Name: _____ Group: _____ Date: _____

STUDENT BOOK:	**Chapter 9, pp. 274–280**
CONCEPTS:	LOCATION OF EARTH IN THE UNIVERSE
METHOD:	EMPIRICAL

CONQUERING SPACE

Humankind has long sought to penetrate the secrets of the solar system. Several countries have launched space probes to explore the planets of the system. Use articles on this subject to build a timeline of probe missions covering the period since those early spacecraft first ventured out.

IDENTIFYING THE RESEARCH SUBJECT

Read pp. 274–280 in your student book and the appendix to this activity for help in answering the following questions.

1. Name four types of spacecraft that can be launched into space.

- _____
- _____
- _____
- _____

2. What distinguishes a space probe from other spacecraft?

_____

_____

_____

3. What is the main function of space probes?

_____

_____

4. What was the first celestial body explored by a space probe?

_____

Name: _____ Group: _____ Date: _____

PLANNING YOUR RESEARCH

5. Which planets of the solar system have already been explored by space probes?

_____

_____

6. Based on your sources of information, what period of time includes all solar system exploration by space probes?

_____

CONDUCTING YOUR RESEARCH

7. Complete the table below by tracking the timeline for 10 of the major space probes. Indicate the space agency or group of agencies responsible for developing the probes as well as the probe launch dates, objectives and outcomes.

Your challenge is to supply the following information:

- Name 10 probes.
- Name at least one mission for each of five different decades.
- Name two or more successful missions.
- Name two or more failed missions.

Description of space probes

Space agency	Launch date	Objective	Success (S) Failure (F)
Name of space probe:			
Name of space probe:			
Name of space probe:			

Name: _____ Group: _____ Date: _____

Description of space probes (*continued*)

Space agency	Launch date	Objective	Success (S) Failure (F)
Name of space probe:			
Name of space probe:			
Name of space probe:			
Name of space probe:			
Name of space probe:			
Name of space probe:			
Name of space probe:			

Name: _____ Group: _____ Date: _____

REFLECTING ON YOUR APPROACH

8. From your reading about space probes, were you able to meet the challenge and supply all of the information requested in question 7?

9. Based on your reading, which space probe produced the most scientific knowledge for humankind? Why?

10. To which celestial body have most space probes been sent? Why, in your opinion?

11. What other information about space probes could you have gathered?

Name: _____ Group: _____ Date: _____

APPENDIX

1. SPACE PROBES

The use of interplanetary probes for close study of the bodies comprising the solar system has revolutionized astronomy, giving rise to a new discipline called planetology.

Space probes have added greatly to the body of knowledge about the planets and so have improved our understanding of the origin, formation and history of Earth. In a symbolic gesture, *Voyager 1* turned one last time to take a final snapshot before moving beyond our solar system. That photo mosaic showed a central star—our Sun—and tiny pinpoints lost in space—our planets.

The Moon, first to be studied

Soviet and American engineers first turned their attention to the Moon. The Soviets' maiden launches were in 1958, but they failed and were never publicized. Several U.S. attempts also went awry, though two of them (*Pioneer 1* and *3*) did voyage almost 100 000 kilometres through space before falling back to Earth.

The first probe to escape Earth's gravity was *Luna 1*, a Russian probe launched January 2, 1959, which passed the Moon and continued into space. The U.S. *Pioneer 4*, launched two months later, followed the same path. Conquest of the solar system began in earnest with the September 1959 hard-landing of *Luna 2* on the Moon. One month later, *Luna 3* photographed the far side of the Moon.

In the mid 1960s, three NASA projects targeted the Moon. The *Ranger* probes crashed on the lunar surface, but first managed to send back some high-resolution photographs. The *Surveyor* probes soft-landed and analyzed the surface; the *Lunar Orbiters* circled the Moon and beamed back images of potential landing sites and regions of general scientific interest.

Shortly before that, the Soviets made similar efforts that were moderately successful (*Luna 9* made a successful Moon landing in 1966, and *Luna 10* was the first probe placed in lunar orbit a few months later). The Soviets subsequently rolled out a series of robotic probes that brought back small samples of lunar soil. They also deployed a pair of robotic rovers christened *Lunakhods* and carried out orbital observations of the Moon.

