# Space Programs Around the World



#### Quick Write

Do you think it's important for astronauts on long space missions to have access to "comfort foods," familiar music, and other reminders of home? Why or why not? What food would you most miss on a long space voyage?



- the history and accomplishments of the Chinese space program
- the history and accomplishments of the Indian space program
- the history and accomplishments of the European space program
- the history and accomplishments of the Japanese space program

o-yeon Yi, a 29-year-old biotech engineer, blasted off on 8 April 2008 to become the first South Korean in space. Among the things she carried in her kit was kimchi. Kimchi is a traditional dish in Korea, made of fermenting cabbage, with garlic and peppers. Koreans say they must eat it wherever they go, wrote *The New York Times* in an article before the mission. When South Korean mothers sent their sons off to war in Vietnam in the 1960s, for instance, they sent clay pots full of the stuff with them.

So when South Koreans decided it was time for one of their own to travel into outer space, they considered how to bring kimchi along. Three top government institutes got involved in the quest to create "space kimchi."

It was a quest on which South Korea spent years, and millions of dollars. The problem, the *Times* reported, was that microbes such as lactic acid bacteria thrive in kimchi. After all, these help ferment the cabbage. On Earth they're harmless. But would they cause problems in space? What if cosmic rays mutated the bacteria?

And how would fluctuating temperatures, common in space, affect kimchi? One nightmare scenario involved a bag of kimchi fermenting out of control, bursting, and then spilling all over essential aerospace electronics. These were serious questions, and some of the finest minds in the country sought answers.

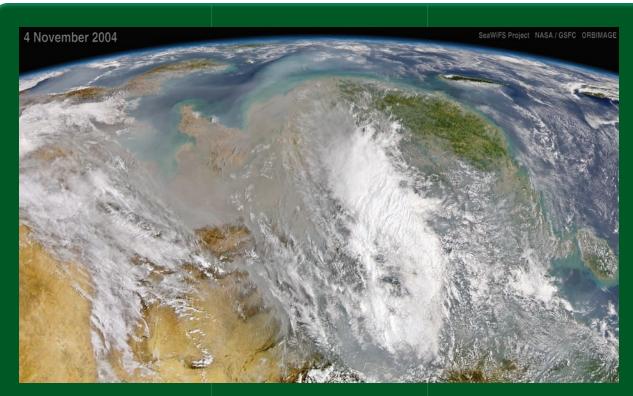
"The key was how to make a bacteria-free kimchi while retaining its unique taste, color, and texture," Lee Ju Woon at the Korean Atomic Energy Research Institute told the *Times*. Eventually the scientists engineered a version of kimchi, plus nine other Korean recipes, that met with approval from the Russian space authorities. Their spaceship carried Yi to the International Space Station (ISS).

Scientists used radiation to kill the bacteria in the kimchi but were able to hang on to 90 percent of its flavor. The "space kimchi" had much less of an aroma, too. That probably made it more appealing to Yi's international crewmates on the ISS.

#### Vocabulary



- incendiary
- taikonaut
- monsoon
- geostationary



A NASA satellite captured this view of China in 2004. It shows a pollution-generated haze over much of the country. While the United States and Russia have dominated the field of space exploration over the decades, China is now counted as the world's No. 3 spacefaring nation.

Courtesy of SeaWiFS Project/NASA/Goddard Space Flight Center/ORBIMAGE

#### The History and Accomplishments of the Chinese Space Program

In the modern era, the United States and Russia have dominated the field of space exploration. But rockets were a Chinese invention—centuries ago. More recently China has made up for lost ground. It now is counted as the world's No. 3 spacefaring nation.

#### The Chinese Use of 'Fire Arrows' in the Thirteenth Century

China can claim to be the birthplace of the Space Age—or at least the Age of Rocketry. Historians say that Chinese warriors may have used "fire arrows" against their enemies as far back as 300 BC. The first fire arrows may simply have been flame-tipped arrows shot off by archers.

But by the thirteenth century AD, the fire arrows of the Sung Dynasty's army were rockets packed with gunpowder. These were the first solid-fuel rockets. The Chinese used them against the Mongol horde. In 1232 they repelled Mongol invaders at the battle of Kai-fung-fu.

