourism. by Feng Dapeng/Xinhua

persistently kept notes, especially in places like the riverside park with over 1,000 Chinese poems carved in an extraordinarily long corridor. He believes there are many similarities between the ancient cultures of China and his motherland.

Atop the narrow streets of the county are the occasional motorized vehicles flanked by a mix of bicycles, electric bicycles and tricycles. The heavy concentration of clean-energy transportation is a sign of the town's endeavors to promote green transportation. Along the streets, giant billboards for smartphone brands

Students from the Emerging Markets Institute of Beijing Normal University examine ancient Chinese poems carved on the wall in a long riverside corridor in Hebi City, Henan Province. by Zhou Xin

such as Oppo and Vivo—now seen in numerous small Chinese towns—evidence the massive expansion of smartphone marketing and sales in China's rural areas. The influence of the mobile internet has reached every corner of China. Some buildings are a bit run-down but maybe just temporarily as they await renovation.

Big Data Agriculture

Henan Province has been a traditional agricultural powerhouse. Expectedly, Hebi City is a strong agricultural producer, with per capita output value of animal husbandry, meat and milk ranking top in the province for over two decades in a row. In the era of e-commerce and information technology, the city is also modernizing its agricultural production and sales. Perhaps the most impressive is a digital platform providing information on agricultural products, services and e-commerce.

On the screen of a smart agricultural experience center, one can find the information of the prices of agricultural products, the situation of farm production in certain places and other important information. According to the head of the center, it is also trying to collect information on agricultural products from Henan Province and labeling them to improve the quality of agricultural production by tracing the source of every single agricultural product. Alongside selling products online, the platform also invites teams of drones to perform agricultural work. The pesticide-spraying drones can be ordered online by farmers according to their needs.

The technology was developed by Hebi Agricultural Silicon Valley, which has been operating since 2013. It was established by a Beijing-based company working with agricultural information. The ambitious agricultural information platform has been working on constructing "new infrastructure for agriculture" in the internet age: cloud computing, big data, the Internet of Things, and artificial intelligence.

Hisham Abubakr Metwally Mohamed is an economic researcher from Egypt. He praised the development of smart agriculture in Hebi. "This is an advanced system that our country doesn't have, so there are a lot of opportunities for cooperation," he opined.

Drones have been widely applied in agricultural activities in Henan Province. by Feng Dapeng/Xinhua

December 21, 2018: Students from the Emerging Markets Institute of Beijing Normal University pose for a group picture at a tourist spot in Hebi City, Henan Province. by Zhou Xin

March 2, 2018: A smart self-propelled irrigation machine operates at a high-standard agricultural demonstration zone in Xunxian County, Henan Province. by Li An/Xinhua

Experience for Emerging Markets

Hu Biliang, dean of the Emerging Markets Institute of Beijing Normal University, noted that the experience of Hebi's transformation is significant for other developing countries. Hu once taught in places including Xunxian County in 1985. When he returned for a survey arranged by the central government in 2007, he was astonished by the drastic change that had taken place over 22 years.

He remarked that Henan is strong in both industrial and agricultural production. The province is always known for its agricultural production: It produces a quarter of the nation's wheat and a tenth of all the nation's grain. But Henan is also home to large-scale industry, with its GDP ranking among the top in China. The province has enjoyed a relatively fast economic growth rate, with a gradually balanced development of agriculture and industry.

As a young city established in 1957, Hebi emerged around its abundant coal mines. With a proven reserve of 1.74 billion tons of coal, the city was once prosperous due to industries related to coal and power production. It is now in the process of restructuring its economy to become more balanced.

Liu Wenbiao, vice mayor of the city, declared that Hebi is in the process of transformation. Its conventional industries are becoming smarter, he said, citing companies producing smart household decoration and LED products instead of coal byproducts. As for agriculture, he said that the city is working to integrate primary, secondary and tertiary industries as well as large e-commerce enterprises that offer services to villages.

"This province, especially this city, has become a good place for developing countries to research agricultural and industrial modernization and transformation," added Hu.

Transforming Jobs in the Age of AI

Text by Joe Luc Barnes

Should companies use AI to increase productivity and profits, or do they also have a duty to improve the day-to-day routine of their employees?

The future of labor in a digital economy has become a heated topic alongside the emergence of artificial intelligence (AI). Will the proliferation of AI and robotics herald human redundancy as a working species?

This prospect has inspired pessimism in many Western countries that is not shared by most Chinese. Indeed, according to a survey compiled by the Dentsu Aegis Network, just 18 percent of British and German citizens feel that new digital technologies will create job opportunities over the next five to ten years. In China, a country with a labor force of around 800 million, 65 percent of people believe that AI will create even more work.

Government Backing

A major factor is that few governments are embracing the digital age with as much gusto as China. In July 2017, China's State Council set a national goal of becoming the world's primary AI innovation center, aiming to foster an AI industry that produces in excess of one trillion yuan (US$147.7 billion) by 2030.

Such enthusiasm has seeped right down to the municipal level, with local governments especially keen to support startups in the sector.

"The business environment in China and especially Shanghai is very attractive," says Stéphane Truong, founder of Actionable Data, an AI consultancy service company. "I have seen a lot of initiative from several city districts such as collaboration with incubators to propose ancillary services, organizing competition for financial subsidies and providing a flexible fiscal policy."

But Beijing has perhaps created the most fertile environment for tech startups. The capital's Zhongguancun area is known as China's "Silicon Valley" due to concentration of tech startups based there. Its proximity to China's two premier academic institutions, Peking and Tsinghua universities, makes it a happy hunting ground for new talent.