The U.S. *Lunar Prospector*, placed in orbit on January 11, 1998, had on board a gamma spectrometer for probing down several metres to detect metals and ores such as iron, uranium, silicon and titanium and an alpha spectrometer for locating gases such as nitrogen and radon. Analysis of those survey samples produced a geochemical atlas of the lunar surface and eventually confirmed tectonic activity there. One early result of the analyses sent back by *Lunar Prospector* apparently confirmed the presence of a large amount of water (in the form of ice) at the bottom of polar craters.

However, observations from the deliberate crash of the *Lunar Prospector* inside a polar crater (July 31, 1999) failed to confirm those first measurements by showing no presence of water within the lunar soil. Based on analysis of data gathered at the same time by the *Hubble* space telescope, the *Submillimeter Wave Astronomy Satellite (SWAS)*, the McDonald Observatory in Texas and the Keck telescope in Hawaii, there was no chemical evidence that molecules of water had been splashed up by the crash.

Name: _____ Group: _____ Date: _____

1. SPACE PROBES (*continued*)

The discovery of Venus

On February 21, 1961, before Yuri Gagarin made his historic flight, a Soviet craft named *Venera 1* left Earth for Venus and flew by the planet in silence, having lost all contact with Earth 15 days into the flight. But the first craft to successfully reach the planet was the U.S. *Mariner 2* probe, which flew by Venus on July 22, 1962 and observed the planet for 42 minutes, gathering and transmitting the first thermal data and orbital parameters. *Mariner 5* sent back detailed measurements during a flyby in 1967.

Venus was explored by Soviet probes as well. After three failures, *Venera 4*, a 1106-kg probe launched June 12, 1967 reached Venus and transmitted data on the Venusian atmosphere for 97 minutes. On August 17, 1970 *Venera 7* descended through the Venusian atmosphere and touched down on the surface. The planet's unveiled atmosphere was very dense, composed of carbon dioxide and very hot (about 475°C.) The probe survived 23 minutes at a pressure of 90 bars! In 1972 *Venera 8* survived 50 minutes on the planet surface, analyzing the surface basaltic rocks and gauging their radioactivity.

In 1975–1976 the Soviets launched their successful *Venera 9* and *10* missions. The probes set down on the surface of Venus and beamed back pictures of the planet surface.

In 1978 two U.S. probes that were thrust into space five days apart reached Venus. *Pioneer 1* carried 12 experiments bearing on chemical parameters and atmospheric dynamics. *Pioneer 2* was outfitted with four mini-probes that descended through the Venusian atmosphere to the surface.

In 1982 the Russians' *Venera 13* and *14* took colour photographs of the Venusian surface. *Venera 14* also recorded panoramic images. In 1983 *Venera 15* and *16* orbited Venus for nine months and radar-mapped the surface at a resolution of two kilometres.

The *Venera* missions were followed by the twin *Vega 1* and *2*, which deployed balloon capsules. The Soviet probes established vertical profiles of the atmosphere as well as spectrometric, chromatographic, cartographic and aeronomic measurements to uncover the complex dynamics of Venus' violent winds and storms. They also collected a substantial amount of data about the Venusian surface and its composition.

The American probe *Magellan*, launched May 4, 1989, produced a radar map of the Venusian surface as of August 10, 1990 revealing marvellous pictures of a volcanic planet with large-scale tectonic activity.

Observation of Mercury

Launched November 3, 1973, *Mariner 10* passed over Venus on February 5, 1974, then was put into orbit tangent to the trajectory of Mercury, which it reached in 176 days. During its mission, *Mariner 10* photographed 45 percent of Mercury's surface and studied its magnetic field and atmospheric properties.

Flights to Mars, the enigmatic planet

Probes were launched to Mars at spaced intervals. After failures by the Soviets (*Zond 1*) and the Americans (*Mariner 3*), *Mariner 4* flew over the red planet at a distance of 9844 kilometres in July 1965. It sent back 17 pictures showing recognizable craters and basins.

Despite numerous attempts, *Mars 5* was the only Soviet mission to reach the planet Mars, sending back a few images of the surface in 1973. The other missions were lost, missed their mark or simply died. Whereas the Soviet probes crashed near the target, the U.S. *Mariner 9* went into orbit around Mars. For 11 months, it sent back an impressive 7000 remarkably detailed snapshots. This allowed planetologists to begin mapping fossilized flow structures and gigantic volcanoes such as Mount Olympus (500 kilometres in diameter and more than 25 kilometres high).