Old records show that the biggest of these rockets carried iron shrapnel and incendiary material—material *able to set fire to something*. The noise from the blast of one of these early rockets could be heard for 15 miles.

#### **China's National Space Administration**

Seven centuries later, China developed a modern space program, which now includes satellites and manned spaceflight. The Asian giant has two major space agencies to organize these missions.

The People's Liberation Army, or PLA, is in charge of manned and military space missions. The China National Space Administration (CNSA) is in charge of civil and scientific projects. By early in the twenty-first century, China had become the world's No. 3 spacefaring nation, after the United States and Russia.

#### The Chinese Satellite and Human Spaceflight Programs

China's space program really took off in 1970 with the launch of its first satellite, the *Dong Fang Hong I*. It took many years of hard work and tests, plus lots of technical help from the United States and the Soviet Union, for China to get to this point.



China owes much of its modern success with rockets and missiles to a scientist who had a brilliant career in the United States but was later deported as a suspected communist. Qian Xuesen was born in China in 1911, as its imperial government was collapsing. He came to the United States as a young man and studied at the Massachusetts Institute of Technology. Later, he helped found the Jet Propulsion Laboratory, now one of NASA's premier research facilities.

His mentor and colleague, physicist Theodore von Karman, called Qian "an undisputed genius whose work was providing an enormous impetus to advances in high-speed aerodynamics and jet propulsion." In 1949 Qian wrote a proposal for a winged space plane. It would later be described as the inspiration for NASA's space shuttle.

But Qian's American career was over by 1950. This was the period known as "the Red Scare." Many Americans were worried that communists had gained influence over government and other institutions. And China had just gone through a communist revolution. When Qian tried to go there to visit his parents, FBI officials stripped him of his security clearance. They accused him of secretly being a communist.

And so in 1955 the United States sent him back to China. There the Chinese welcomed him as a hero. The government put him to work at once making rockets. He led the research that produced China's first ballistic missiles, its first satellite, and its Silkworm antiship missile.

Qian died at 98 years of age in January 2010.

According to a report by the US Department of Defense, China launched 78 satellites into space in addition to the *Dong Fang Hong I* through October 2003. In all, 67 succeeded in reaching orbit, but the other 12 failed—or at least didn't reach their correct orbit. These satellites included all kinds: communications, weather, remote sensing, navigation, and scientific.

#### Star POINTS

About three dozen countries have sent at least one astronaut into space since 1961. But except for Russia, the United States, and now China, those countries have all sent their people up in another country's spaceship.

China's space program has more recently expanded into manned spaceflight as well. On 15 October 2003 Lt Col Yang Liwei of the PLA took off into space aboard the *Shenzhou 5* ("divine vessel"). His mission lasted some 21 hours and included 14 orbits around Earth. The spaceflight also brought China into the exclusive club of nations that have launched their own citizens into space.

Almost exactly two years after Col Yang's mission, China successfully launched a second manned spacecraft. The *Shenzhou* 6 sat atop a Long March-2F rocket. The launch occurred at a remote site on the edge of the Gobi desert. The two taikonauts (*Chinese astronauts*) were Fei Junlong and Nie Haiheng. They were both former pilots in the Chinese Air Force. Their mission lasted nearly five days. They orbited Earth 75 times.

China's third manned space mission, with three taikonauts, took place in September 2008. Mission commander Zhai Zhigang became the first taikonaut to walk in space. This mission was a sign of China's steady efforts to establish a permanent human presence in space.



Chinese Vice Premier Deng Xiaoping gets a briefing on NASA's manned space program from Johnson Space Center Director Christopher C. Kraft during a visit to the center in Houston, Texas, in February 1979. It took many years of hard work and tests, plus lots of technical help from both the United States and the Soviet Union, for China to join the space club.

#### China's Use of Communications and Weather Satellites

In 1986 China said it intended to enter the commercial space launch business. This is largely about lifting satellites into orbit. It gets less attention than do manned space missions. But it's an important part of the global aerospace industry.

