JIN LIWANG/XINHUA/EYEVINE

Chinese astronaut Nie Haisheng works inside the Tianhe module.

CHINA'S SPACE STATION IS PREPARING TO HOST 1,000 SCIENTIFIC EXPERIMENTS

Researchers are eagerly awaiting the completion of Tiangong, to study topics from dark matter and gravitational waves to the growth of cancer and pathogenic bacteria.

By Smriti Mallapaty

China launched the core of its space station in April, and sent three astronauts up in June. But although the space station won't be complete until late 2022, there is already a long queue of experiments from around the world waiting to go up. Scientists in China told *Nature* that the China Manned Space Agency (CMSA) has tentatively approved more than 1,000 experiments, several of which have already been launched.

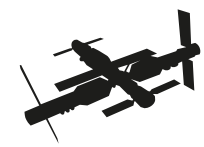
Before April, the International Space Station (ISS) was the only space laboratory in orbit, and many researchers say Tiangong (or 'heavenly palace') is a welcome addition for astronomical and Earth observation, and for studying how microgravity and cosmic radiation affect phenomena such as bacterial growth and fluid mixing. However, others argue that crewed space stations are costly, and serve more of a political than a scientific purpose.

"Increased scientific access to space is of scientific benefit globally, no matter who builds and operates platforms," says Julie Robinson, chief scientist for human exploration and operations at NASA in Washington DC.

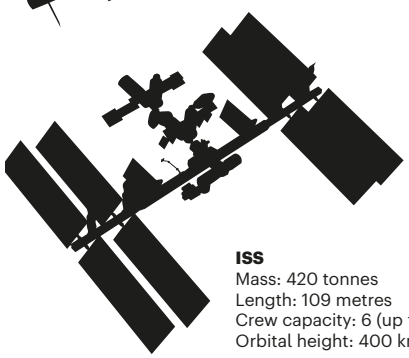
"We need more space stations, because one space station is definitely not enough," adds Agnieszka Pollo, an astrophysicist at the National Centre for Nuclear Research in Warsaw who is part of a team sending an experiment to study γ-ray bursts.

VARIATIONS ON A THEME

Tiangong will be much smaller than the International Space Station (ISS), but will still have space for plenty of scientific experiments.



Tiangong
Mass: 66–100 tonnes
Length: 37 metres
Crew capacity: 3 (up to 6)
Orbital height: ~400 km



ISS
Mass: 420 tonnes
Length: 109 metres
Crew capacity: 6 (up to 9)
Orbital height: 400 km

The ISS was launched in 1998, as a partnership between space agencies from the United States, Russia, Europe, Japan and Canada (see 'Variations on a theme'). It has housed more than 3,000 experiments since then, but China is barred because of US rules that prohibit NASA from collaborating with China.

Although most experiments slated for Tiangong will involve Chinese researchers, China says that its space station will be open to collaboration from all countries, including the United States.

Open to the world

In June 2019, the CMSA and the United Nations Office for Outer Space Affairs (UNOOSA) chose 9 experiments — in addition to the 1,000 that China has tentatively approved — to go up once the space station is complete. Simonetta Di Pippo, director of UNOOSA in Vienna, says these involve 23 institutions in 17 nations.

China previously launched two small space labs — Tiangong-1 and Tiangong-2. These hosted more than 100 experiments, circling Earth for several years.

The space station offers brand new facilities, and China is encouraging experiments

not attempted in space before, says Tricia Larose, a medical researcher at the University of Oslo, who is leading a project planned for 2026. "They're saying, yes, build your hardware, make it brand new, do something that has never been done before."

Even though most approved projects are led by Chinese researchers, many have international collaborators, says Zhang Shuang-Nan, an astrophysicist at the Chinese Academy of Sciences (CAS) Institute of High Energy Physics in Beijing, who advises the CMSA.

The first section of Tiangong to arrive was a core module known as Tianhe ('harmony of the heavens'). In late May, a cargo ship named Tianzhou-2 ('heavenly ship') was sent up and docked, delivering fuel, space suits and experimental equipment. In June, three Chinese astronauts – or 'taikonauts' – aboard *Shenzhou-12* ('divine vessel') also docked, entering the 17-metre-long chamber that will be their home for the next three months.

Over the next year or more, the CMSA will send another eight missions to Tiangong. Two will deliver the Wentian ('quest for heavens') and Mengtian ('dreaming of heavens') modules, which will mainly house scientific experiments (see 'China's first space station').

These will be "the playrooms of scientists", says Paulo de Souza, a physicist at Griffith University in Brisbane, Australia, who develops sensors used in space.

The space station will have more than 20 experimental racks, which are mini-labs with pressurized environments, says Yang Yang, director of international cooperation at the CAS Technology and Engineering Center for Space Utilization in Beijing. Outside, there will be 67 connection points for research hardware facing Earth or the sky, says Yang. A powerful central computer will process data from experiments before beaming them back to Earth.

Organoids and dark matter

The experiments being sent up encompass numerous fields. Zhang is the principal investigator for HERD (High Energy Cosmic-Radiation Detection facility), which is a partnership involving Italy, Switzerland, Spain and Germany, slated for 2027. This particle detector will study dark matter and cosmic rays, and will cost some 1 billion to 2 billion yuan (US$155 million to $310 million), says Zhang.

