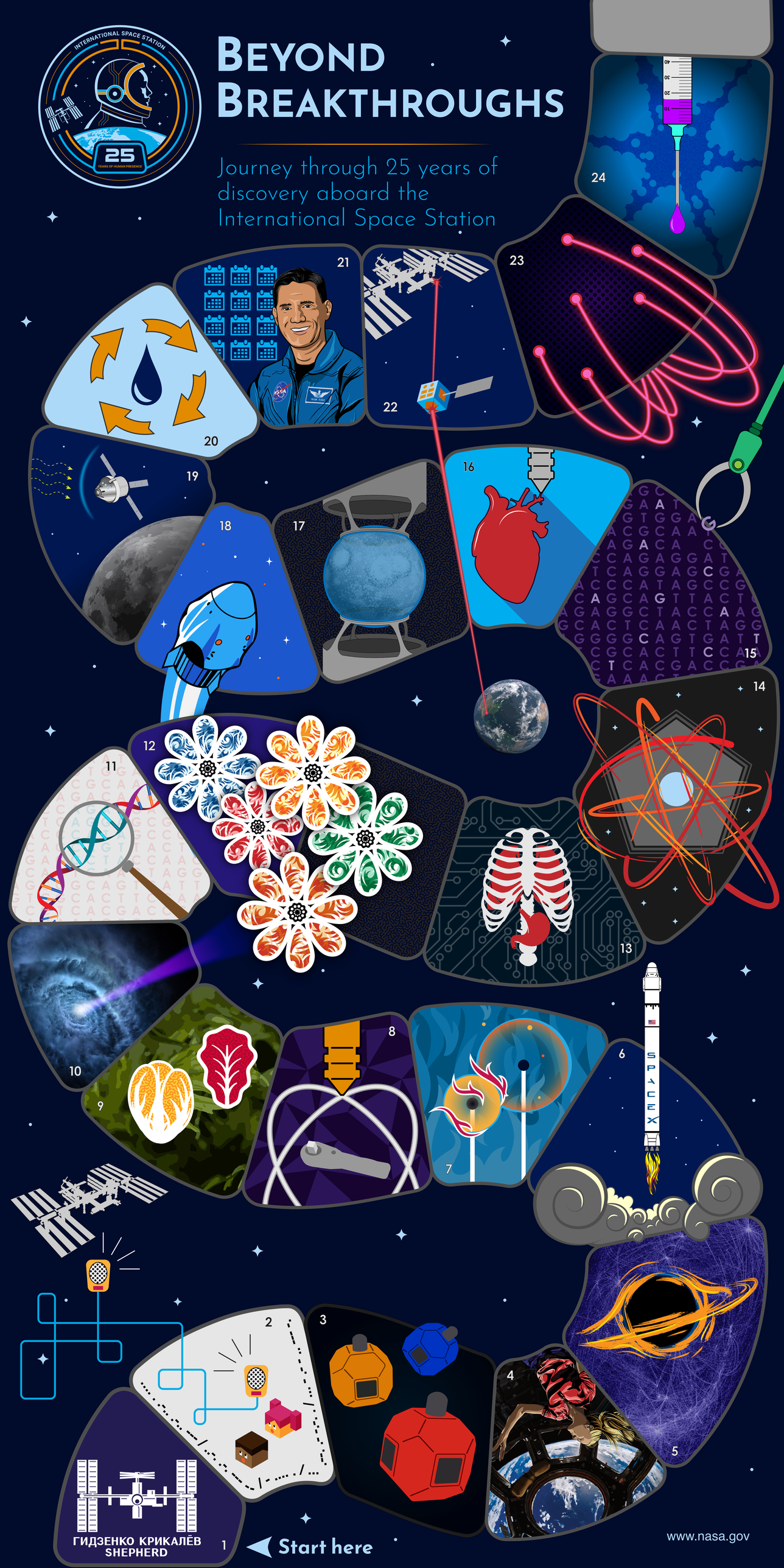
Beyond Breakthroughs

Journey through 25 years of discovery aboard the International Space Station



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Beyond Breakthroughs

November 2025 marked 25 years of continuous human presence aboard the International Space Station. A global endeavor, the space station has been visited by more than 290 people from 26 countries and a variety of international and commercial spacecraft. Crews aboard the orbiting laboratory act as the eyes and hands of researchers on Earth, conducting, maintaining, and facilitating more than 4,000 microgravity experiments thus far.

Having humans aboard the space station expands research capabilities beyond what satellites and autonomous platforms can achieve. Performing science in the absence of gravity's physical forces leads to discoveries that improve life on Earth, support Artemis missions to the Moon, and enable future exploration of Mars and beyond.

Explore a few of the many research accomplishments aboard the space station over the last quarter century.

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1) 2000: Expedition 1 science
The first crewed International Space Station mission conducted 25 experiments on human health, hardware, Earth observations, and physical and biological sciences. Researchers tracked astronaut health and performance, studying cardiovascular function, fluid shifts, nutrition, radiation, immunity, and sensory perception. Engineers assessed the station's environment, including magnetic interference and structural dynamics, to ensure safety and accurate science activities. Other experiments examined protein crystal growth, fruit fly genetics, and plant development.

