SPACE EXPLORATION

Stars and planets have fascinated people since ancient times, but it wasn't until the 20th century that exploring space became possible. In recent decades we have sent astronauts to the Moon, robotic spacecraft to the outer reaches of the Solar System, and used huge telescopes to peer across the vastness of the Universe.

EXPLORING THE PLANETS

The planets are too far for manned missions, so robotic spacecraft are sent instead. The first to visit another planet was *Mariner 2*, a US craft that flew past Venus in 1962. Since then, and despite a number of early failures, hundreds of spacecraft have visited the Solar System's planets, moons, asteroids, and comets. Most spacecraft either fly past or orbit their target, but some also release landers that touch down on the surface.

Robot explorers

Robotic spacecraft can visit places too far or dangerous for human beings. Launched into space by rocket, they travel vast distances across space and may take years to reach their target. There are various types of spacecraft, each suited to a particular mission.

FLYBY SPACECRAFT
Some spacecraft observe a target as they fly past. NASA's famous *Voyager 1* and *Voyager 2* flew past several planets.

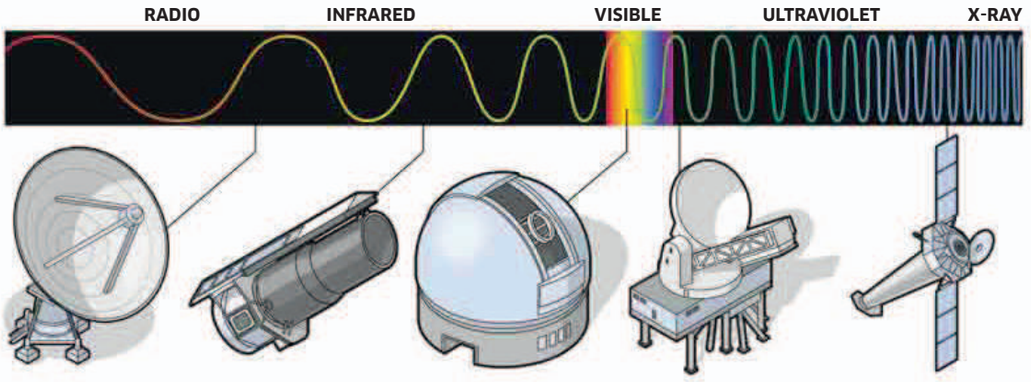
ORBITER
An orbiter flies around a planet repeatedly, giving it plenty of time to study its target. Orbiters have visited the Moon and all the planets except Uranus and Neptune.

OBSERVING THE SKIES

For centuries, astronomers have observed the heavens with their eyes alone or used simple telescopes that magnify the view. But the visible light we see is just one part of a much bigger spectrum of electromagnetic rays that reaches Earth from space. Stars and other objects also emit invisible radio waves, X-rays, infrared, and ultraviolet rays. Modern telescopes can see all of these, and each type of radiation reveals something different.

Capturing light

Telescopes come in many different styles and designs, but basically all do the same thing: collect electromagnetic radiation from space and focus it to create an image. Earth's atmosphere can block or blur the image, so some telescopes are located on high mountaintops or even launched into space.



Radio telescopes
Huge, curved dishes are used to focus radio waves given out by sources such as galaxies, pulsars, and black holes.

Infrared telescopes
These instruments, some of which are sent into space, detect the heat from objects such as clouds of gas and dust.

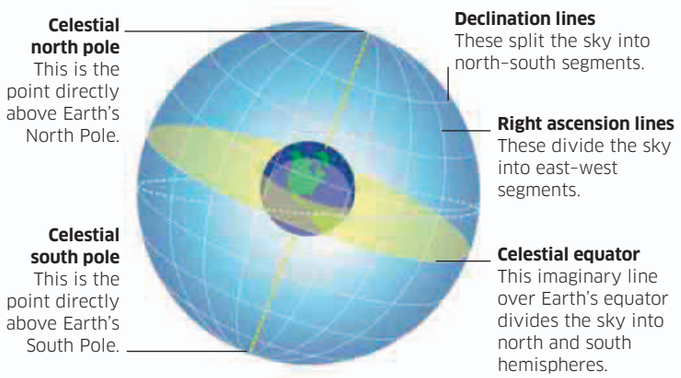
Optical telescopes
Using large lenses or mirrors, optical telescopes gather faint visible light and can see much further than the human eye.

Ultraviolet telescopes
Astronomers use ultraviolet telescopes to examine radiation from the Sun, stars, and galaxies.

X-ray telescopes
These telescopes capture high energy rays from extremely hot objects. X-ray telescopes only work in space.

Mapping the stars

Because Earth is surrounded by space, when we look at the night sky it seems as though all the stars are pinned to the inside of a giant sphere. Astronomers call this the celestial sphere and use it to map the positions of stars and planets. Vertical and horizontal lines are used to divide the celestial sphere into a grid, just like the grid of longitude and latitude lines used to map Earth's surface.