Zhang and Pollo are also involved in POLAR-2, which will study the polarization of γ-rays emitted from distant explosions, with the goal of clarifying the properties of γ-ray bursts, and possibly even gravitational waves.

Larose plans to send up 3D blobs of healthy and cancerous tissue, known as organoids. She wants to find out whether the very-low-gravity environment will slow or stop the growth of the cancerous cells, which might lead to therapies.

Other projects from India and Mexico will study ultraviolet emissions from nebulae and infrared data from Earth, to study meteorological conditions and what drives intense storms.

Despite many of the projects being partnerships between Chinese and Western scientists, geopolitical tensions have made collaborations more difficult, notes Larose. She says Norway has yet to sign a bilateral agreement with China that would give her project the green light. Merlin Kole, an astrophysicist at the University of Geneva in Switzerland, who is also working on POLAR-2, adds that stricter adherence to export regulations means there is added bureaucracy around sending electronic hardware to China.

"We need more space stations, because one space station is definitely not enough."

But Di Pippo says that tensions have so far had no impact on the projects selected by UNOOSA, adding that the agency is discussing plans with the CMSA to send more experiments to Tiangong by the end of next year.

Some scientists have argued that crewed space stations are a waste of money – the cost of Tiangong has not been made public, but the ISS cost some €100 billion (US$118 billion) to build and maintain for its first decade.

"You'd get a much bigger scientific bang for the buck with robotic missions," says Gregory Kulacki, an analyst on China security issues for the Union of Concerned Scientists, an advocacy group in Cambridge, Massachusetts. "Within China, as within the United States, there has been a tension between scientists who want to do the best science they possibly can and who prefer robotic missions, and governments who want to use human space-flight programmes largely for political purposes."

But other researchers point out that although satellites offer an alternative for some observations, for many experiments, particularly those requiring microgravity, crewed space stations are essential. They provide a home for long-term observations, data-processing capacity and access for astronauts who can perform maintenance tasks and run the experiments.

Furthermore, as well as housing experiments, Tiangong is intended to test human space-travel technologies to support China's space-exploration goals, says Zhang.

With current ISS funding running only until sometime between 2024 and 2028, it's also possible that Tiangong will eventually become Earth's only space station in operation.

Tiangong is projected to operate for at least a decade, and China already has plans to launch other spacecraft to work in tandem with it. The China Survey Space Telescope, or Xuntian ('survey the heavens'), is a 2-metre optical telescope that will rival NASA's Hubble Space Telescope and periodically dock with Tiangong for maintenance. Launching in 2023, it will have a larger field of view for peering into the deep Universe than does Hubble.

CHINA'S FIRST SPACE STATION

China aims to finish construction of Tiangong in late 2022. The station will be used to test technologies for human space exploration and as a laboratory for scientific experiments.

□ Set to launch in 2022

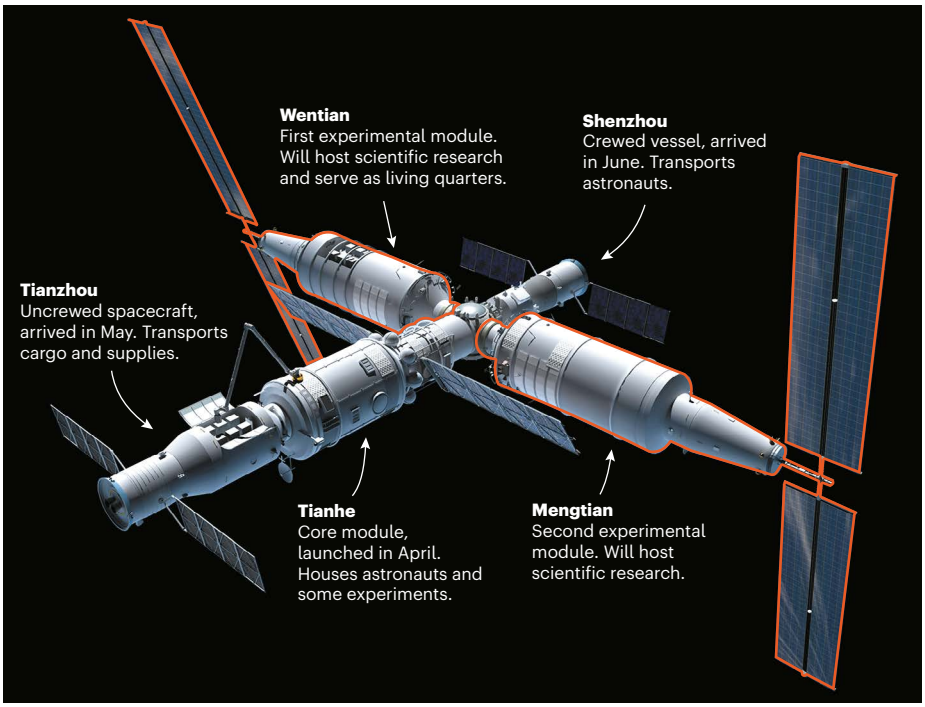


IMAGE: ADRIAN MANN/STOCKTREK IMAGES/ALAMY