2) 2000: First ham radio contact with station
Amateur radio equipment launched to the International Space Station, and ISS Ham Radio has operated continuously since, connecting more than one million participants with astronauts. Conversations between astronauts and students spark interest in STEM and inspire the next generation of explorers.

The program has linked more than 250 crew members with students in 49 states, two U.S. territories and over 100 countries. In 2022, it reached every continent when NASA astronaut Kjell Lindgren spoke with students at Argentina's Esperanza Base in Antarctica.

3) 2009: First student competition aboard station
NASA introduced students to Zero Robotics, a competition that was conducted aboard the space station for the first time. The program engages secondary school students in station-based research by having them develop autonomous software for in-orbit robotics. Since then, NASA has hosted the winning project annually aboard station and expanded student engagement through additional educational programs that connect students worldwide with the orbiting laboratory.

4) 2010: Cupola supports worldviews, crew morale
A seven-windowed observation module, called the cupola, was installed, providing the crew with stunning views of Earth and space. It plays a critical role in monitoring spacecraft, operating robotic arms and capturing high-resolution images for Earth observations and research. The cupola is also used for disaster response, atmospheric monitoring, urban lighting studies and tracking bird migration. Beyond its technical value, it boosts crew morale by offering a visual connection to home, making it one of the station's most beloved spots.

5) 2011: Observation of a black hole swallowing a star
The JAXA (Japan Aerospace Exploration Agency) MAXI instrument, mounted outside the International Space Station, helped detect a supermassive black hole consuming a star in a galaxy 3.9 billion light-years away. The event produced a bright ultraviolet and X-ray flare, followed by fading emissions. Scientists believe they had seen this fading aftermath before, but this was the first time they observed the onset of such a phenomenon.

6) 2012: First commercial resupply launch
On Oct. 7, the space station received cargo from a commercial cargo spacecraft for the first time. SpaceX delivered 390 pounds of scientific research to the orbital complex. After 18 days, the SpaceX Dragon undocked and splashed down in the Pacific Ocean off the California coast, returning 866 pounds of cargo. The flight also marked the first time frozen samples were returned to Earth, expanding research capabilities aboard the station.

7) 2012: Cool flames created in space
Cool flame — faint, nearly invisible flames that burn at much lower temperatures — were discovered aboard the space station. These flames are nearly impossible to create in Earth's gravity but form easily in microgravity, offering researchers insights into low-temperature combustion chemistry. Subsequent investigations examined this phenomenon in more detail, with potential applications for fire safety during future deep space missions and more efficient engines and fuels on Earth.

8) 2014: First 3D print on station
Additive manufacturing, or 3D printing, offers an inexpensive way to create tools and parts for equipment maintenance. This capability is especially important for missions to the Moon and Mars, where resupply and cargo capacity is limited.

The first 3D printer launched to the space station in 2014 and used plastic feedstock to produce more than a dozen parts, including a ratchet wrench. The effort demonstrated that designs could be transmitted from Earth and printed more than 250 miles above.

9) 2015: First food harvested on station
Crew members from NASA, JAXA, and Roscosmos were the first to eat space-grown vegetables, enjoying lettuce grown for the Veg-01 investigation.

Plant research aboard the space station is advancing the technology and knowledge needed to grow plants during long-duration missions beyond low Earth orbit. This work also supports improvements in indoor and urban agriculture on Earth.

10) 2015: Pioneering blue jet observations
Transient luminous events, or TLEs, are electrical discharges at the tops of thunderstorm clouds, rarely visible from the ground. They can disrupt communication systems and affect aircraft and spacecraft. Understanding these phenomena could improve atmospheric models and weather forecasts.

In 2015, European Space Agency astronaut Andreas Mogensen captured the first video from the International Space Station's cupola of blue jets—a type of TLE that shoots into the stratosphere.

The station's orbit offers a unique view of TLEs. From 2016 to 2020, the Lightning Imaging Sensor observed these phenomena, and ESA's ASIM, installed in 2018, continues to collect data on high-altitude lightning.

11) 2016: DNA sequenced in space
Space-based DNA sequencing can identify microbes and monitor crew health without sending samples back to Earth. In 2016, scientists sent two devices to the International Space Station: one to copy DNA segments, an important step in analyzing genetic materials and another to read nucleic acid bases in DNA samples. That August, NASA astronaut Kate Rubins sequenced DNA in space for the first time. A year later, Peggy Whitson combined the devices to identify the station's first unknown microbe.

12) 2016: First flower grown in space
The Veg-01 investigation tested plant growth hardware in space by germinating lettuce and zinnia seeds. Astronauts cared for plants, like they would on future missions to the Moon and Mars, with basic guidance from teams on Earth. Along with a successful lettuce harvest, the zinnias also bloomed in orbit.

13) 2018: First tissue chip investigation
Tissue chips — small devices containing human cells that mimic human tissues and organs — help researchers study microgravity's effects on the body, disease development, and potential treatments.