Celestial north pole
This is the point directly above Earth's North Pole.

Declination lines
These split the sky into north–south segments.

Right ascension lines
These divide the sky into east–west segments.

Celestial south pole
This is the point directly above Earth's South Pole.

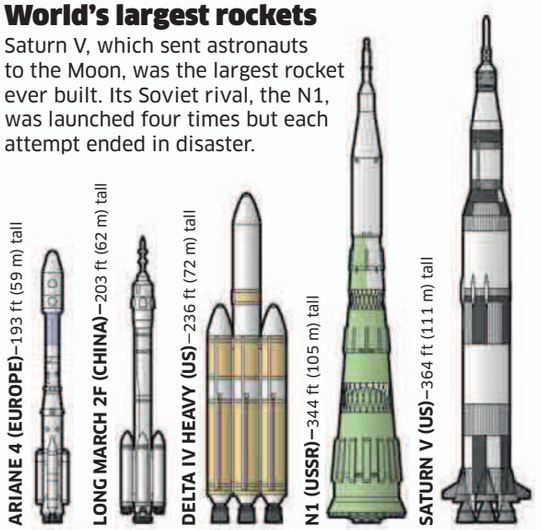
Celestial equator
This imaginary line over Earth's equator divides the sky into north and south hemispheres.

LAUNCH VEHICLES

Space is only 60 miles (100 km) above the Earth's surface and takes less than 10 minutes to reach in a rocket. Although the journey is short, it takes tremendous power to escape the pull of Earth's gravity. Launch vehicles are built to make the journey only one time, and most of their weight is fuel.

World's largest rockets

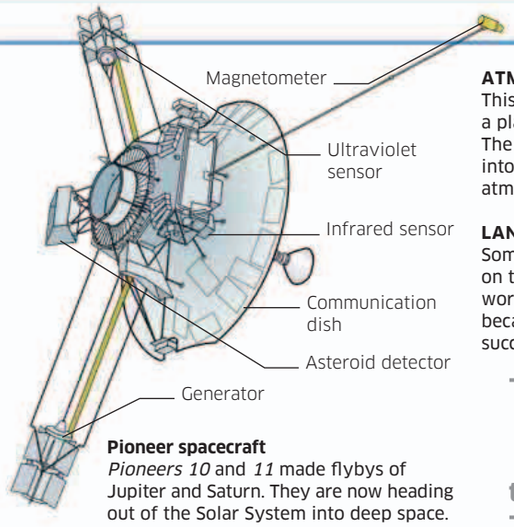
Saturn V, which sent astronauts to the Moon, was the largest rocket ever built. Its Soviet rival, the N1, was launched four times but each attempt ended in disaster.



Launch sites

Many countries have spaceflight launch sites. Sites closer to the equator can launch heavier cargo, because rockets there are given a boost by the speed of Earth's spin.

MAJOR LAUNCH SITES



Pioneer spacecraft
Pioneers 10 and *11* made flybys of Jupiter and Saturn. They are now heading out of the Solar System into deep space.

ATMOSPHERIC PROBE
This type of craft enters a planet's atmosphere. The *Galileo* probe dove into Jupiter's stormy atmosphere in 2005.

LANDER
Some craft can touch down on the surface of another world. In 1976, *Viking 1* became the first craft to successfully land on Mars.

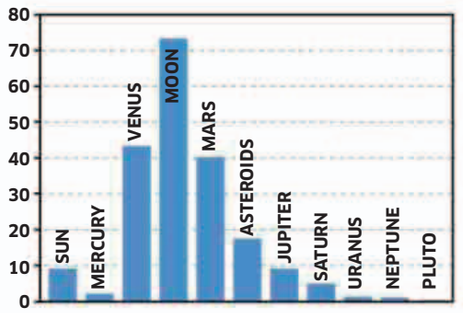
ROVER
A rover is a robotic lander with wheels that can drive around. Rovers sent to Mars have studied its rocks for signs of ancient life.

PENETRATOR
A penetrator is designed to hit its target at high speed and bury itself. In 2005, *Deep Impact* penetrated the surface of a comet.

12 years and 43 days – the time it took the spacecraft *Voyager 2* to reach Neptune from Earth.

Solar System missions

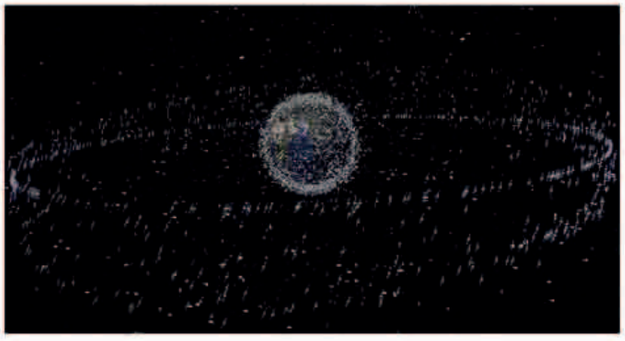
In little more than 50 years, around 200 spacecraft have left Earth's orbit and headed off to explore the Solar System. More than half the missions have been to Earth's nearest neighbors in space: the Moon and the planets Mars and Venus.