And it's an area of Chinese industry that has close links to the United States. Almost all communications satellites needing commercial launch services are either built in the United States or include US components. This means that companies must obtain US export licenses before they can send satellites to China for launch. That is, the US government has to approve each move, generally for national security reasons.

In 1988 the Reagan administration gave conditional approval of the first export licenses to send three satellites to China. Early the following year, China met the conditions for the export to proceed. But then in June 1989 China's violent suppression of the Tiananmen Square uprising led to a souring of US-Chinese relations. Since then, China's satellite business has been subject to the changing political winds.

China has its own communication and weather satellites as well. These service customers in China and elsewhere.

#### China's Use of an Anti-Satellite Weapon

In fact, a Chinese weather satellite was recently involved in a very controversial space-news story. On 11 January 2007 the Chinese successfully "tested" an antisatellite missile. They used it to shoot down one of their aging weather satellites. It was a stunning development—from the perspective of space science as well as foreign and military policy. The mobile missile demolished the satellite, the *Feng Yun 1C*, orbiting at 537 miles (859 km) above the Earth.

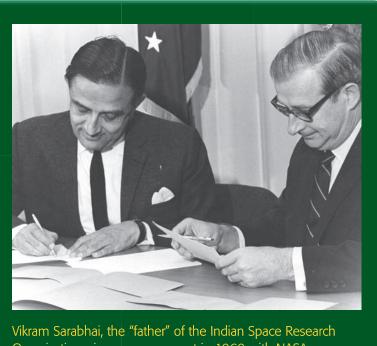
The missile's target was, after all, just a weather satellite, and one of China's own, at that. But the shootdown showed the Chinese had mastered key technologies important for advanced military operations in space. The missile was unmistakably a weapon. It was plain that China could someday direct such a weapon at satellites belonging to other countries.

The whole episode had outside analysts scratching their heads. For one thing, it occurred at a time when China's leaders were promoting the idea of "peaceful rising." By this they meant that China's advance as a world power did not have to threaten its neighbors.

The missile test was controversial for another reason, too. It looked like a deliberate decision by China to make the problem of space debris, or space junk, even worse. The destruction of the *Feng Yun 1C* created a cloud of hundreds of fragments. There had never been anything like it. Those fragments will clog the spaceways for many years to come.

#### The History and Accomplishments of the Indian Space Program

India's space program, in contrast with China's, has long been modest and low-key. The country has mainly focused on launching satellites that look back down on India itself, with its 1.2 billion people. It uses satellites to help Indians understand their own country, to put it another way. But India's space policy is changing. There's even talk of another race for the Moon—this time between India and China.



Organization, signs an agreement in 1969 with NASA Administrator Thomas Paine to work together to deliver TV shows via satellite to Indian villages. When India began its space program back in the 1960s, it concentrated on technology for economic development—particularly satellites. Courtesy of NASA

# The Indian Space Research Organization

When India began its space program back in the 1960s, it concentrated on technology for economic development—particularly satellites. The Indian Space Research Organization, the driving force of India's space program, has made the practical uses of space science, rather than prestige, a priority.

The government decided from the beginning to use space technologies to help ease poverty. India uses satellites to search for water and minerals, to map resources, and to monitor the health of its forests. Satellite technology also helps India monitor its monsoon season, an annual period of heavy rainfall. This is important to the health of India's huge agricultural economy.

But India is now moving beyond that traditional focus. It has planned its first manned space mission for 2015. India wants to join the club of spacefaring nations. If it succeeds in putting an astronaut up in 2015, India will join the club just a dozen years after China.

#### The Chandrayaan-1 Moon Orbit Satellite

The first step along this new path for Indian space policy was *Chandrayaan-1*. This was an unmanned lunar probe launched in October 2008. Its two-year \$83 million mission was to orbit the Moon and to map its surface in three dimensions. The probe carried payloads from NASA, the European Space Agency, and Bulgaria. Among the payloads were instruments used to detect water and minerals.

The mission experienced technical problems. Several months into its mission, *Chandrayaan-1* (the name is Hindi for "moon craft") overheated. And so the Indian space agency moved the probe into a new orbit 62 miles (100 km) farther from the Moon. Later a steering sensor failed. But even before a full year was out, India's space scientists declared the mission a success.