Disappearing Jobs

One startup is Oriental iFly, which aims to use AI to create an automatic grading system for essays that provides instant feedback to teachers on students' work and saves time spent marking.

I asked one of the company's product designers, Kailin Xie, whether this innovation might put teachers out of work.

"Teachers aren't hired to grade," she asserts. "As long as there are students, teachers will be necessary. Grading is just an extraneous part of the job. Our product enables a teacher to save dozens of hours a week on marking essays."

Is a school likely to pay those teachers the same for less work? Or will it instead use those extra hours to give them more classes, which would reduce personnel requirements?

Such questions could be some of the defining issues of the digital age. Should companies use AI to increase productivity and profits, or do they also have a duty to improve the day-to-day routine of their employees?

Business Optimism

Much of the tech community has adopted the belief that these problems will simply sort themselves out. This is certainly the attitude of Stuart Leitch, founder of Lollipop.ai, a Seattle and Shanghai-based software company that uses AI to improve customer engagement with online products. "Firms have a very bad habit of hiring for unnecessary positions. The employees aren't bad, but their duties usually involve repetitive, brainless and low-value work."

"We want to release people from those positions and reduce the cost of that kind of work so those people can do more meaningful things. At the end of the day, we expect to create jobs across industries rather

January 16, 2019: In the clinic hall of the Chinese PLA General Hospital (Hospital 301), four new intelligent guidance robots offer counseling services. VCG

than put people out of work," explains Leitch.

He has plans to expand his seven-strong team considerably in 2019.

But what of the manufacturing jobs that have served as the backbone of China's economic growth? Many are likely to go, admits Denny Xu, vice president of the Shanghai Haihe IT Company, which produces intelligent speech robots.

"AI will change future employment trends and patterns," he explains. "Now, the labor force is too costly, so lower-level labor will largely be replaced by AI-related technology. But humans won't be completely unnecessary—human-machine coupling will become a future trend for enterprises and businesses."

Skills Gap

To a large extent, the challenge is retraining people. Thousands of brand new jobs are being created. In fact, a growing complaint from business leaders and recruiters is a lack of talent with the necessary skills to fill emerging jobs.

Stuart Leitch notes, "It's especially difficult to find talent on the development front. Since the skills most in-demand for our business are hard data science and machine-learning skills, we're finding that we need PhD-level candidates, which are few and far between. It may become necessary to just hire go-getters who can learn quickly but don't necessarily have experience."

Stéphane Truong at Actionable Data has similar issues. "My company would ideally employ candidates with at least a master's degree in computer science. We offer a very competitive package, but the battle for talent is rough because employees are more attracted to mature companies."

Technology Education

With such a limited talent pool, domestic Chinese tech giants like Alibaba and Tencent usually have first pick of the best talent.

But China's edge on other countries may be its realization of the role that education plays in digitalizing the economy. Beijing has sunk major investment into computer science programs at its major universities, which is slowly starting to pay off.

Tsinghua University produced more of the top one-percent most highly cited papers in math and computing disciplines than any other in the world between 2013 and 2016. Much of the situation is about money: While Chinese professors still don't earn as much as their American counterparts, many of them are still offered over US$100,000 per year, making China vastly more competitive academically.

U.S. News & World Report even ranked the university as the number one computer science institution in the world in 2018. The fact that China is now competing with Western universities in this vital field is an immense achievement and will be key to unlocking AI potential in the country.

"After all," says Denny Xu, "AI is a new tech field—millions of young people with dreams will choose to work in this realm."

The author is a recent graduate from the University of Oxford.

Discovering Children's Museum Education

Text by Gong Haiying

Photographs courtesy of the Children's Museum Research Center and the Laoniu Children's Discovery Museum at China National Children's Center

In today's China, museum education designed for children is attracting more and more attention. Efforts to harness museum resources have created a better environment to meet the growing needs of children.

Children play in the "Happy Ball" exhibition area. At the Laoniu Children's Discovery Museum, having fun seems to be the ultimate goal for children.

The project called "Construction Site" combines hands-on experience with skills such as climbing, using building blocks, transporting and collaborating to inspire children to explore architecture freely.

"Adventurous Stairs" can help children build courage and determination and enhance coordination and physical balance by climbing up floor to floor.

The Laoniu Children's Discovery Museum inside China National Children's Center is one of the largest children's museums in Beijing. It features exhibits and entertainment facilities for children up to age seven. Unlike the passive entertainment facilities in theme parks, the 2,400-square-meter museum is designed to blend knowledge about culture, society and science. The exhibitions combine interesting educational content to inspire children to think and explore actively.

Exploration Fun

After stepping into the museum with his mother for the first time, five-year-old Guoguo was instantly drawn to the climbing facilities resembling those found in amusement parks. He quickly climbed to the highest level seven to eight meters above the ground. Then, he noticed several children throwing foam blocks of various shapes into a glass tube and immediately joined in. His mother discovered that the whole climbing area was designed to be integrated with the glass tube, and long conveyer belts were installed on both sides. Several children and parents were transporting building blocks to the climbing area. As all of them worked together, the stacked blocks gradually formed a wall.

Zhao Yaqin, curator of the museum, explained that the project called "Construction Site," combined hands-on experience with skills such as climbing, adding

The Laoniu Children's Discovery Museum inside China National Children's Center is one of the largest children's museums in Beijing. It features exhibits and entertainment facilities for children up to age seven.

On May 31, 2018, with the support of the governments of Inner Mongolia Autonomous Region and Hohhot City, another Laoniu Children's Discovery Museum began trial operation in Hohhot.

building blocks, transporting and collaborating to inspire children to explore architecture freely.

