

SPACE NEXT

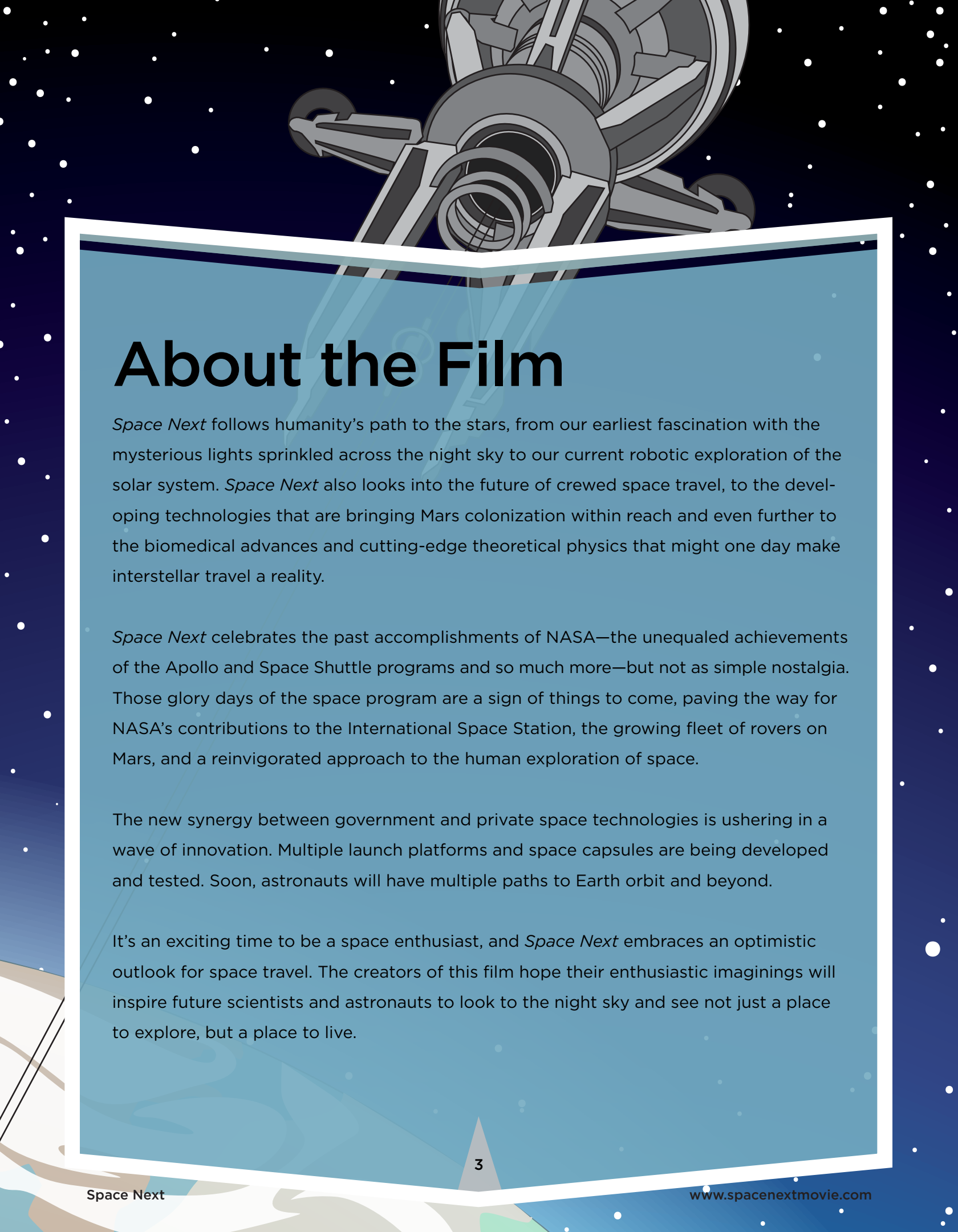


Educator's Guide

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About the Film

Space Next follows humanity's path to the stars, from our earliest fascination with the mysterious lights sprinkled across the night sky to our current robotic exploration of the solar system. *Space Next* also looks into the future of crewed space travel, to the developing technologies that are bringing Mars colonization within reach and even further to the biomedical advances and cutting-edge theoretical physics that might one day make interstellar travel a reality.

Space Next celebrates the past accomplishments of NASA—the unequalled achievements of the Apollo and Space Shuttle programs and so much more—but not as simple nostalgia. Those glory days of the space program are a sign of things to come, paving the way for NASA's contributions to the International Space Station, the growing fleet of rovers on Mars, and a reinvigorated approach to the human exploration of space.

