Astronomy 101

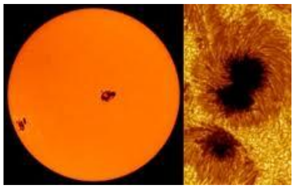
How To Explore

Since we humans first created technology (like shelter, fire pits, and the wheel), sailed the seas, and built the first built civilizations, we've wondered what those pinpoints of light were in the sky at night: we've noticed those points as well as "wandering" stars drifting in front of the rest of the cosmos. And we've dreamt of getting closer to the great heavenly globes that created day and sometimes illuminated the Earth at night.

Today we know that…

- those points of light are **stars** like our Sun – we've even photographed the visible surface of some and discovered that the ones we can see are part of a larger **galaxy** of hundreds of billions of such objects

- those "wanderers" – it turned out – were the **planets**, appearing to move against the far-more-distant stars in the 'background.'



- one of those brilliant spheres – we discovered – was the Sun, our local star. While it wasn't the centre of the **universe**, we discovered that this million-km-wide ball of gas *is* the centre of a system of planets that Earth and its Moon (that *other* "heavenly sphere" in our sky) orbited around.

While we've explored the heavens from Earth for hundreds of years (*thousands* of years, by some definitions), the last 50 years have seen us send pieces of technology into space to explore our Solar System.

We've even gone into space ourselves (though not very far) with our crowning achievement in human spaceflight so far being a series of in-person trips to the Moon, the world next-door in the neighbourhood of the Solar System.

Here's a closer look at the different ways we can (and *might*) explore space:

TELESCOPES

Optical Telescopes

For more than 400 years, we've been using lenses and mirrors to magnify objects in space. In 1610, Italian astronomer Galileo Galilei used his one-inch-wide homemade **telescope** to discover the major moons of Jupiter, the moon-like 'phases' of Venus, the rings of Saturn, observe **sunspots** on the Sun, and spot craters as well as mountains on the Moon.

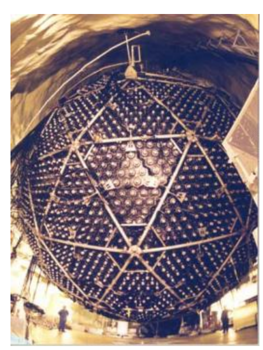
Since then, astronomers have used ever-larger pieces of glass to look at the universe: Astronomers have used telescopes with optics between 1 and 10 metres (30 feet) in diameter to learn about the existence of black holes, galaxies beyond our own, the fact that the universe is expanding, and even find planets beyond our own Solar System. An example of such modern optical instruments is the Canada-France-Hawaii Telescope, located on Hawaii's Mauna Kea.

Radio Telescopes

Giant **radio telescopes** – like the 300 metre (1,000 foot) wide dish in Arecibo, Puerto Rico or the 27-dish Very Large Array in New Mexico (equivalent to one dish 36 km wide) – scan the skies for radio emissions from objects in deep space.

Radio telescopes have provided evidence for how the universe formed and have been used to search for signals from alien civilizations beyond Earth.

Other Gear



Other types of non-optical telescopes include ones that scan the heavens for **X-rays**, **Gamma-rays**, **Cosmic rays**, and **Neutrinos** (one of the most advanced neutrino observatories in the world is located 2 km underground in Sudbury, Ontario).

In the next decade, optical telescopes as large as 39 metres (128 feet) in diameter will help unlock the secrets of the universe's missing mass (so-called **dark matter**) and directly photograph planets around other stars. in

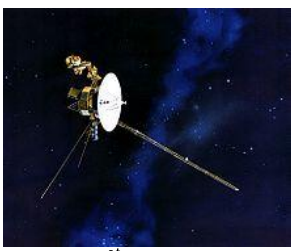
ROBOT SPACESHIPS

'Space telescopes'

Free of the distortion of Earth's atmosphere, **space telescopes** like Hubble, NASA's Chandra X-Ray Observatory, and the upcoming James Web Space Telescope produce images of distant objects more clearly than ground-based instruments many times their size.

Space Probes

Having a camera or sensor right in front of a world in our Solar System often offers vastly more information and insight than scoping it out from afar. The constant drawback to distant observation is the much-higher cost of sending spacecraft to other worlds.

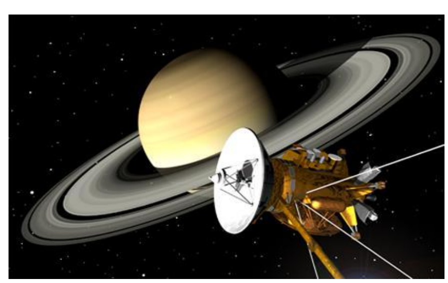


Since the 1960s, we've sent crewless probes to every planet in our Solar System: In the 1960s and U.S. and Soviet spacecraft flew by Mercury, Venus and Mars. In the 1970s NASA sent spacecraft to orbit Mars and fly by Jupiter and Saturn. In the 1980s and 1990s spacecraft flew by Uranus and Neptune, Halley's Comet and drove across the surface of Mars.

In the 21st Century, we've sent space probes to **asteroids** and **comets**, the moons of Mars, Jupiter, and Saturn, and on semi-permanent "assignments" to observe Mars like Earth-observing satellites do in orbit above our planet. (While no longer considered a planet, NASA's New Horizons spacecraft will fly by Pluto in 2015.)