At the museum, "having fun" seems to be the ultimate goal for children. Each theme exhibition area integrates learning into a game by adding fun elements that enhance children's cognitive abilities. "Happy Ball" is a favorite for children. They place balls on different conveyer belts to feed them into a big box overhead. When the box is filled with balls, it automatically opens, and the balls fall together. Eager to feel the balls falling on them, the children wait in groups below. The task subtly demands cooperation from children playing the game.

American Concept Comes to China

The idea of founding the discovery museum originated from Niu Gensheng, founder of Laoniu Foundation, during an environmental project tour in Hawaii at the end of 2011. By chance he visited the Hawaii Children's Discovery Center in the United States, where exhibitions focus on experience and interaction. Contrasting traditional exhibition-themed museums, it focuses on catering to children's hands-on exploration. After the visit, Niu decided to introduce the project to China, which led to the opening of the discovery museum.

At that time, the Magic Bean House Children's Museum in Beijing was China's only museum that integrated leading international educational ideas. Founded in 2010, the museum is in fact the country's first children's museum registered as a member of the Association of Children's Museums. The idea to establish this museum popped into the head of its founder Zhang Ni when she was studying for a master's degree in education at Columbia University. She was struck by the difference between Chinese and American educational concepts. After graduation, she raised the funds by herself and collaborated with professional teams in the United States and Singapore to establish the small experimental institution of only 500 square meters. Shortly after the Magic Bean House opened, Zhang wrote that exhibits of a successful children's museum must interact with visitors in some way rather than just sit on display.

After extensive preparatory work involving Zhang, the Laoniu Foundation and Beijing Normal University established the Children's Museum Research Center in China, and Zhang Ni was invited to serve as its executive vice-director. The organization directly pushed for the development of the Laoniu

Children's Discovery Museums in Beijing, Shanghai, Hong Kong and other regions and eventually became a leading educational research institution in China's museum education for children.

As Zhang pointed out, unlike Western children's museums funded mostly by non-governmental public welfare donations, the Laoniu Children's Discovery Museums have received strong support from Chinese government agencies. For instance, the Beijing-based Laoniu Children's Discovery Museum that opened in 2015 has received a special allocation of more than 20 million yuan (about US$3 million) from the central government. On May 31, 2018, with the support of the governments of Inner Mongolia Autonomous Region and Hohhot City, another Laoniu Children's Discovery Museum began trial operation in Hohhot.

Zhang Ni (third right), executive vice director of the Children's Museum Research Center in China, at a seminar on museum education for children in Guangdong Museum in July 2018. These specially designed museums are drawing more and more attention in China these days.

The Children's Museum Research Center has made great efforts to promote children's museum education. In May 2018, representatives of the research center went to Denmark to participate in the third phase of a Laoniu Chinese early childhood education talent training project sponsored by H.C. Andersen International Kindergarten College.

A Brighter Future

The museum project advocates the idea that a "children's museum should not convey adults' understanding of knowledge, but instead adapt to children's growth patterns." It provides a new method for improving and enriching the children's education function of Chinese museums and a new idea for China's early childhood education reform.

In 2015, China promulgated and enacted the *Regulations on Museums*, which lists education as the primary function of museums. This aligns with the international concept of museums. Zhang pointed out that traditional museums are also greatly influenced by children's museums and have begun investing more into their educational role for children. She said that the Children's Museum Research Center has been increasing cooperation with traditional museums in recent years and has conducted many training programs on designing exhibition projects suitable for children, which has achieved promising results.

As a form of extensional education, how will children's museum education affect overall educational reform in China? Zhang believes that educational equity should be the primary concern. At present, the Laoniu Children's Discovery Museums are making tremendous efforts in this regard. They have launched the "Children+365 Program," which aims to help poor children, children with special diseases and other vulnerable groups enjoy children's museums. Organizers hope that with guidance and education for parents, advanced educational concepts can enter every family.

In China, more and more attention has been placed on children's museum education. Efforts to promote children's museum education have created a better environment to meet the growing needs of children.

Starry Skies

—Spring Festival Visit to Beijing Space City by China Artists Association

Text by Zhao Yue **Photographs by** Guo Shasha

"We hope that the future will bring more chances for artists to visit satellite and rocket launch sites and workplaces of frontline aerospace professionals. We want to see and inspire more artistic works on China's space heroes."

"I look quite resolute and firm in this painting," Chen Dong remarked, pointing at a portrait of him that Professor Sun Hao of China's National Defense University of the People's Liberation Army created. "It looks like I am ready to get down to business." Chen, a 41-year-old astronaut, successfully participated in the Shenzhou-11 manned mission in 2016. "I was quite excited for this event because it was my first chance to work as a model," grinned Chen. Astronauts and other space workers don't usually pose on site for artists. The unusual scene happened during the Spring Festival visit of China Artists Association's volunteers to Beijing Space City located in the northwestern suburb of China's capital city. The visit was part of the "Going Grassroots and Delivering Joy" campaign, a key cultural project of the China Federation of Literary and Art Circles.

During the campaign, renowned artists volunteered to form groups to provide the general public with "artistic services." China's aerospace industry has developed at breakneck speed in recent years. From China's manned spaceflight program Shenzhou to the country's lunar mission Chang'e, a series of key space projects have been successfully completed. On January 3, 2019, China's Chang'e-4 probe touched down on the far side of the moon, stirring up a huge sensation both at home and abroad. Many flight control tasks for the Chang'e-4 mission were performed at Beijing Space City. To salute to aerospace workers, a volunteer group of painters and calligraphers from China Artists Association visited Beijing Space City to pay respect to space heroes with their artistic works.