The new synergy between government and private space technologies is ushering in a wave of innovation. Multiple launch platforms and space capsules are being developed and tested. Soon, astronauts will have multiple paths to Earth orbit and beyond.

It's an exciting time to be a space enthusiast, and *Space Next* embraces an optimistic outlook for space travel. The creators of this film hope their enthusiastic imaginings will inspire future scientists and astronauts to look to the night sky and see not just a place to explore, but a place to live.

The Path to Space— A Timeline of Highlights

Circa 1600 BC:

Babylonian records indicate an understanding that the morning star and evening star are a single object, what we know as the planet Venus.

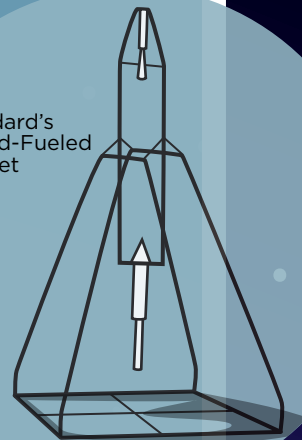
AD 800–1300:

The Chinese invent gunpowder, fireworks, and rockets.

March 16, 1926:

Robert Goddard launches the first liquid-fueled rocket.

Goddard's
Liquid-Fueled
Rocket



October 24, 1946:

A V-2 missile launched from White Sands Missile Range in New Mexico provides first photos of Earth from space.

October 4, 1957:

The Soviet Union launches Sputnik 1, the first artificial satellite of Earth. Sputnik broadcasts the first signal from space.

January 31, 1958:

The United States launches Explorer 1, its first satellite. Explorer 1 returns data from orbit, confirming the existence of the Van Allen radiation belts.

October 1, 1958:

The newly formed NASA, the National Aeronautics and Space Administration, takes over the US space program from the National Advisory Committee for Aeronautics.

Vostok 1:
Soviet
Spacecraft

April 12, 1961:

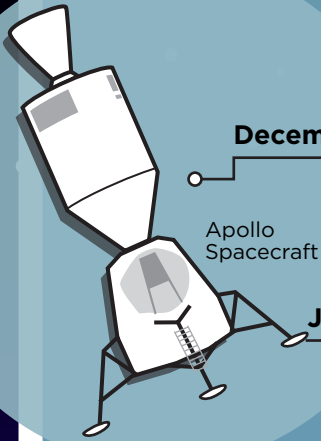
Cosmonaut Yuri Gagarin of the Soviet Union becomes the first man in space while orbiting the Earth a single time.

May 5, 1961:

Alan Shepard's suborbital flight makes him the first American in space.

February 20, 1962:

John Glenn becomes the first American to orbit the Earth, circling three times.



December 21, 1968:

Apollo
Spacecraft

Apollo 8 launches on a six-day mission, becoming the first crewed spacecraft to the moon. Astronauts Frank Borman, James Lovell, and William Anders orbit the moon ten times.

July 20, 1969:

Neil Armstrong of Apollo 11 is the first man to walk on the moon.

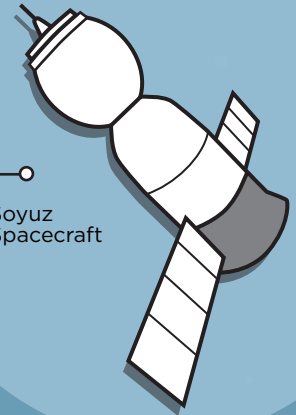
May 14, 1973:

NASA launches Skylab, the first US space station.

July 17, 1975:

The last Apollo module to travel to space docks with Soyuz 19 in the first US-Soviet joint space mission.

Soyuz
Spacecraft



July 20, 1976:

The first successful Mars lander, Viking 1, touches down on the red planet.

April 12, 1981:

The first launch of the Space Shuttle. Columbia orbits for two days before gliding to a landing in California at Edwards Air Force Base.

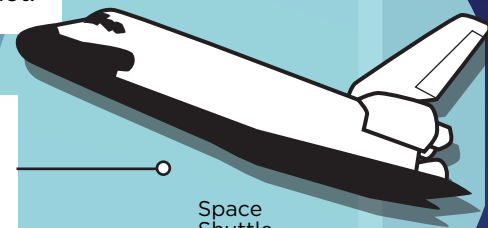
January 24, 1986:

Voyager 2 makes its closest approach to Uranus, the only spacecraft to have visited the seventh planet.