Most visited
This chart shows the number of missions to the major bodies in the Solar System.

SATELLITES

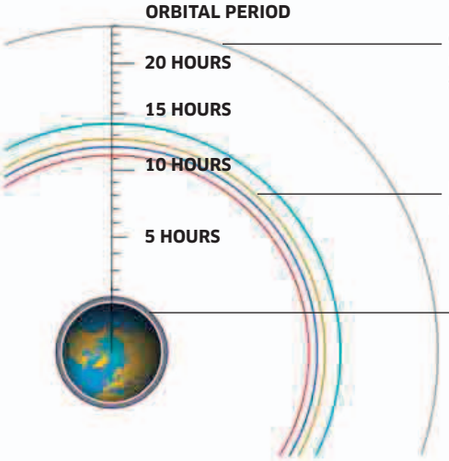
About 1,000 operational satellites orbit the Earth, carrying out tasks such as beaming TV signals around the world, gathering data for weather forecasters, and spying for the military. Many thousands more pieces of space junk—old satellites, discarded rocket parts, and debris from collisions—also circle our planet. The growing cloud of space debris is a hazard to spacecraft.



Over 500,000 objects, including satellites and space junk, orbit Earth.

Satellite orbits

Some satellites are a few hundred miles above Earth's surface, but others are much further. Some of the highest ones, such as weather, TV, and phone satellites, have geostationary orbits, which means they stay over a fixed point on Earth. Satellites with lower orbits change position all the time.

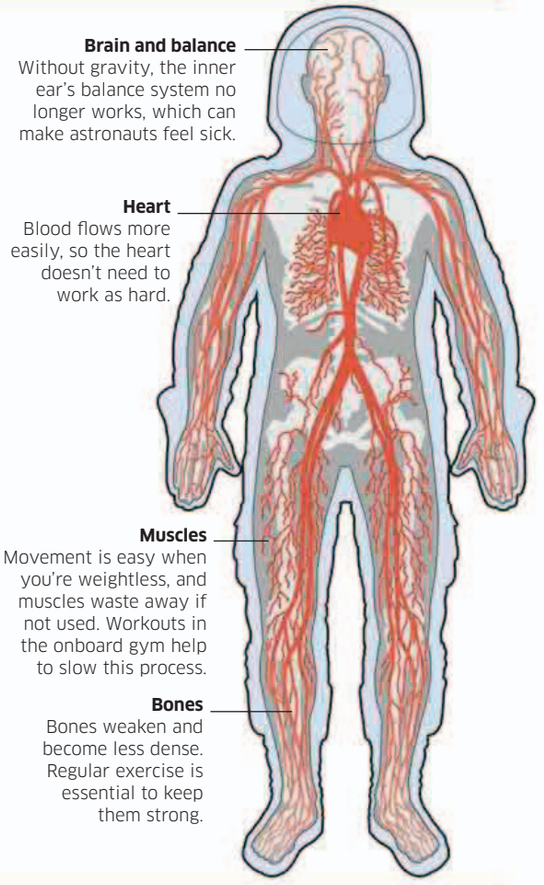


LIVING IN SPACE

Astronauts must adapt to a zero-gravity environment when living in space. Although floating weightlessly can be fun, it can also cause medical problems. Space stations are cramped places with few luxuries. Astronauts eat ready-made meals that are either freeze-dried or served in pouches. All water is recycled, including the water vapor from human breath. Astronauts clean themselves with special shampoos and soaps that don't need water, and they use space toilets that suck away waste rather than flushing with water.

Effects on the body

When the human body spends a long time in space, it changes. Without gravity pulling on the spine, the body gets about 2 in (5 cm) taller. Body fluids that flow downward on Earth build up in the head. This gives astronauts swollen faces and blocked noses, making food seem tasteless. When astronauts come back to Earth, the return of full gravity can make them feel extremely weak.



Brain and balance
Without gravity, the inner ear's balance system no longer works, which can make astronauts feel sick.

Heart
Blood flows more easily, so the heart doesn't need to work as hard.

Muscles
Movement is easy when you're weightless, and muscles waste away if not used. Workouts in the onboard gym help to slow this process.

Bones
Bones weaken and become less dense. Regular exercise is essential to keep them strong.

Space stations

A space station is a crewed satellite—a kind of orbiting laboratory in which astronauts and scientists live and work. The USSR launched the first station, *Salyut 1*, in 1971. The US soon followed with *Skylab*, in 1973. Russia's *Mir*, in use from 1986 to 2001, was the most successful station until the US, Russia, and more than 10 other countries joined forces to build the *International Space Station*, in orbit since 1998. China's own space station prototype, *Tiangong-1*, was launched in 2011.