Name: _____ Group: _____ Date: _____

1. SPACE PROBES (*continued*)

Viking 1, an American probe launched August 22, 1975, soft-landed in the red desert of Chryse Planitia on July 26, 1976. *Viking 2* landed in Utopia Planitia on September 3, 1976. They revealed a surreal world beneath a red sky with ochre sands and wind-burnished pebbles. The Martian soil was analyzed *in situ*. These probes conducted three experiments to detect possible life forms, but the results were inconclusive.

In 1989 the Soviet Union sent two probes to Phobos, a Martian moon, but lost control of one of them shortly after liftoff. The other one completed only part of its mission.

The early Jupiter missions

The first missions to Jupiter were made by *Pioneer 10* and *11*, two U.S. probes thrust into space by *Atlas Centaur* rockets in 1972–1973. It took them more than two years to reach their destination before continuing on to the outer solar system. Their measurements of Jupiter's environment, especially the turbulence encountered in its radiation belts, set the stage for the *Voyager* probes, launched in 1977. *Voyager 1* and *2* discovered some new features of the Jovian system such as unknown satellites, a narrow ring and volcanic activity on the moon Io. The *Galileo* probe, launched by the *Atlantis* shuttle on October 18, 1989 made its way toward Jupiter. Although defective because its main antenna failed to deploy, *Galileo* provided invaluable data. For instance, it sent back the first pictures of the Gaspra asteroid (#951) on crossing its trajectory in October 1991.

The atmosphere of Saturn

Saturn was first visited in 1979 by *Pioneer 11*. The next year, the *Voyager* probes made flybys in the vicinity of the planet, measuring its environment and observing its atmosphere, satellites and impressive ring system. *Voyager 2* continued on its way and was the first probe to reach Uranus in 1986. It then flew by Neptune and its largest moon, Triton, in 1989.

Comets

In 1978 NASA launched the *International Sun-Earth Explorer* into high lunar orbit, then rerouted it five years later for a rendezvous with the comet Giacobini-Zinner.

In 1986 spacecraft completed their rendezvous with Halley's Comet. Americans, Soviets, Europeans and Japanese mobilized to probe the comet as well as possible. The Americans sent *ISEE-3* and the Soviets launched two missions, *Vega 1* and *2*, which flew by Venus before heading for Halley's Comet and photographing it. The Japanese sent out two probes, *Planet A* and *MS-T5.*

The European Space Agency sent up *Giotto* on July 2, 1985 by means of the *Ariane 1* launcher. That 950-kilogram probe flew by Halley's Comet on March 14, 1986 at a distance of 605 kilometres. Although small, *Giotto* was equipped with a view camera, three spectrometers, two plasma analyzers, a magnetometer, a particle detector and a polarimetric optical probe. *Giotto* survived its encounter with the comet, but lost its photographic instruments. After being kept in hibernation for a time, the probe was resuscitated in 1990 to meet up with another comet, Grigg-Skjellerup, which it passed "blind" on July 10, 1992.

Name: _____ Group: _____ Date: _____

1. SPACE PROBES (*continued*)

The pace of probe missions has slowed since the "year of the comets." The Soviets put together two ambitious projects, *Phobos 1* and *2*, which failed very near the target. The U.S. *Mars Observer* mission failed in 1993.

Out to discover a star: the Sun

The first *Pioneer* probes were launched for multifaceted observation of the Sun. Two German probes, *Helios 1* and *2*, were put into orbit around Mercury to measure the Sun's magnetic field and characterize its environment. The most recent mission to date is the U.S.—European probe *Ulysses*, sent to explore the polar regions of the Sun. It was launched by the shuttle *Discovery* on October 6, 1990 and reached the Sun's south pole on September 13, 1994 after a flyby of Jupiter in February 1992. It continues to study the internal heliosphere and solar winds.