#### Star POINTS

In September 2009 NASA scientists made headlines around the world: They had found water molecules on the Moon's surface. The actual instrument that detected the water was NASA's Moon mineralogy mapper, one of the payloads aboard *Chandrayaan-1*.

#### The Indian National Satellite System (INSAT)

Another of India's accomplishments is the Indian National Satellite System, known as INSAT. It's the largest domestic communication system in the Asia-Pacific region. Its satellites are geostationary. That term refers to *orbiting at a speed and altitude that keeps satellites in the same place above the Earth at all times*. The system began in 1983. INSAT meets India's telecommunications, broadcasting, meteorology, and emergency rescue needs.

#### The Mission of Indian Remote Sensing (IRS) Satellites for Earth Resources

The Indian Remote Sensing (IRS) satellite program supports India's national economy. It provides information on agricultural water resources, forestry, ecology, geology, watersheds, marine fisheries, and coastal management. This constellation of satellites is one of the largest in the world.

IRS can tell the healthy coconuts from the diseased ones hanging from the region's thick palms. The satellites can also spot swarms of mosquitoes in the jungle. Now high-resolution satellites are available. Indians are using them to study urban sprawl and plan infrastructure.

#### The Mission of the METSAT Weather Satellites

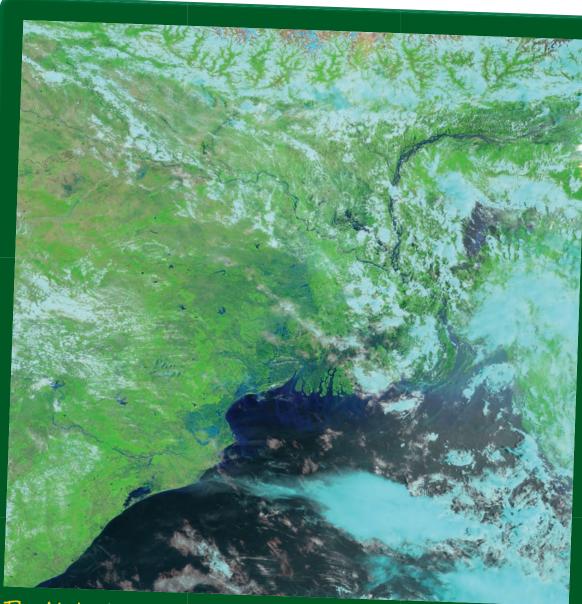
On 12 September 2002 India launched the first of a new series of meteorological (weather) satellites called METSAT. Scientists intended these to take a load off the rest of the INSAT system. Up to that point, INSAT's telecommunications and broadcasting satellites had also carried instruments for gathering weather data. But weather instruments impose certain design limits on a satellite. It's hard to design a satellite that "does everything." And as India and its economy grow, its telecommunications and broadcasting

sectors make more demands than ever on India's satellite networks

Most countries find weather data useful. But India has more reason than most countries to want the best possible weather data. Monsoons strike it annually. The country is also subject to cyclones (hurricanes) and floods.

#### Star POINTS

India named its weather satellites after, Kalpana Chawla, a naturalized American citizen of Indian descent who died in the *Columbia* space shuttle accident in 2003.



The Moderate Resolution Imaging Spectroradiometer aboard NASA's <u>Terra</u> satellite took photos of flooding in India from a monsoon in 2007.

The black, or dark blue, portions show the Bay of Bengal, but the light blue scattered around the image is the actual flooding. Water mixed with mud shows up in the fainter shade. Due to annual monsoons, India has more reason than most countries to want the best possible weather data. Courtesy of NASA/Jesse Allen/MODIS Rapid Response Team

#### The History and Accomplishments of the European Space Program

Europe is a collection of wealthy but small countries. As in many other activities, so in space, too—Europeans have found strength in numbers. They have banded together to do more than any single country could do alone.

#### The Activities of the European Space Agency (ESA)

As its name suggests, the European Space Agency (ESA) is the organization through which Europe undertakes space research and missions. Eighteen European countries belong to the ESA. The agency has special arrangements with other countries as well. (Note that the ESA is not part of the European Union [EU]. The ESA's membership overlaps largely with the EU's, though.)