Space 'Robots'

Starting in the 1970s, we've sent probes with robot arms to land on Mars, with wheeled Mars rovers following in the 1990s (the third generation of Mars rovers – NASA's huge nuclear-powered Curiosity – is currently driving across the Red Planet; one of its main sensors – a Rubik's-cube-sized spectrometer – is 'Made in Canada,' developed at the University of Guelph).



Farther from Earth, NASA and the European Space Agency (ESA) have sent probes into the atmosphere of Jupiter and to land on the surface of Saturn's moon Titan (left, compared to scale to a Moon landing image), where it sent back the first pictures from the surface of a world in the Outer Solar System.

By physically *touching* other places in the solar system, we've learned about the origins of Earth (comet sample return mission), proved beyond a reasonable doubt that liquid water exists on planets beyond Earth (Spirit and Opportunity rovers on Mars), and looked at how life might have evolved elsewhere among the planets (ESA's Huygens lander on Titan).

HUMAN SPACE EXPLORATION

Orbital (and Sub-Orbital) Spaceships

In 1961, cosmonaut Yuri Gagarin became the first human in space, orbiting Earth and starting both the dawn of the space age, as well as the 'space race' between the United States and the Soviet Union to capture a series of 'firsts.'

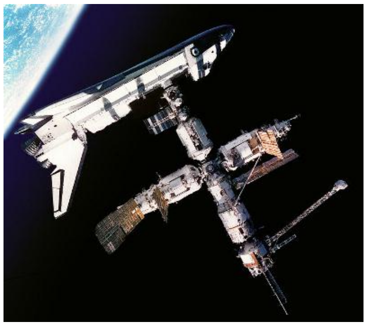
In 1965, cosmonaut Alexey Leonov became the first person to perform a spacewalk, leaving the spaceship that carried him into orbit and floating free in zero-G.

1981 saw the introduction of NASA's **Space Shuttle** – the first ever reusable crewed spaceship. Six of these huge multi-purpose space planes were built – five flew in space over 30 years.

Spaceship 'Fun'

In 2004, SpaceShipOne became the first privately-funded craft to reach space. The minivan-sized space plane would eventually lead to the beginnings of the space tourism industry, sending members of the general public into sub-orbit and paving the way for privately-funded corporations to contribute to space exploration.

Space Stations



The Soviet Union was again first in the category of building and inhabiting the first **space station** – Salyut 1 in 1971.

In 1973, NASA launched Skylab – built from a huge unused Saturn moon rocket.

Skylab was the first large-scale space station and in 1986, the Soviet Union launched Mir, the first long-term space outpost (it stayed in orbit for 15 years.

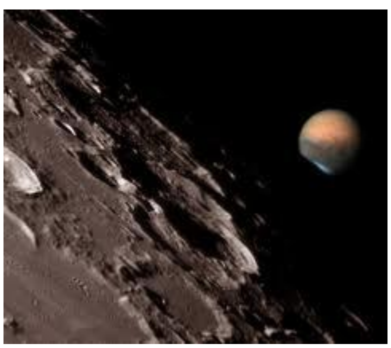
Moon Landings

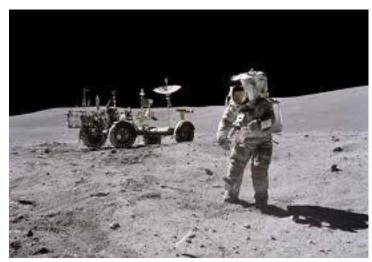
Between 1969 and 1972, NASA launched 7 missions to land on the surface of the Moon – the first (and – so far – only) human missions to another world. Apollo 13 has problems that prevented its crew from landing on the Moon, but the other six missions put two astronauts each on the Moon's surface.

While on the lunar surface, these 12 men conducted science experiments, set up permanent gear like reflectors for lasers on Earth to bounce off of, and collected soil samples – including whole moon rocks – for return to Earth.

While the Moon landings of the 1960s and 70s were partially militaristic in nature (the U.S. was aiming to "beat" the Soviet Union to land people on the lunar surface), they still represent a milestone in human history and technological achievement.

The advantages of sending people to Mars, on the other hand, will be for the scientific and technological benefit of many co-operating nations: A human mission to Mars could be *the* breakthrough to discovering life beyond Earth after decades of preparation and a detailed on-the-ground search, past obstacles that a remotely-controlled robot just couldn't get past. Such a mission would likely jumpstart massive technological advances on Earth (from waste management to solar energy to food production and medical advancements), just as the Apollo Moon program did in the 1960s.





Human Mars mission advocate and U.S. space author Robert Zubrin puts it this way: "Nations, like people, thrive on challenge and decay without it. The challenge of a humans-to-Mars program would be an invitation to adventure to every young person in the country, sending out the powerful call: 'Learn your science and you can become part of pioneering a new world.'"

Mars, the Asteroids, and Beyond…

As of 2013, NASA's goal is to land a human crew on an asteroid by 2025, followed by a group of people on Mars "around 2030." The extensive research into the effects such multi-year missions would have on humans is actually already underway as one of the main research focuses of the $100-billion-dollar International Space Station – a football-field-sized science outpost built over the last 10 years by 16 different countries, including Canada.
Such a mission to the Red Planet could cost between $200 and $500 billion US.

But various space agencies have proposed ways to cut this cost down many times by spreading the cost over several decades, sending supplies and crews in stages, and even by going with a highly controversial “one-way” plan to send people to Mars with no return trip.