January 28, 1986:

Loss of Space Shuttle Challenger seventy-three seconds after launch. A shuttle would not fly again until Discovery launch on September 29, 1988.

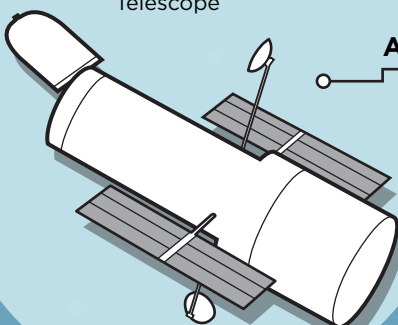
Space
Shuttle
Program



August 25, 1989:

Voyager 2 makes its closest approach to Neptune, the only spacecraft to visit the eighth planet.

Hubble Space
Telescope



April 25, 1990:

The Hubble Space Telescope is placed in orbit by Space Shuttle Discovery.

July 4, 1997:

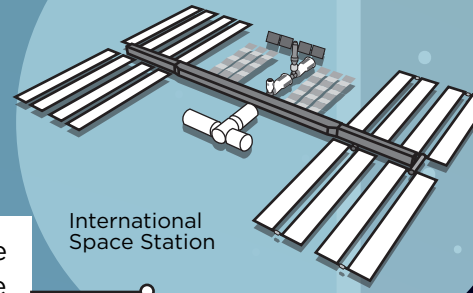
Mars Pathfinder lands on Mars with Sojourner, the first successful planetary rover (the Soviets deployed robotic lunar rovers in the 1970s).

November 20, 1998:

Russia launches Zarya, the first module of the International Space Station.

April 28, 2001:

Multimillionaire Dennis Tito becomes the first space tourist when he launches to the International Space Station aboard Soyuz TM-32.



February 1, 2003:

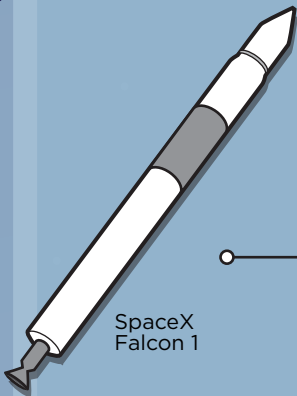
Loss of Space Shuttle Columbia during reentry. The shuttle again grounded until Discovery launch on July 26, 2005.

June 21, 2004:

SpaceShipOne's first suborbital spaceflight is also the first privately funded crewed flight to space.

September 28, 2008:

SpaceX's Falcon 1 becomes first privately funded liquid-fuel rocket to achieve orbit.



July 21, 2011:

The Space Shuttle program comes to an end as Space Shuttle Atlantis touches down at the Kennedy Space Center after its final mission.

August 25, 2012:

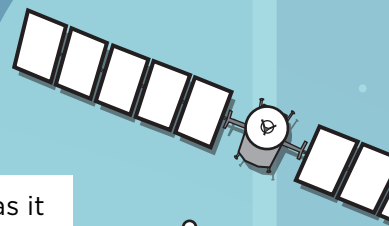
Voyager 1, which launched on September 5, 1977, officially enters interstellar space, the first spacecraft to do so. At the time it was approximately 11.2 billion miles from the sun.

November 12, 2014:

The European Space Agency's robotic lander Philae makes the first soft landing on a comet.

March 6, 2015:

The space probe Dawn is the first to visit a dwarf planet as it enters orbit of Ceres, the largest object in the asteroid belt.



July 14, 2015:

New Horizons makes its closest approach to Pluto.

Becoming an Astronaut

Throughout the US space program of the twentieth century, there was a single path to orbit: NASA. With the growth of privately funded space flight in the twenty-first century, that's changing. But NASA's requirements are still indicative of what it takes to get to space. Do you have the "right stuff"?

According to NASA's website, these are the basic standards for astronaut candidates:

- A Bachelor's degree in biological science, engineering, mathematics, or physical science. Advanced degrees preferred.
- The degree must be followed with three years of professional experience related to the degree or a minimum of 1,000 hours flight time in jet aircraft as pilot in command.
- Must pass NASA's space physical, similar to a flight physical, including these requirements:
 - ▶ Eyesight correctable to 20/20 in both eyes.
 - ▶ Blood pressure of 140/90 or below in a sitting position.
 - ▶ Height between 62 and 75 inches.

Private companies such as Virgin Galactic have their own requirements, but obviously flight experience will remain a priority for any spaceship pilot. However, requirements for space tourist passengers is significantly lower, with a focus on ensuring the person's ability to undertake the physical rigors of a space launch and landing.

