Chapter 1

Space Exploration in a Nutshell

In This Chapter

- Understanding the very basics of astronomy and rocket science
- Becoming an astronaut and learning from space accidents
- Competing in the Space Race
- Delving into current and future missions

In order to fully understand the stories and legends of space exploration, it's helpful to take a few steps back and see the big picture. Why have humans (and a few animals) gone into space? How has society's concept of the "frontier" changed over time, and why do we feel the need to keep pushing the boundaries of our known world? This chapter is your introduction to the study of space exploration; it examines what achievements have already been made in the field and gives you a few sneak peeks at what may be in the works.

A Quick Spin around the Universe

From the time when humans first began making maps, they've had an urge to map the skies. Ancient Greek and Roman astronomers were among the first to formally name the constellations; Arabic, Chinese, and Native American cultures also had their own sky maps.

Theories, both religious and scientific, abound as to how the universe was formed. Astronomers generally agree, though, that an explosion of magnificent proportions was the starting point for our universe and that the Sun formed from a collapsing cloud of gas and dust. In the ensuing years, gravity pulled together the leftover gas, dust, ice, and other particles from the Sun's formation to create the planets in our solar system, which is roughly divided into inner (Mercury, Venus, Earth, and Mars) and outer (Jupiter, Saturn, Uranus, and Neptune) regions. The Sun and planets form one solar system, which, along with the many stars in the sky, all belong to the Milky Way Galaxy, one of billions of galaxies that comprise the known universe.

In Chapter 2, we provide information on how early humans viewed the sky and describe the solar system in detail; we also fill you in on extrasolar planets, stars, and galaxies.

A Crash Course on Rocket Science

Rocket science, more formally known as *aerospace engineering* or *aeronautical engineering,* is the technology that allows spacecraft to make it into orbit. A spacecraft launched from Earth must be able to operate both inside the Earth's atmosphere and in the vacuum of space; typically, a launch vehicle such as a rocket is used to travel through the atmosphere to reach orbit. Unlike traditional airplanes, spacecraft have to deal with extreme temperature and pressure; they must not only endure the harshness of outer space but also conduct science and support human life out there. That's quite a tall order for technology.

Although ancient Greek and Chinese astronomers experimented with rocketry and fireworks, the real beginnings of rocket science can be traced to Leonardo da Vinci and his Renaissance-era sketches of flying machines. As technology, science, and engineering evolved in the following centuries, spaceflight advanced in leaps and bounds, culminating in the launch of the Soviet Union's *Sputnik 1* satellite in 1957, followed by the formation of the United States' National Aeronautics and Space Administration (NASA) in 1958.

All spacecraft are designed by a full team of specialists who are trained in different areas. Some engineers focus on propulsion technologies, for example, whereas others are experts in materials, ergonomics, aerodynamics, or other areas.

Flip to Chapter 3 for a summary of rockets in history, as well as details on how rockets lift off and travel in space, different sources of rocket and spacecraft power, and communication via radio telescopes.

An Astronaut's Life and Times

Being an astronaut is no walk in the park. The requirements of the job necessitate not only very intensive training and knowledge but also the ability to function under living and working conditions that are often literally out of this world.

Earning the privilege to become a United States astronaut is a long and difficult road. Astronauts must possess advanced degrees, often in physics or another technical field, and must train constantly to stay in optimal physical condition. They endure grueling practice sessions in order to be prepared for survival both in space and upon their return to Earth. Astronauts train underwater so they can ready their bodies for performing activities in a low-gravity environment; they also work on all the different maneuvers that will be expected from them over the course of their journey.

When it comes to living in space, the International Space Station (ISS) may have the best view in town, but the accommodations and living conditions are a tad less than ideal.

- **Accommodations:** Until very recently, the ISS was a three-bedroom, one-bathroom house (and one of those bedrooms doubled as a laboratory). New living space and an additional bathroom were brought to the ISS, courtesy of Space Shuttle *Endeavour,* in November 2008.
- **Living conditions:** Astronauts aboard the ISS cope day in and day out with *microgravity,* a very low-gravity environment, which calls for some pretty specific changes in the way they do basic things. Activities that must be modified include eating (wouldn't want your food to float away from you!), sleeping, and using the restroom.

Check out Chapter 4 for the full scoop on the requirements to become an astronaut, the various titles of a space mission's crew, and the basics of living and working in space.