Led by Xu Li, secretary of the Party Committee and vice president of the Standing Committee of China Artists Association, the volunteer group created works for space workers. Artists produced Spring Festival couplets, various calligraphic works featuring the Chinese character for "happiness," landscape paintings, and bird-and-flower paintings. The

Space worker Li Haitao examines his portrait. Li made important contributions to China's lunar program.

Wang Yaping (left), the second Chinese woman in space for the Shenzhou-10 mission, poses for a picture with Professor Peng Huajing from Capital Normal University beside her portrait painted by Peng.

Space worker Zhang Jinwei examines his portrait. Zhang is an outstanding representative of the Chinese aerospace support personnel.

Xu Li, secretary of the Party Committee and vice president of the Standing Committee of China Artists Association, writes calligraphy for space workers.

painters also produced portraits of astronauts Jing Haipeng, Wang Yaping and Chen Dong on site as well as those of three other space science and technology professionals. All of the three astronauts had successfully returned from manned space missions. Among them, Jing Haipeng has gone to space three times. As for the three space workers, Liu Yong and Li Haitao have made important contributions to China's lunar exploration program, and Zhang Jinwei is an outstanding representative of Chinese aerospace support personnel. Through the brushes of the painters, the features and personalities of those space heroes were vividly captured.

Artists also toured the space city to visit scientific research venues and facilities. Contrasting its counterparts around the world which gained fame due to space programs such as Houston, Beijing Space City is not so much a "city," but the location of China Astronaut Research and Training Center. It is China's first and the world's third space mission control center with high-level capabilities in measurement, flight control and orbit determination. Its tasks include the command, dispatch and flight control of China's manned spaceflight missions, as well as the selection and training of astronauts. It has nurtured several world-renowned Chinese astronauts.

Through the visit, the artists gained a deeper understanding of the hardship of space work. "We felt quite honored and happy to visit Beijing Space City," declared Xu Li. "We hope that the future will bring more chances for artists to visit satellite and rocket launch sites and workplaces of frontline aerospace professionals. We want to create more artistic works to honor China's space heroes."

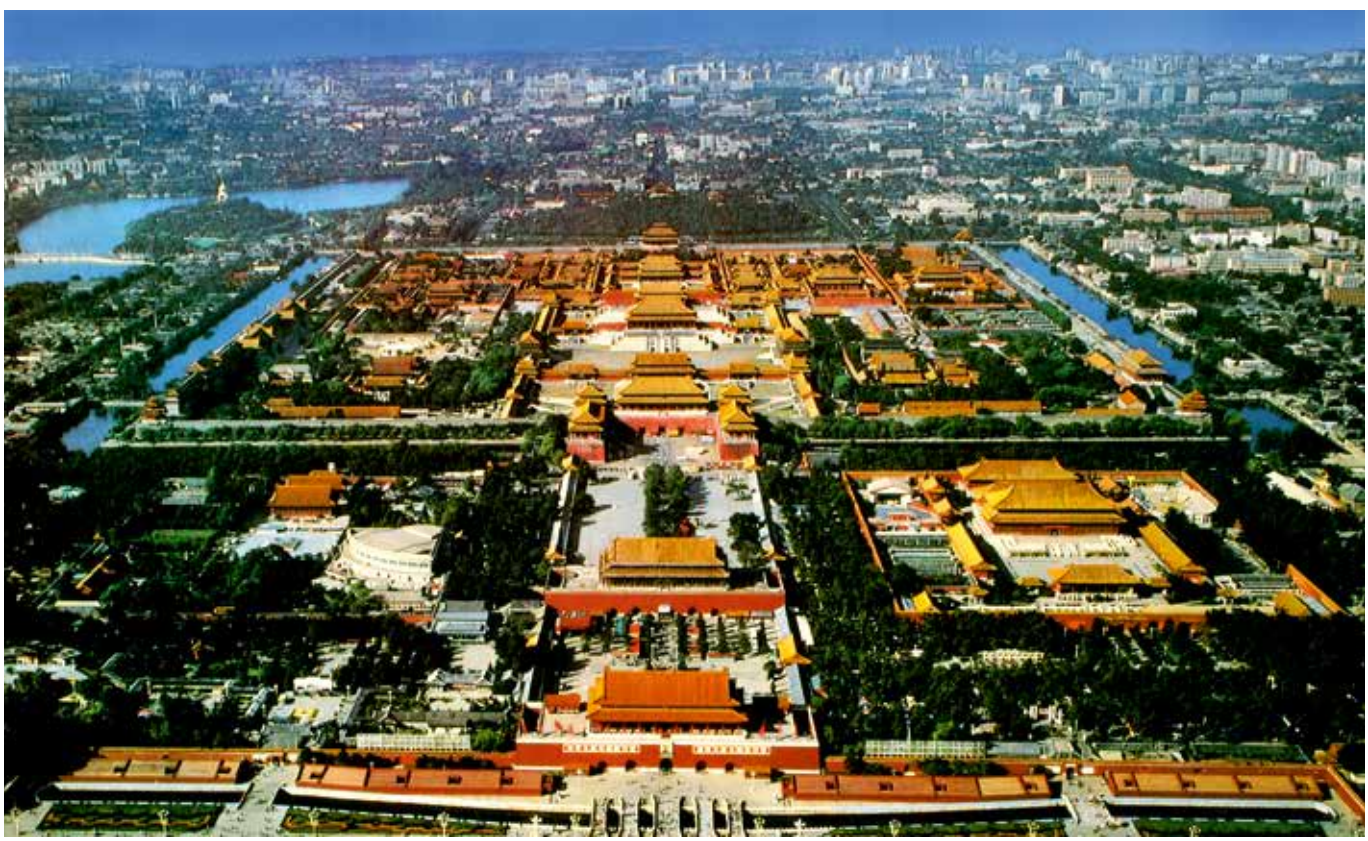
The Forbidden City, a book compiled by the production team of the documentary series with the same title and published by China Workers Publishing House in October 2018.