When Virgin Galactic or other space tourist companies begin flights, the chance to earn astronaut's wings will no longer be limited to test pilots and scientists!

Where does outer space start?

The transition from Earth's atmosphere to the vacuum of space is long and gradual. The US Air Force and NASA award astronaut wings to people who have flown above an altitude of 50 miles.

The Fédération Aéronautique Internationale (World Air Sports Federation) uses an altitude of above 100 kilometers (62 miles) to define spaceflight.

Virgin Galactic plans to fly its passengers above 62 miles to ensure that their spaceflight participants are considered astronauts around the globe.

Activity:

Beating Gravity Going Up

Overcoming gravity during launches is a major challenge for space travel and exploration, as is seen in *Space Next*. As missions get more ambitious, crew modules, space probes, and rovers get larger, requiring bigger rockets to overcome gravity and leave Earth orbit.

In this activity, students experiment with lifting increasingly heavy payloads against the force of gravity using rockets fueled by their own breath . . . balloons.

Materials needed:

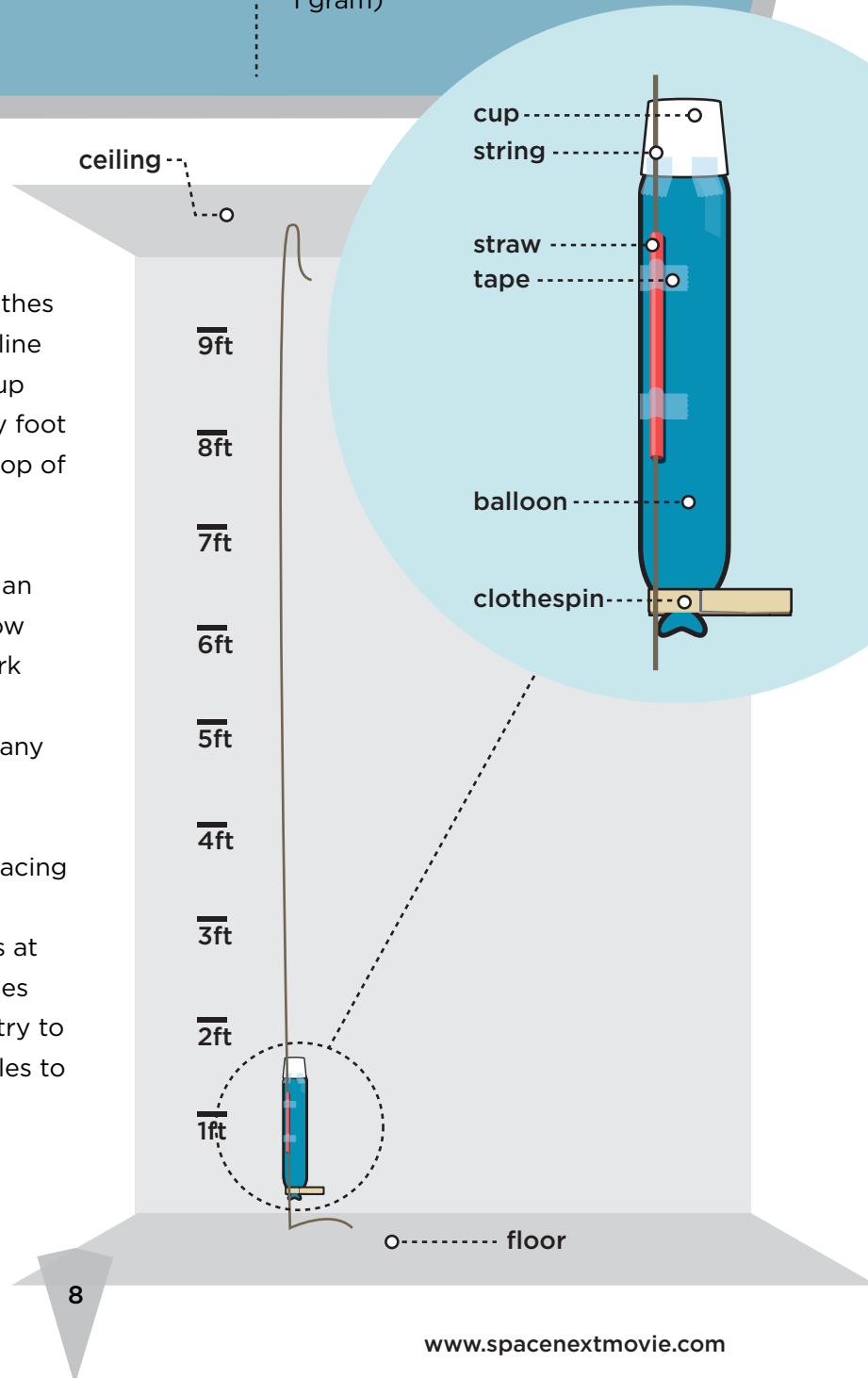
long balloons, tape, clothes pins, string or fishing line, small paper cups.