The first tissue chip investigation aboard the space station examined how aging affects immune system function. Insights from this research could help protect astronaut health during future long-duration missions and lead to new treatments for elderly and immunocompromised patients on Earth.

14) 2018: Fifth state of matter produced in space
NASA's Cold Atom Lab, or CAL, became the first facility to produce the fifth state of matter, called a Bose-Einstein condensate (BEC), in low Earth orbit. The lab chills clouds of atoms to about one ten-billionth of a degree above absolute zero. On Earth, gravity limits observations to less than a second, but in microgravity, BECs can float, allowing longer study. Ultra-cold atom clouds give quantum physicists a powerful tool for exploring fundamental physics.

15) 2019: CRISPR gene editing on station
CRISPR is a gene-editing tool that makes precise breaks in specific gene locations. The student-led Genes in Space-6 investigation used CRISPR to cut DNA of a common yeast sample, repair the breaks, and sequence the patched-up DNA to confirm its original order was restored, all during spaceflight. This research improves our understanding of DNA repair in microgravity, which could help protect astronauts on future missions and support treatments for radiation exposure on Earth.

16) 2019: First 3D bioprinted human tissue
The BioFabrication Facility is a 3D biological printer that uses living cells, proteins, and nutrients to bioprint human tissues for research and treatments aboard the orbiting laboratory. Microgravity enables printing of complex organ structures, including heart tissues and a knee meniscus, that could be used to treat diseases and injuries during future space missions and on Earth. Bioprinting could eventually support in-space production of entire functional organs for transplant.

17) 2019: Biological samples processed without containers
The Ring Sheared Drop investigation studies protein behavior without container interference by suspending a liquid drop between two rings—a setup possible only in microgravity. Researchers have used it to examine amyloid formation, fibrous protein deposits linked to neurodegenerative diseases like Alzheimer's. Removing the influence of solid surfaces could reveal how proteins form and support future treatments.

18) 2020: First crewed commercial launch
NASA astronauts Doug Hurley and Bob Behnken launched to the space station aboard NASA's SpaceX Demo-2 mission — the first crewed flight under the agency's Commercial Crew Program. During their 62-day mission, they contributed more than 100 hours of research. NASA continues working closely with its commercial partners to develop transportation systems to safely, reliably, and cost-effectively carry humans, science experiments, and other cargo to low Earth orbit and back.

19) 2022: Pre-lunar orbit testing of radiation safety
Investigations aboard the space station helped refine radiation detection systems for NASA's Orion spacecraft ahead of the Artemis I mission. During Orion's 25-day mission around the Moon, a suite of instruments — including systems first tested on space station — measured radiation levels. The data showed Orion can shield its crew from potentially hazardous radiation during lunar missions.

20) 2023: Station recovers 98% of its water
The U.S. segment of the space station hit a major milestone when its water recycling system — which turns humidity, sweat, and urine into clean drinking water — achieved a 98% recovery rate. The achievement is a critical step toward supporting long-duration human space exploration, where resupply is limited, and self-sustaining life support systems are essential.

21) 2023: A record-breaking mission
NASA astronaut Frank Rubio set NASA's record for longest single spaceflight, spending 371 days in space. During his mission, Rubio became the first astronaut to join a study on exercising with limited gym equipment and helped test whether an enhanced diet improves adaptation to space. He also contributed to several experiments on how spaceflight affects human physiology and psychology, helping prepare for missions beyond low Earth orbit.

22) 2023: Station's first laser communications link
NASA's ILLUMA-T investigation tested laser communications aboard the International Space Station, using infrared light instead of radio waves to boost speed and efficiency. In 2023, ILLUMA-T exchanged data with NASA's Laser Communications Relay Demonstration, marking the agency's first two-way, end-to-end laser relay. Both systems are part of NASA's SCaN (Space Communications and Navigation) Program, which supports reliable communication and navigation for the station and future Moon and Mars missions.

23) 2024: Commercial-scale optical fiber production
The Flawless Space Fibers-1 investigation manufactured more than seven miles (11.9 kilometers) of optical fiber over about a month, setting the record for the longest fiber produced in space. This includes more than 3,700 feet (1,141 meters) in a single day. This achievement also marks the first time commercial lengths of fiber have been produced in space. The fibers are made from ZBLAN, a glass alloy that has unique properties that allow light to travel through a fiber over a broader range.

Microgravity yields higher-quality fibers that can carry more than 10 times the data of traditional silica-based fibers, potentially advancing communications in space and on Earth.

24) 2025: Station research supports FDA-approved cancer treatment
Since 2014, scientists have flown multiple crystal growth experiments to the space station, yielding early insights into improving cancer therapies. For one medication, treatment times previously took up to two hours; station research informed a new formulation that reduces treatments to just one- to- two-minute injections.

The medical research aboard the orbiting laboratory focused on growing crystalline suspensions in microgravity, helping the medication dissolve more easily in liquid for injection. Crystals formed in space are often higher quality than those produced on Earth.

Learn more about space station research here: **www.nasa.gov/iss-science**