Grand Tribute to the Forbidden City

The book, The Forbidden City*, captures information gathered from the production process of the documentary series with the same title and delivers new understanding and insights into the history and stories of the imperial palace and cultural relics collected there over the centuries.*

As the imperial palace of the Ming (1368-1644) and Qing (1644-1911) dynasties, the Forbidden City preserved the cultural essence of ancient China, especially of the Ming and Qing periods, and became one of the most important carriers of Chinese civilization.

The book, *The Forbidden City*, derives from the 12-episode large-scale documentary series with the same title presented by China Central Television (CCTV)



A bird's-eye view of the Forbidden City. As the imperial palace of the Ming (1368-1644) and Qing (1644-1911) dynasties, the Forbidden City is dubbed one of the most important carriers of Chinese civilization.

in 2005. Featuring many experts from CCTV, the Palace Museum and other related fields, the documentary was produced in a parallel structure to comprehensively display the rich historical, social and cultural connotations of the Forbidden City from aspects of its architecture, functionality, cultural relics, development and evolution. The production has been regarded as a model work with grand narration.

More than a simple transcript of the documentary's commentary, the book provides a deeper interpretation of concepts featured in the documentary. It highlights many new understandings and perceptions of the construction process and architectural features of the imperial palace, important ritual activities, political and living functions, representative cultural relics and its history and stories over the centuries.

However, the book aligns with the documentary in terms of narrative methods such as detailing, oral style and scene reproduction, so it helps readers grasp the stories of many imperial figures and historical events including some previously unknown to the public. It provides a better way to understand history.

Furthermore, the documentary series, *The Forbidden City*, employed many unprecedented techniques in shooting. Chinese cinematographer Zhao Xiaoding, who was nominated for the Academy Award for Best Cinematography in 2005, and famous Japanese cinematographer Tsutomu Akahira were invited to provide photographic consultation, so the production became China's first documentary to earn both rave reviews internationally and impressive viewership domestically.

Former Chinese Vice Minister of Culture Zheng Xinmiao, who ever served as director of the Palace Museum, wrote in the preface to the book that the documentary's success was based on the painstaking efforts of many contributors. Not only was it the first profitable documentary in CCTV history, but it has become the most highly regarded work interpreting the history and culture of the Forbidden City.

Zhao Wei, lead producer and writer of the documentary, pointed out that this book would not only be an honor to all contributors to the film, but also bring new life to the documentary.

The Qianlong Emperor in Ceremonial Armor on Horseback, by Giuseppe Castiglione (1688–1766). Castiglione was originally an Italian missionary. After he became a court painter in the Qing Dynasty (1644-1911), he devoted himself to the integration of Chinese and Western painting, which greatly influenced the style of court painting in the Qing Dynasty.

Celebrating Spring Festival in the Palace

Text by Yi Mei

The exhibition "Celebrating Spring Festival in the Forbidden City" takes visitors back hundreds of years to witness how royal families celebrated Chinese New Year.

Chinese New Year, also known as the Spring Festival, is the most important traditional festival in China, during which the Chinese people paste couplets on doors, make dumplings and watch the Spring Festival Gala. But in centuries past, how did the Qing Dynasty (1644-1911) emperors celebrate this major festival? Held in the Palace Museum (also known as the Forbidden City), the exhibition "Celebrating Spring Festival in the Forbidden City" provides some insight with 900 pieces (or sets) of cultural relics on display to fully illuminate celebration customs for Chinese New Year during the Qing Dynasty. Imbued with festive atmosphere and offering extensive interactions, the exhibition provides a feast for visitors' eyes and noses as well.

"Just like today, the central theme of Chinese New Year in ancient times involved, royal families and ordinary people alike, bidding farewell to the past year and welcoming the new one," explains Shan Jixiang, director of the Palace Museum. "In ancient times, emperors were representative figures of the nation. So, the celebration of Chinese New Year in the imperial palace carried dual meaning for both the family and the nation." Shan believes that patrons will find items and scenes similar to

their own lives, but also plenty of totally new discoveries.

Festive Atmosphere in the Forbidden City

During the Spring Festival, each Chinese household posts a piece of paper with Chinese character *fu* (blessing) on the door. The royal family was no exception. On the first day of the 12th lunar month, emperors would use a brush specially made for the occasion called "Cifu Cangsheng" (literally "bestow blessings on common people") to write the Chinese character *fu* on paper referred to as "dragon letter." It would be posted in the Palace of Heavenly Purity, where emperors lived and dealt with daily political affairs. Then emperors would write another dozen *fu* to be posted in other palaces. This exhibition showcases the versions of *fu* brushed by Emperors Kangxi, Yongzheng, Qianlong, Jiaqing and Daoguang, which are expected to bring abundant blessings to spectators.