The ESA seeks to ensure that investment in space delivers benefits to the citizens of Europe and the world. ESA takes part in human spaceflight largely through the International Space Station program. ESA also carries out unmanned exploration missions to the Moon and planets in the Solar System. The agency maintains a spaceport at Kourou, French Guiana, and has a rocket program as well. It is a significant launcher of commercial satellites.

The ESA's headquarters are in Paris. The agency has several science centers around Europe. Cologne, Germany, is the home of the European astronaut training facility, for instance. The agency also includes liaison offices and tracking stations as needed around the world.



Space shuttle Discovery makes a brilliant arc in the sky as it heads toward the ISS for the station's 30th construction and maintenance mission on 28 August 2009. Mission STS-128's crew members included Christer Fuglesang of the European Space Agency. ESA takes part in human spaceflight largely through the International Space Station program. Courtesy of NASA/Ben Cooper



#### The ESA's Member States

- Austria
- Belgium
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Ireland
- Italy
- Luxembourg
- Netherlands
- Norway
- Portugal
- Spain
- Sweden
- Switzerland
- United Kingdom

Canada has a cooperation agreement with the ESA. Hungary, Romania, and Poland are designated as European Cooperating States. Estonia and Slovenia have recently agreed to work with the ESA, too.

Saturn's icy moon Enceladus hovers in the foreground while Saturn's ring shadows fill the background. The *Cassini-Huygens* probe took this shot on 28 June 2007 from 181,000 miles (291,000 km) away. The Saturn probe is a joint venture of NASA, the ESA, and the Italian space agency, ASI.

Courtesy of NASA/JPL/Space Science
Institute

## The ESA's Joint Activities With Russia and the United States

When ESA astronaut Frank De Winne, a Belgian, returned to Earth after six months in space on 1 December 2009, he landed at the Russian space facility in Kazakhstan. And he, along with Russian cosmonaut Roman Romanenko and Canadian astronaut Robert Thirsk, made the trip in a Russian reentry module. All this suggests how closely the ESA works with its Russian counterpart.

The ESA has also cooperated with Roscosmos on launch services, which have become a Russian specialty. In November 2009, for instance, the ESA launched two *Earth Explorer* satellites from a site in northern Russia. Russia possesses proven rocket technology. Sharing this with the Europeans gets the Russians access to the ESA launch site in French Guiana. The site's location near the equator makes it a better place from which to launch heavy payloads.



The ESA also has an extensive program of joint activities with NASA. For instance, the two agencies will undertake a two-part exploration of Mars set for 2016 and 2018. The Hubble Space Telescope is a joint NASA-ESA project. And the *Cassini-Huygens* Saturn probe was a joint venture of NASA, the ESA, and the Italian space agency, ASI. The probe was the largest interplanetary spacecraft ever built.

#### The Mission of the Venus Express

You might call the ESA's *Venus Express* mission an example of space research on the economy plan. *Venus Express* is a follow-on from the *Mars Express* mission, which the ESA launched on 2 June 2003. The *Mars Express*—so called because it was developed on such a short, streamlined timetable—represented the ESA's first visit to another planet in the Solar System.

Many of the instruments aboard the *Venus Express* were simply upgraded versions of those sent off aboard the *Mars Express*. The ESA launched the *Venus Express* on 9 November 2005. After a 153-day cruise to Venus, the spacecraft went into orbit around the planet on 11 April 2006. Its mission is to run until the end of 2012. The *Venus Express* is looking for answers to a number of essential questions about Venus. The overarching question, however, is this: Why has Venus evolved so differently compared with the Earth, in spite of the similarities in terms of size, basic makeup, and distance to the Sun?