Accidents in Space

With success comes the occasional mishap, and space exploration has had its fair share of accidents, as you discover in Chapter 5. These faux pas have ranged from the relatively minor (like the 1961 sinking of a Mercury capsule) to the near-miss-but-largely-salvageable (like the Apollo 13 mission to the Moon in 1970, which failed in most aspects but returned the crew back to Earth alive). However, they've also featured the utterly catastrophic, such as the explosion of Space Shuttle *Challenger* in 1986, which killed all astronauts aboard.

Space accidents come with a heavy price in terms of human life, tax-funded research dollars, and negative publicity for the space program. The saving grace of accidents in space though? Researchers learn from them and continually improve designs, technology, and safety with an eye toward future success.

In the Beginning: The Great Space Race

The Space Race, which began with the launch of the Soviet satellite *Sputnik 1* in 1957, was the ultimate intercontinental throw-down. The world's major superpowers at the time, the Soviet Union and the United States, had similar goals in the realm of space exploration. Both countries were determined to prove their superiority in technology and spaceflight, resulting in fierce competition that drove the two nations to break boundaries and achieve goals previously thought to be impossible. The following sections highlight the major accomplishments of the Space Race.

A duo of firsts: Sputnik 1 and animals in space

The first victory of the Space Race took just 98 minutes to secure. On October 4, 1957, the Soviet Union launched *Sputnik 1,* the first artificial satellite designed to orbit Earth, which returned a beeping signal that could be (and was!) tracked worldwide. The significance of this hour-and-a-half voyage went far beyond the orbit itself: The U.S. realized it had some immediate catch-up work to do and created NASA (the National Aeronautic and Space Administration) in order to get that work done.

Sending robotic satellites into space was one thing. Sending living, breathing human beings into space was something else entirely, and (despite earlier suborbital animal flights) it was a few years after the launch of *Sputnik 1* before Soviet and American engineers were confident enough in their designs to start using human test subjects. Consequently, a range of animals (including monkeys, dogs, and insects) became the world's first astronauts. Although not all of these animal astronauts survived, scientists were able to learn from early tragedies and eventually make human spaceflight possible. Flip to Chapter 6 for more information on the adventures of animals in space.

The first people in space

The first people to travel into space all did so as part of two series of missions: the Vostok program in the Soviet Union and Project Mercury in the U.S. The Soviets claimed another early victory with the triumphant orbital flight of Yuri Gagarin in 1961; the Americans followed with flights by Alan Shepard in 1961 and John Glenn in 1962. Want more details? Be sure to read Chapter 7.

Robots to the Moon

By the mid-1960s, both the U.S. and the Soviet Union were on track to send humans to the Moon, and robotic missions were needed to pave the way (see Chapter 8 for details).

- The Soviet Union made headway with its Luna missions in the 1960s and early 1970s, culminating with four missions that returned Moon soil samples to Earth. Two missions even included a robotic rover that drove over the lunar surface!
- The U.S. developed its own program beginning with the Ranger missions in the 1960s; the first few missions were failures, but *Rangers 7, 8,* and *9* returned many close-range photos of the Moon. The NASA Lunar Orbiter missions in the mid-1960s produced detailed lunar maps from orbit, and the Lunar Surveyor program in the late 1960s put the first American spacecraft on the Moon. Equipment was tested and techniques were refined, both of which led to the reality of human lunar landings.

Human exploration of the Moon

Sending people to the Moon was, in many ways, the ultimate goal of the Space Race. Both the Soviets and the Americans desperately wanted to be the first to accomplish this Herculean goal — a goal only one nation would achieve.

Due to perseverance, ingenuity, and a little bit of Soviet bad luck, the Americans pulled ahead in the race to the Moon by 1968. In 1969, Americans Neil Armstrong and Edwin "Buzz" Aldrin became the first humans to explore the surface of the Moon when the Apollo 11 mission touched down on the Sea of Tranquility (see Chapter 9). Five other successful Apollo Moon landings followed, as we describe in Chapter 10, allowing astronauts to explore different parts of the lunar surface and bring back hundreds of pounds of precious Moon rocks. After a series of failures with its N1 rocket, the Soviet Union abandoned its goal of sending humans to the Moon in the early 1970s and refocused its sights on its space station program.