In addition

A close-up to part of a "longevity lamp," featuring the patterns of dragons and Chinese characters for auspicious words. by Yin Xing

A pair of "longevity lamps" is restored to stand in front of the Palace of Heavenly Purity. Having disappeared for 200 years, the tradition to set up "longevity lamps" used to be a major event in the early and mid-Qing Dynasty to celebrate Chinese New Year. It took a considerable amount of labor to set up the tall lamps. by Yin Xing

to the *fu* posters, patrons can see various couplets and pictures of "door gods" as well as palace lanterns made of varied materials in different patterns, shapes and colors. In front of the Palace of Heavenly Purity stand a pair of "heavenly lamps" and a pair of "longevity lamps," a tradition that disappeared 200 years ago. Lighting "heavenly lamps" and "longevity lamps" used to be a major event in the early and mid-Qing Dynasty to celebrate Chinese New Year. It took a considerable amount of labor to set up the tall lamps. In 1840, the event was canceled by Emperor Daoguang, causing the grand ceremony to be lost in history and related relics to be scattered sporadically around the world. Fortunately, after reading relevant literature, researchers at the Palace Museum located historical records on the custom and methods and even noted the detailed dimensions of the special lamps. In the storehouse, they found the model for the lamps' bodies, samples of their links and their original poles. Using these parts, they restored the lamps to enable the special event from the height of the Qing Dynasty to return.

The royal family also hosted dinners for Chinese New Year. Following a record about imperial meals dating back to 1783, the exhibition arranged over 200 relics to recreate the settings for royal family reunion dinners during the Spring Festival. A New Year concert was also held in the imperial palace to mark the occasion. The exhibition features musical instruments used to play the highest-class court music, which would be performed when ministers, senior officials and royal families visited emperors during the festival. Full court music required 18 categories of musical instruments, but only six are exhibited including the bell and drum.

Living Relics

In ancient times, an emperor's every move could influence state affairs. Although emperors would hold a stamp-sealing ceremony to herald the beginning of the holidays, they couldn't really stop working. The exhibition restored a scene of an emperor beginning his first writing of the new year. The emperor would use a special brush to write some auspicious words on paper to wish blessings for his

1 At the exhibition, many varieties of lanterns are put up just as they used to be during the Chinese New Year holiday in the Qing Dynasty. by Duan Wei

2 Pictures of the "door god" are posted, a custom prevailing both in today and in ancient times. by Duan Wei

3 Imperial "red envelopes." by Duan Wei

4 The royal family also hosted dinners for Chinese New Year. Following a record about imperial meals dating back to 1783, the exhibition arranged over 100 relics to recreate the settings for royal family reunion dinners during the Spring Festival. by Duan Wei

compatriots. The paper would then be placed in a yellow box which no one was allowed to open. Not until today have people been able to see them.

Chinese New Year is not only a family-gathering holiday but also a carnival. Powerful emperors also seized the chance to have fun. The painting *Games on Ice* depicts skating entertainers performing on the iced Taiye Pond on the eighth day of the 12th lunar month. Watching opera was another major entertainment activity for the royal family. Eight exquisite opera costumes are on display accompanied by musical instruments, scripts, opera paintings and a stage, from which visitors can easily imagine the lively and jubilant scene.

In addition to traditional methods, the exhibition also adopts new media such as video, animation, music, projectors, incense and infrared induction as well as many interactive offerings to enrich the visitor experience. With new technologies like virtual images and motion capture, a digitalized pavilion featuring immersive experience is open to whisk people back to the festive Forbidden City hundreds of years ago.

Thanks to modern technologies, the exhibition has reproduced imperial celebration activities during the Spring Festival to provide a unique glimpse into imperial life. In this exhibition, cultural relics are no longer removed from their environment but placed in their original historical context. This enables the audience to feel the "life" of the relics and better understand Chinese wishes for the New Year, blessings for the motherland and hopes for life.

"The exhibition is also the fruit of our introspection," says Ren Wanping, deputy director of the Palace Museum. "For management convenience, we usually sort relics into different categories. This approach, however, removes them from their previous historical context. Today we don't think such relics have any relationship with us, but back then, they were a central part of people's lives. These items were not relics originally. They were not separate but correlated. So, we decided to put them back where they used to be and breathe new life into them in front of the public's eyes."

Worth the Effort

Text by José A. Morente Pérez

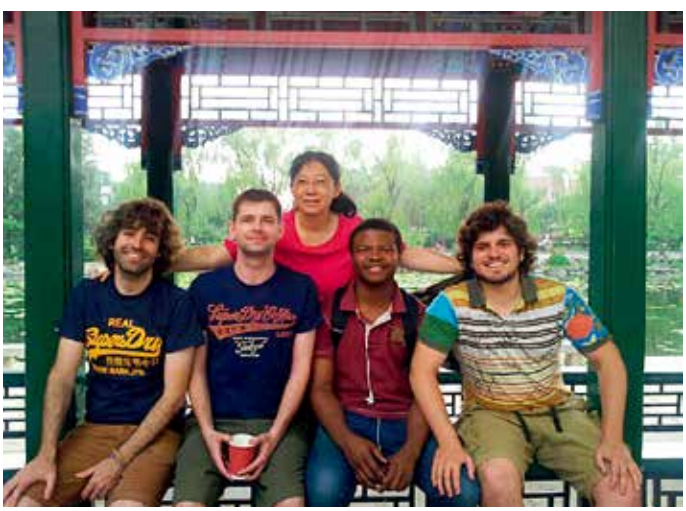
After enduring the challenges of studying Chinese for several years, I am sure that embarking on this journey was the right choice.

"I will learn Chinese!" This idea popped into my head some time ago. It was not a new year's resolution, bet among friends or a sudden thought. It was born of something deeper inside. The idea has changed my life completely. When other people asked me why I started studying Chinese, I frequently joked that I was inspired by the nice tank of goldfish in the Chinese restaurant my family frequented when I was young. The real reason is that I started studying Chinese because I was always attracted to Chinese culture, and I knew that learning the language was key to fulfilling my dream of traveling around China.