Source: Christopher Prugnaud, website on the solar system, accessed November 9, 2006. [*Translation*]

Name: _____ Group: _____ Date: _____

2. SPACE EXPLORATION

The space age began with the launch of the first artificial satellite, *Sputnik 1*, which the USSR thrust into orbit around Earth on October 4, 1957 (*sputnik* is the Russian word for "companion").

Unmanned lunar missions

As Earth's closest neighbour, the Moon has been the destination of numerous space missions. In 1958, the first lunar probes from the United States and the USSR were unsuccessful. The Russian probe *Luna 2*, launched September 12, 1959, reached the Moon in 36 hours. From then on, both countries made many attempts to reach the Moon with varying results. The first photographs of the dark side of the Moon were taken by *Luna 3*, launched by the Russians on October 4, 1959. One of the most productive missions was *Ranger 7*, launched by the United States on July 28, 1964. Before crashing in the Fra Mauro region, it beamed back 4316 pictures of the lunar surface taken at altitudes of between 300 metres and 1800 kilometres.

Luna 9 left Earth on January 31, 1966 and made the first soft landing on the Moon. On May 30 of that year, it was followed by *Surveyor 1*, which sent back 11 150 close-ups of the Moon.

While the collected scientific data were certainly interesting, the main objective was still to put a human on the Moon. The many unmanned flights preceding that event included *Surveyor 3* and *5*, which soft-landed on the Moon in 1967 after a two-day voyage. Those two probes sent back a great many pictures of the lunar surface. *Surveyor 3* gathered lunar soil samples and examined them with a television camera. *Surveyor 5* performed chemical analyses of the soil using an alpha particle diffusion technique—the first ever *in situ* analysis of an extraterrestrial body.

Between 1966 and 1967, the *Lunar Orbiter* program made the *Apollo* missions possible. Five orbiters circled the Moon taking thousands of photographs in search of future landing sites.

The USSR conducted two other unmanned lunar missions. *Luna 16*, launched September 12, 1970, scooped up 113 grams of lunar soil, which it consigned to a sealed container and shipped back to Earth. *Luna 17*, launched November 10, 1970, set down the moon walker *Lunokhod 1*, a remote-controlled robot fitted with television cameras and a solar cell array to replenish its batteries. That moon walker travelled 190.5 kilometres for 10 lunar days, sending back both pictures and data. There was a repeat performance in 1973 when *Luna 21* delivered *Lunokhod 2* to the Moon.

Exploring the planets

The scene then moved beyond the Moon as space probes landed on Mars and Venus and flew by every planet of the solar system. ... Some of them studied comets and asteroids as well.

Mars

In May 1971 the USSR launched the *Mars 2* and *3* probes, which crash-landed on Mars after transmitting some data. *Mars 4, 5, 6* and *7* followed in August 1973, but those missions were disrupted by a series of technical problems. In July 1988 the Russians sent *Phobos 1* and *2* to the Martian moon for which they were named. The first was lost through human error. The second shut down on March 27, 1989 after sending back pictures of Phobos taken less than 200 kilometres above the surface.

Name: _____ Group: _____ Date: _____

2. SPACE EXPLORATION (*continued*)

The Americans launched *Mariner 9* in May 1971. That probe orbited Mars from November 13, 1971 to October 1972 as it photographed the red planet from virtually every angle (more than 7000 pictures), discovered many unknown landscapes and provided the data for the first nearly complete map of Mars. *Viking 1* and *2* were launched August 20 and September 9, 1975 respectively on an 11-month voyage to Mars. Each of them carried an orbiter and a landing module equipped with two colour video cameras, a seismometer, meteorological sensors, instruments to detect possible life on Mars (none of the biological experiments were conclusive) and a three-metre articulated arm that was remote-controlled from Earth. Both probes operated well for several years.

The *Mars Global Surveyor* probe, launched November 7, 1996, ushered in NASA's new Mars exploration program. But the Russians' *Mars 96*, equipped with Russian, European and American scientific equipment and also launched in November 1996, plummeted into the Pacific Ocean after burning up in Earth's atmosphere. The Russian Space Research Institute had put all its hopes in that probe, which carried a craft designed to orbit the planet. The Americans learned from their past failures and opted for less expensive but more frequent missions (about every two years). That led to *Mars Pathfinder* (1997), *Mars Climate Orbiter* (1998), *Mars Polar Lander* (1999) and *Mars Odyssey* (2001), still in orbit around the planet.