Missions to other parts of the solar system

Exploring the Moon was of paramount importance to the Space Race, but it wasn't the only outlet for space exploration — on either side of the contest. Both the American and Soviet space programs sent space probes to Mars and Venus in the 1960s and 1970s, with highly variable rates of success. NASA also sent several missions to Jupiter and Saturn. Although more than a few of

these missions failed, the successful ones sent back imagery that provided people worldwide with the first views of these planets and revealed new information about the planets' compositions and origins. Flip to Chapter 11 for full details on missions to other parts of the solar system.

The end of the Space Race

A joint American-Soviet mission in 1975 marked the end of the Space Race (which had been slowly fizzling out since the success of Apollo 11, despite continued Cold War tensions throughout the 1970s). As you discover in Chapter 12, a series of Soviet Salyut space stations, and the NASA Skylab station, led to this joint mission that involved the docking of a Soyuz spacecraft and an Apollo capsule in orbit. This joint mission featured a handshake that symbolically ended the Space Race. Thus, although it began with a bang, the Space Race ended quietly and without fanfare as both countries took their space programs in new directions with the realization that continued success in space would require future collaboration.

The Second Generation of Missions

American success with placing humans on the Moon in no way signaled the end of the space program. On the contrary: Now that the world knew what was possible, expectations began to rise for what other brave, new worlds could be explored. Several major series of second-generation missions, made possible by the successes of the Space Shuttle and Soyuz spacecraft, allowed astronauts to construct the world's first large-scale space habitations. New views of Mars flooded the news thanks to two spunky little rovers, and the mysteries of the inner and outer solar system began to unravel.

The Space Shuttle and Mir

During the prime Space Race years, significant collaboration between the U.S. and Soviet space programs was impossible with these two superpowers competing directly against one another. After the Space Race concluded, though, pathways opened for such collaboration to take place.

Enter the Space Shuttle-Mir program, a joint venture whereby Russian cosmonauts traveled to the Russian space station Mir aboard an American Space Shuttle. American astronauts also traveled to Mir, learning from Russian experience about living and working in space for extended periods of time. In addition to knowledge transfer, the Space Shuttle-Mir program formalized a new spirit of international cooperation, replacing the previous years of bitter competition.

Check out Chapters 13 and 14 if you're interested in finding out more about Space Shuttle missions and the Mir space station.

Journeys to Mars

Studying the Martian landscape and environment hasn't come easily. Although there've been a few great successes (including the Mars Pathfinder mission in 1996, which successfully placed the *Sojourner* rover on the surface of the Red Planet), there've been some rather spectacular failures. Several missions to Mars in the 1990s failed for a number of reasons, leading to dashed expectations and an increasing sense of futility regarding Mars research. Was Mars, a planet of incredible interest to scientists because of its striking similarities to Earth and its possibilities for life, going to remain shrouded in mystery? Within the next decade, these questions and more would be answered. Head to Chapter 15 for all the details.

Exploration of the inner solar system

Although Mars remained an important goal for the American space program in the 1990s, NASA's attention turned to several targets in the inner solar system in the last decade of the 20th century and the first decade of the 21st century, as we explain in Chapter 16. The SOHO mission has returned valuable information about the Sun, and the Magellan and Venus Express missions have vastly increased scientists' knowledge of the surface and atmosphere of Venus. Other recent missions have returned to the Moon and sought to unravel the mysteries of asteroids and comets.

Missions to the outer solar system

One of mankind's primary goals in exploring outer space is determining to what extent life, past or present, can be found. When looking for life, the NASA motto is "follow the water" — where there's water, there may be some form of life.

Scientists have several targets of primary interest in the search for life in the outer solar system, as we explain in Chapter 17. Jupiter and its moons were the focus of the Galileo mission in the 1990s, and significant discoveries about subsurface water came to light. From the late 1990s through the first decade of the 21st century, the Cassini mission, which carried the *Huygens* probe at one point, has made similar discoveries on Saturn's moons. The more that's known about life in the solar system, the closer scientists come to understanding more about the origins of humanity.