Starting with *"Ni Hao"*

I admit I was lucky for many reasons. Back in 2010, Chinese was not as popular with foreigners as it is today. For certain groups of foreigners, Chinese was considered esoteric and not a tool as valuable as it may be considered today. Despite this, my family lent me firm support from my first year abroad in China to today, years later when I still live there. Even though they cannot see me often and miss me so much, I still have their support. I was also very fortunate that a Confucius Institute opened in Granada, the city where I was living. I will always be grateful to its excellent staff and all the great people I met there.

Ni hao! The word "hello" in Chinese was the first word I learned in my first Chinese class at the marvelous Confucius Institute at the University of Granada. I remember the first day on my way back home after class, I was filled with enthusiasm and couldn't stop thinking about *"ni hao"* and all the new words yet to come. Not only were many more words and



With his Chinese grammar teacher and classmates, the author (right) visits the Old Summer Palace in Beijing.

The author (left) in an activity about China's traditional musical instruments during his stay in Beijing in 2013.

February 3, 2018: Chinese and American students participate in an activity to spread Chinese culture. by Wang Ying/Xinhua

phrases awaiting, but also a succession of enriching experiences I never expected.

Your Chinese Is Good

At my school, Chinese learners were only a minority, but we all felt motivated. I was eager to participate in any Chinese-related activity I heard about. Among them, I can still remember my special affection for Chinese Bridge—the Chinese language competition for foreigners. In the 2012 event in Spain, I finished third and was rewarded with an invitation to attend the Chinese Bridge Final in China.

"Your Chinese is very good!" This is a phrase you will hear often during your learning process. Local Chinese are extremely supportive to foreign people learning their language and, believe me, you will need a lot of support and encouragement during this journey. Chinese language is not easy to learn, especially for Westerners, so the language and culture gap is huge. Chinese people, who conversely struggle with European languages, seem to relate to this difficulty. Awareness of the big challenge in learning Chinese makes you particularly patient during the learning process. It also helps you feel less embarrassed when making mistakes, which is extremely helpful and makes you comfortable with using Chinese.

Moving to China

Because the Chinese language is difficult to learn, I recommend that anyone committed to it consider moving to China. That is exactly what I did after my second year studying Chinese. Thanks to the Confucius Institute's scholarships program, I got the chance to go to Beijing and take advantage of a year-long full scholarship. But it was not my first visit to China. Because I had joined the Confucius Institute's summer and winter programs and the Chinese Bridge competition before, it was my fourth visit in two years. But only in Beijing did I really start learning Chinese. In fact, learning Chinese is interesting and conducting your first conversation with local Chinese is even more fun. Learning the language goes hand in hand with learning and understanding the local culture. I have always thought that the essence of a culture lies in language, and of course Chinese language and its accompanying culture are equally fascinating.

After considerable efforts to learn Chinese over several years, I am sure that I took the right decision when embarking on this journey. The ability to speak a new language and understand its culture has opened the door to a new world of possibilities. My career has made a 180-degree turn. Perhaps because Chinese is so difficult to learn, my ability to read and speak Chinese has provided plentiful career opportunities. During the wonderful years I have been working in China, I have always worked in a Chinese environment. Talking every day with Chinese colleagues and customers has been key to learning and understanding both the language and culture. As time passes, my enthusiasm for Chinese language and culture has not diminished, but only increased. What began as a hobby slowly became something serious and evolved into a central pillar of my life.

The author is a Spanish engineer who has been living in China for six years.

Pioneering: Chinese Artists Abroad in France and Chinese Modern Art (1911-1949)

January 12, 2019 – March 3, 2019
Central Academy of Fine Arts, Beijing

This exhibition highlights the phenomenon of Chinese artists studying abroad in France in the first half of the 20th century. A number of art pioneers returned to China after graduation, bringing along new art forms, languages and concepts such as oil painting and sculpture that contrast traditional Chinese painting and calligraphy. This era greatly contributed to the modern transition of Chinese art from traditional expressions.

The exhibition displays more than 200 works of over 50 Chinese artists who ever studied in France. This is the largest research exhibition concerning works of Chinese artists studying abroad in the early 20th century. It aims to reflect on the development and nature of Chinese contemporary art and the possibilities for future art in the digital and image era.

The Son of the Earth by Pang Xunqiang, watercolor on paper, 45×37.2cm, 1934.

The Forbidden City by André Claudot, oil on canvas, 57×70cm, 1928.

Pomegranate by Li Chaoshi, pastel on paper, 36.1×46.9cm, 1952.

Splendors of Great Han: Exhibition Commemorating the 50th Anniversary of the Excavation of the Han Dynasty Tombs in Mancheng

December 28, 2018 – March 28, 2019
National Museum of China, Beijing

Tombs of the Han Dynasty (202 B.C.-220 A.D.) at Mancheng are ranked among the top 100 archaeological discoveries in China during the 20th century. As a large-scale cliff cave tomb cluster of a king of the Han Dynasty, the tombs at Mancheng are large and well preserved. Tens of thousands of precious cultural relics were unearthed in the tombs.

The exhibition was designed based on the life of Liu Sheng (a son of Liu Jing, Emperor Jing of the Han Dynasty, 165-113 B.C.) and the flourishing era in China at the time to illustrate the archaeological excavation results of the tombs, which includes 151 sets of 724 cultural relics, including 62 sets of first-class relics, demonstrating the great historical and cultural value of the tombs at Mancheng.

Poster for "Splendors of Great Han: Exhibition Commemorating the 50th Anniversary of the Excavation of the Han Dynasty Tombs in Mancheng."

