SPACE EXPLORATION

Exploring outer space started off with the extensive use of optical and radio telescopes. The advent of rockets, and the ability of humans to rise above the Earth's atmosphere or to land on other celestial bodies like the moon or Mars, have added wider abilities and ventures.

Modern space exploration
Today, manned space flight is largely concerned with the problems experienced by humans who venture out of the protection of the Earth's magnetic field and are exposed to increased radiation and the effects of micro gravity.

Space telescopes
The advent of robotic space flight has opened up new opportunities including the possibility of placing space telescopes beyond the Earth's atmosphere so as to observe frequencies that would be blocked for a telescope on Earth.

They include:

- *Hubble Space Telescope*, designed for near-infrared, visible light and ultraviolet wavelengths and fitted with a 2.4m diameter mirror. Its mission is optical astronomy.
- *Spitzer Space Telescope*, an infrared telescope with an 85 cm mirror that is designed to carry out astronomical imaging and photometry in infrared wavelengths.
- *Kepler Space Telescope*, designed to survey a portion of the Milky Way to discover exoplanets (extrasolar planets).
- *Chandra X-ray Observatory*, designed to detect X-rays that are blocked by the Earth's atmosphere.
- *James Webb Telescope*, designed to observe red and near infrared radiation (0.6 – 2.38μm) for infrared astronomy with greater resolution and sensitivity than any of its predecessors. It has a 6.5m primary mirror operating behind a 5-element heat shield to keep it extremely cold (< 50K -223°C) to observe the faint infrared signals from the very early universe 180 million years after the Big Bang.
- *Solar Space Telescopes*, like SOHO (Solar and Heliospheric Observatory), Solar Dynamics Observatory, Stereo A and Stereo B, all for observing our sun from different angles.

Robotic space exploration
Robotic space exploration started with spacecraft conducting fly-bys of other planets, the best known being the two *Voyager* spacecraft launched in 1977 which are both still functional and have travelled into inter-stellar space.

The highlights of robotic spacecraft have been the Mars rovers *Spirit* and *Opportunity* that landed on Mars in 2004. *Spirit* carried out its mission until 2010 and *Opportunity* until 2018. Both had planned mission durations of 90 sols (Martian days) only. *Curiosity* is still operating on Mars after landing there in the Gale Crater in 2012. It has not detected any sign of life on Mars. *Perseverance* landed in Feb 2021 and has since conducted extensive geological analyses, gathered selected rock samples for potential future recovery, searched for signs of ancient life and tested technology demonstrators for future explorations: The recovery of oxygen from the Martian atmosphere, which was successful, and its *Ingenuity* helicopter, which had completed 29 successful flights as of June 2022.

Extra-terrestrial civilisations
Astronomers such as Isaac Asimov and Carl Sagan have long advanced the theory that there are between 100 and 400 billion stars in the Milky Way. Statistically, some or many of these stars should be similar to our sun and planet. Prior to Asimov and Sagan, physicist Enrico Fermi, creator of the world's first nuclear reactor, asked the question: "Where is everybody?" According to his reasoning Earth should already have been visited by extra-terrestrials but there is no proof of such a visit (known as 'Fermi's Paradox').

Search for extra-terrestrial intelligence (SETI)
Shortly after the advent of radio in the early 1900s the SETI commenced. The availability of radio telescopes expanded this search to a larger number of frequencies and supercomputers have since enabled an increase in the search density. In the USA, home computers have been drawn into the search programme known as SETI@home. SETI has yet to produce a result.

Exoplanets
The first extrasolar planet was discovered in 1992. As of May 2022, over 5,000 exo-planets have been confirmed by a variety of space telescopes: Kepler & Tess were dedicated exoplanet telescopes, whereas Spitzer and Hubble's infrared capabilities contributed to the detections. 77% of these discoveries were made by transit observations and 18% by radial velocity variations of the parent star due to the exoplanets.