Modern Space Exploration

We've been to the Moon (and back); we've explored the solar system; we've catalogued the cosmos — what else is there? Plenty, as it turns out. Space exploration in the 21st century continues the work of past missions, but it has also yielded groundbreaking new information about the universe. Powerful telescopes have captured breathtaking views of the cosmos, leading scientists to new understandings of humanity's place in the universe. The International Space Station is laying the groundwork for an enduring human presence in space, and Mars exploration has grown more successful, as you can see in the following sections.

Space telescopes

Despite the success of the Apollo Moon missions, it's not currently practical for humans to make extended visits to other space destinations. Fortunately, space telescopes help provide access to previously inaccessible parts of the universe. The Hubble Space Telescope is one of the best-known because it has taken some of the most-amazing pictures of celestial objects ever seen, but other space telescopes (such as the Spitzer Space Telescope and the Compton Gamma Ray Observatory) have returned their fair share of amazing data as well. See Chapter 18 for more on telescopes in space.

The International Space Station

Are space hotels but a glimpse into the far-distant future? Perhaps not — the International Space Station (ISS), a multicountry collaborative effort, has resulted in a series of modules that have supported a continuous human presence in orbit since late 2000.

Living and working in the ISS comes with a particular set of challenges, and the astronauts are making valuable scientific contributions with the experiments they conduct onboard. Although the station is decidedly unglamorous and can't accommodate untrained astronauts, it provides a basis upon which civilian forays into space might, in the future, be built. Flip to Chapter 19 for details on the ISS.

The latest views of Mars

Despite some early failures in visiting Mars, missions in the 21st century have been able to successfully start exploring the Red Planet. The best publicized of these missions were the Mars Exploration Rovers, which brought two wheeled, fully mechanized rovers (*Spirit* and *Opportunity*) to

the Martian surface. They began their task of documenting the planet's surface in unprecedented detail, and the phenomenal images they sent back home inspired even more interest in discovering the mysteries of Mars. Other ongoing Mars missions include orbiters that have produced stunning maps of the Red Planet's surface; check out Chapter 20 for the full scoop.

Space Exploration in the Future

Even though NASA and other worldwide space agencies have designed and executed many successful missions, all of these accomplishments are but a fraction of the work involved in understanding the cosmos. New missions are constantly being planned — ones that will revisit interesting locations and explore new frontiers.

The next space missions to watch out for

Some robotic missions to watch out for include a return visit to Jupiter's moon Europa, a mission on its way to Pluto, and a Japanese mission to return a sample of an asteroid to Earth. Missions are also planned to provide further details about Mars and to study the Moon with an eye toward future astronaut missions.

On the human spaceflight side, Project Constellation will replace the Space Shuttle with a new Crew Exploration Vehicle dubbed Orion. This capsule-based system will allow astronauts to visit the International Space Station and eventually return to the Moon or head to Mars. Chapter 21 has details on many upcoming robotic and manned missions.

Increased access to space

If that yearly ski trip is starting to seem old and tired, you may soon have new options on the horizon. For those with the means (and we're not talking chump change), purchasing a ticket into space is becoming a reality for the first time in the history of space exploration. Several wealthy individuals have done just that by paying millions of dollars, training and preparing with real astronauts, and taking a ride into space. Although space travel is beyond the means of most folks, prices may eventually come down enough to make spaceflight, or even a stay at a commercial space "hotel," a possibility.

Of course, increased access to space doesn't just refer to the advent of space tourism. As more and more countries over the years have been bitten by the space exploration bug, a third nation has emerged as a true space power. China launched its first *taikonaut* (the Chinese term for astronaut) into orbit

in 2003, followed by a two-person mission in 2005 and a mission with a spacewalk in 2008. China has plans to develop its own space station and eventually send astronauts to the Moon, helping spark some renewed interest in lunar exploration back in the U.S. Could a new Space Race be in the works? Probably not, but a little healthy competition can be good for scientific innovation! Chapter 22 has all the details on space tourism, commercial spaceflight, and China's new space program.

Reasons for continuing to explore space

Why continue to explore space? Why this fascination with the heavens when there are enough problems and diversions here on Earth? Space exploration can be seen as a continuation of humanity's need to explore, to push the limits of the frontier. With future population pressures and the speedy consumption of natural resources, space exploration and colonization may one day become a necessity. In the far-distant future, when the Sun becomes unstable, space exploration may be vital to ensure the survival of the human race. Chapter 23 goes into more detail on the many reasons why space exploration is still a worthy pursuit.