New Directions: Yu Honglei

January 19 – April 14, 2019
Ullens Center for Contemporary Art, Beijing

For the latest installment of the "New Directions" series of solo shows featuring emerging artists throughout China, the Ullens Center for Contemporary Art (UCCA) presents a new series of sculptures and videos by contemporary young Chinese artist Yu Honglei. These works were born in an era in which the internet and movies, television and computer screens offer constant distraction—they imitate and respond to these phenomena.

Yu Honglei was born in 1984 in northern China's Inner Mongolia Autonomous Region and currently lives and works in Beijing. He has been featured at several major exhibitions in China and Germany.

Poster for "New Directions: Yu Honglei."

8102—On Reality

December 29, 2018 – March 10, 2019
OCT Contemporary Art Terminal, Shanghai

8102—On Reality is the sixth installment of OCAT Shanghai's annual emerging artists exhibition series.

The exhibition takes its title "8102" from a satirical internet meme that jumbles the digits of the year 2018. The title presents a realistic landscape of the narrative and evaluative peculiarities and imaginative visions of six young Chinese artists from the '80s and '90s generations.

Poster for "8102—On Reality."

The Momentary Temple: Gong Xu & SHDK Studio

December 8, 2018 – February 24, 2019
Hive Center for Contemporary Art, Shenzhen

This exhibition is divided into two sections. The first features Chinese artist Gong Xu's mythical paintings since 2011 including his most famous painting, *The Dragon's Plan*. The second features trendy toys from "SHDK Studio" created with images of the paintings and other derivatives that Gong developed collaboratively with other artists.

Gong Xu was born in Shanghai in 1986. He received a bachelor's degree from the oil painting department of China Academy of Art in 2010. The exhibition fuses his identities as an artist and founder of a fashionable toy brand.

Poster for "The Momentary Temple: Gong Xu & SHDK Studio."

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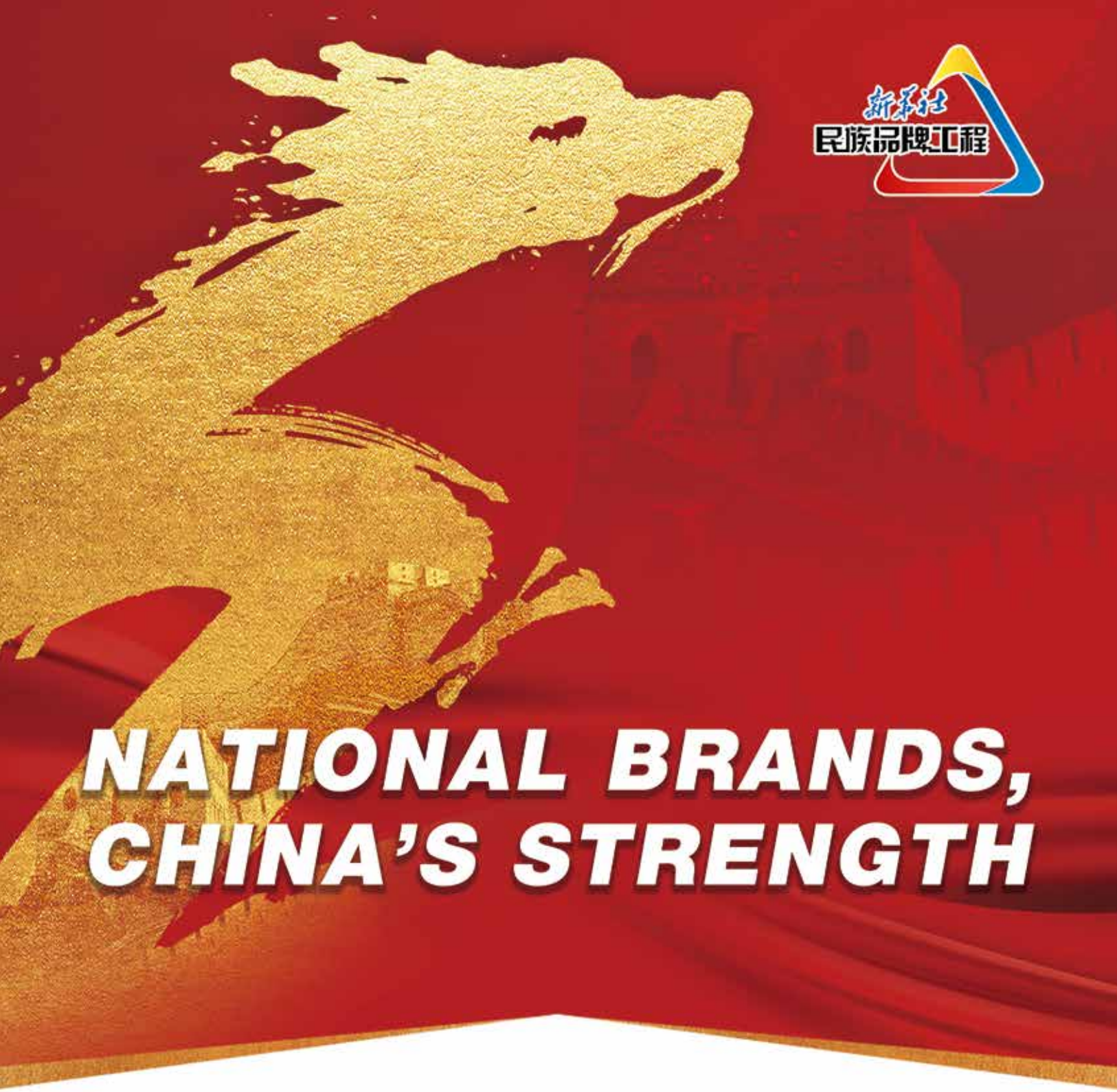

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