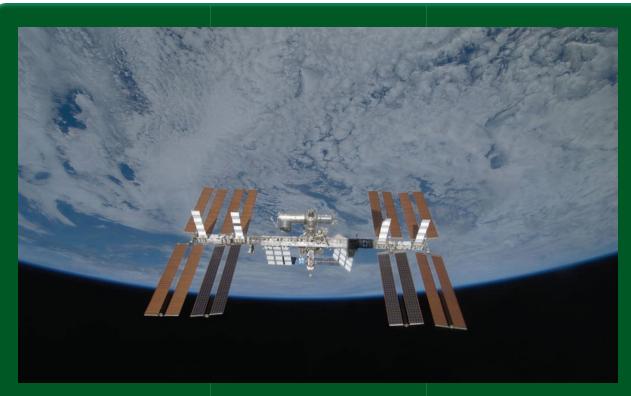
#### The Comet Intercept Mission of the Spacecraft Rosetta

*Rosetta* is the name of an ESA spacecraft with one of the most challenging missions ever: to rendezvous with a comet and study it up close for two years. *Rosetta* has two parts. One is a large orbiter, made to operate for a decade at great distance from the Sun. The other is a small lander called *Philae*.

Rosetta's target is Comet 67P Churyumov-Gerasimenko. Rosetta is to rendezvous with the comet in 2014. It will release its lander onto the comet. Then, as the comet heads for the Sun, the orbiter will continue to circle it. Scientists hope to learn from the Rosetta mission what conditions were like as the Solar System formed. They will also be looking for clues to the origins of life on Earth.

#### The ESA Role in the International Space Station

The ESA is also an important partner with the space agencies of the United States, Russia, Japan, and Canada in the International Space Station (ISS). The ESA describes it as "the greatest international project of all time." Once complete, it will provide more than 42,000 cubic feet (1,200 cubic meters) of pressurized living and working space. It will have room for a crew of seven, plus a wide array of scientific experiments.



Crew aboard the space shuttle Discovery took this photo of the International Space Station as the two spacecraft separated after a 13-day mission in March 2009. The ESA has exclusive responsibility for two key elements of the ISS: the European *Columbus* laboratory and the automated transfer vehicle (ATV). *Courtesy of NASA* 

The ESA has exclusive responsibility for two key elements of the ISS: the European *Columbus* laboratory and the automated transfer vehicle (ATV). The *Columbus* lab represents a substantial part of the space station's research capability. It is specialized for research into fluid physics, materials science, and life sciences. The ATV is the space station's supply ship. It relies on the Ariane 5, the European rocket, to launch into space. The ATV can carry nearly eight tons of cargo.

#### **The History and Accomplishments of the Japanese Space Program**

After World War II, Japan rebuilt from postwar devastation to a position as one of the largest economies in the world. Under occupation by the United States, Japan essentially renounced war. These two factors mean that Japan's interests in space are more like the Europeans' than either those of the Cold War superpowers or the rising giants of Asia—China and India. Japan's interests are civilian and scientific, and pursued in cooperation with others.

#### The Japan Aerospace Exploration Agency (JAXA)

The Japan Aerospace Exploration Agency (JAXA) came into being on 1 October 2003. It was the result of a merger of three different bodies involved in Japanese efforts at space exploration. JAXA is an independent administrative institution like NASA in the United States. It houses all Japanese aerospace activities under one organizational roof.

#### The Work of Soichi Noguchi and Other Japanese Astronauts

The first Japanese in space was Toyohiro Akiyama. He was a TV journalist whose network paid \$10 million for him to spend a week aboard the *Mir* space station in December 1990. He was also the first-ever paying passenger in space.

The first Japanese astronaut in space was Mamoru Mohri. He was on the crew of NASA's space shuttle mission STS-47 in September 1992. Takao Doi was the first Japanese astronaut to walk in space. On shuttle mission STS-87, in 1997, Doi made two spacewalks, in fact, logging 15 hours outside the ship.



Soyuz TMA-17 draws close to the International Space Station (while another Soyuz spacecraft already docked with the ISS is at top left in the photo). Among the crew members onboard the approaching Soyuz is JAXA astronaut Soichi Noguchi. Japan's interests in space are civilian and scientific.

Courtesy of NASA

More recently, on 20 December 2009 Soichi Noguchi launched in a Russian *Soyuz* spacecraft from Kazakhstan. He was off for six months aboard the ISS. Earlier, in 2005, he took part in the first flight of the US space shuttle after the 2003 *Columbia* accident. He has logged extensive periods of spacewalks, testing new procedures for shuttle inspection and repair.