Venus

In 1970 the Soviets successfully penetrated the dense, cloud-covered atmosphere of Venus with the probe *Venera 7* (*Venera* is the Russian name for the planet). Then on July 22, 1972, *Venera 8* became the first spacecraft operating from the surface of a solar-system planet other than Earth. It had the capability to beam back information about the Venusian soil (*Venera 8* measured a temperature of 470 °C and pressure of some 100 bars, or 88 times the atmospheric pressure on Earth's surface). In October 1975 *Venera 9* and *10* set down landing modules that withstood the surface conditions for an hour and transmitted the first black and white photographs of the Venusian surface. *Venera 13* and *14* sent back colour pictures in 1982. The next year *Venera 15* and *16* orbited Venus for radar observation of the planet surface. In 1985, while en route to Halley's Comet, both *Vega 1* and *2* (the name is a contraction of the Russian words *Venera,* meaning Venus, and *Galley*, the Russian transcription of Halley) dropped a landing module, which released a balloon probe into the atmosphere of Venus.

As for the Americans, in 1978 they launched the *Pioneer Venus 1* orbiter and *Pioneer Venus 2*, carrying four atmospheric probes. Those craft reached Venus on December 5 and 9, 1978 respectively. The orbiter mapped almost the entire surface of Venus, with the probes analyzing the composition and movement of the atmosphere and its interaction with solar wind. The *Magellan* probe was launched May 5, 1989 from the *Atlantis* shuttle and put in near polar orbit around Venus. It began sending back radar images of the planet surface in August 1990.

Mercury

Mercury, the planet closest to the Sun, was studied close up by *Mariner 10* during a flyby at an altitude of less than 692 kilometres on March 29, 1974 (in February of that year, the spacecraft had used the gravity of Venus to manoeuvre onto the right trajectory). It took thousands of pictures, revealing a surface similar to the crater-pocked lunar surface. During its second flyby in September of that year, *Mariner 10* came within 317 kilometres of Mercury's surface.

Name: _____ Group: _____ Date: _____

2. SPACE EXPLORATION (*continued*)

Jupiter and Saturn

Pioneer 10 and *11*, U.S. probes launched March 3, 1972 and April 5, 1973 respectively, made it safely through the asteroid belt lying beyond the orbit of Mars—an area unexplored until then. In December 1973 *Pioneer 10* became the first probe to fly by Jupiter, which it passed over again in December 1974 before achieving another first by voyaging beyond the solar system into interstellar space. As for *Pioneer 11*, it flew by Jupiter in December 1974, using Jupiter's attraction to bend its trajectory toward Saturn, which it was the first to fly by on September 1, 1979. That mission charted the way for *Voyager 1* and *2*, both of which observed Jupiter and its moons in 1979. Then *Voyager 1* flew by Saturn in November 1980, passing near the Titan moon. The *Voyager 2* flyby came in 1981.

In December 1995 the *Galileo* space probe went into orbit around Jupiter after a six-year voyage through the solar system. *Galileo's* study of Jupiter and its four large moons (Ganymede, Europa, Io and Callisto) was among the most rewarding space explorations of scientific discovery.

Uranus and Neptune

After a flyby of Saturn, *Voyager 2* continued on to Uranus. On January 24, 1986, it passed within 107 000 kilometres of the planet, discovering four additional rings and 10 new moons. The probe passed within 30 000 metres of the Uranus moon named Miranda and transmitted spectacular pictures of that ice-covered body. Next, *Voyager 2* then set its sights on Neptune, flying by the planet at less than 5000 kilometres on August 24, 1989. The next day, it came within 38 500 kilometres of Triton, Neptune's largest moon, revealing the presence of an extremely thin atmosphere. The flyby of *Voyager 2* also revealed six new moons (three other moons were discovered further from the planet in 2003, bringing the total number of Neptune's moons to 11).

Voyager 1 and *2* continued travelling into deepest space, billions of kilometres from our Sun. It is hoped that they will continue transmitting signals until 2015 (a videodisk describing Earth and its inhabitants was placed aboard each of the probes in case they encounter members of an extraterrestrial civilization).

Source: *Microsoft Encarta Encyclopedia Online*, 2007. [*Translation*]