#### Star POINTS

When Japanese astronaut Soichi Noguchi lifted off from Baikonur Space Center in Kazakhstan in December 2009, he carried with him the first sushi into space. He told a news agency, "We had a training in Japan and I was stupid enough to train [my fellow astronauts] to be sushi lovers."



Even astronauts have to let their hair down once in a while.

JAXA's Soichi Noguchi wears a fun and festive hat as he enters the ISS after docking via the *Soyuz* TMA-17 in December 2009.

Courtesy of NASA

#### The Mission of the Japanese Moon Probe Kaguya

JAXA launched its *Kaguya* probe of the Moon on 14 September 2007 from the Tanegashima Space Center. *Kaguya*'s mission objectives were to obtain data on the Moon's origin and to develop technology for future exploration there.

The probe consisted of a main orbiting satellite maneuvered into position about 60 miles (100 km) above the Moon's surface. It included two smaller satellites released by *Kaguya* into polar orbit around the Moon. Over the course of *Kaguya*'s mission, its controllers steered it into ever-lower orbits.

*Kaguya*, in Japanese folklore, is the name of a legendary princess who spurns earthly suitors and returns to the Moon, never to leave again. The probe lived up to its name. On 10 June 2009 it made a planned crash landing onto the Moon's surface.

#### Japan's Contribution to the ISS Program

Japan has spent at least \$3 billion developing its *Kibo* lab for the International Space Station. *Kibo* means "hope." This major piece of hardware—and Japan's biggest contribution to the ISS—has two elements: a pressurized module and an "exposed facility." An indoor lab and an outdoor one, you might say. Astronauts will use the outdoor lab for long-term experiments in open space as well as for observations of Earth and the heavens. The control room at the Tsukuba Space Center, northeast of Tokyo, manages *Kibo*'s operations 24 hours a day, 7 days a week.

At the height of the Cold War, the original TV series *Star Trek* featured an international (even interplanetary) crew aboard the starship *Enterprise*. Besides Americans, these included an African radio operator, a Russian ensign, a Japanese pilot, and a Scots engineer. Today more and more nations are launching into space or participating in the International Space Station. It makes far more sense for nations to pool their resources and cooperate in reaching out into space. It's a lot cheaper for everybody, too.

The next chapter will pick up the story of manned space missions after the Moon landings. It begins with the space shuttle and discusses the various American and Russian/Soviet space stations. You'll also learn about the many past, present, and future unmanned missions to different locations in the Solar System.





### Lesson 3 Review

Using complete sentences, answer the following questions on a sheet of paper.

- 1. Who had the first solid-fuel rockets, and against whom did they use them?
- 2. What are China's two major space agencies, and what does each do?
- 3. What did Lt Col Yang Liwei's October 2003 mission accomplish for China?
- **4.** Why does China's commercial space launch business link it to the United States?
- **5.** What does the Chinese satellite *Feng Yun 1C* have to do with the problem of space debris?
- **6.** How is India moving beyond its traditional focus on the use of space technology for economic development?
- **7.** Identify the mission of *Chandrayaan-1*.
- **8.** How does the Indian National Satellite System rank within the Asia-Pacific region?
- **9.** What does the Indian Remote Sensing satellite program do?
- **10.** Why has India launched a new series of meteorological (weather) satellites?
- **11.** Why is Kourou, French Guiana, important to the European Space Agency?
- **12.** How does the December 2009 mission of astronaut Frank De Winne of Belgium show how closely the ESA works with the Russian space agency?
- **13.** What overarching question are ESA scientists seeking to answer with their *Venus Express* probe?
- **14.** Identify *Rosetta* and its mission.
- **15.** For which two key elements of the ISS does the ESA have exclusive responsibility?
- **16.** Identify JAXA.
- 17. What important space mission did Soichi Noguchi undertake in 2005?
- **18.** How did the Japanese Moon probe *Kaguya* live up to its name?
- **19.** Identify *Kibo*.



**20.** On 11 January 2007 the Chinese successfully tested an anti-satellite missile. What might this mean for the United States?