Optional: a scale to determine exact weight of payloads (two small paperclips are approximately 1 gram)

Blow up a cylindrical balloon (rockets are tube-shaped, not spherical!) and seal it with a clothes pin. Tape a straw to its side. Run string or fishing line through the straw, and attach the string straight up from the floor to the ceiling. Mark the string every foot from the floor up. Tape a small paper cup to the top of the balloon. This is the payload module.

Release the clothes pin to launch the rocket with an empty payload module. Note how high it flies. Now refuel the rocket and add payload. Paperclips work nicely. Try to guess how many paperclips you can propel all the way to the ceiling, then load that many and see how high the rocket gets.

Experiment with different amounts of payload, placing a cone over the paper cup, and adding booster balloons (although releasing multiple clothes pins at the same time might be tricky). Record all variables and the heights reached. Discuss the results and try to design more effective rockets and payload modules to get maximum paperclips to the ceiling.



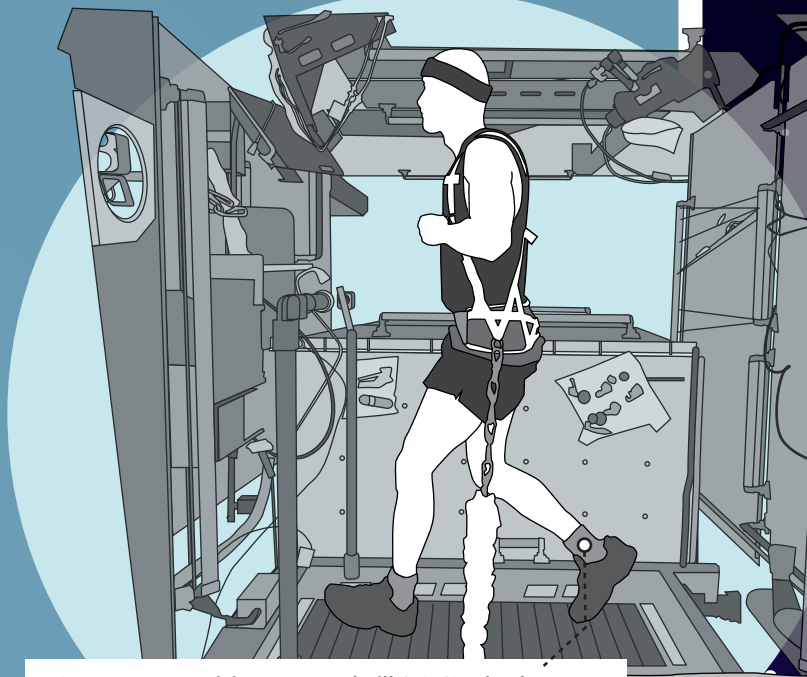
Living in Space

Early spaceflights could be measured in mere minutes or a handful of orbits. But as technology advanced, so did the duration of missions. Lunar missions lasted five to twelve days. Space shuttle missions ranged from two to fifteen days. The development of various space stations, from Salyut to Skylab to Mir to the International Space Station, however, allowed astronauts and cosmonauts to test the limits of human endurance in microgravity environments, measuring missions not just by days or weeks but months.

The Soviet Union/Russia has dominated long-term life in orbit, holding the records for all top-ten longest spaceflights, ranging from 207 to 437 days in space. Long US missions have generally been around six months. But that is changing as NASA prepares for an eventual crewed mission to Mars, which will last at least a year.

On March 27, 2015, astronaut Scott Kelly lifted off from the Baikonur Cosmodrome in Kazakhstan with cosmonaut Mikhail Kornienko to begin their One-Year Mission aboard the International Space Station. Kelly and Kornienko will undergo extensive physical tests during their year aboard the station. Kelly's twin brother, astronaut Mark Kelly, will be tested on Earth for the first comparative twins study of the effects of life in space.

The results of the One-Year Mission will provide valuable information for future long-term missions, helping astronauts stay physically and mentally fit during months of travel to and from destinations such as Mars or the dwarf planet Ceres.



Astronaut exercising on Treadmill 2 (T2), also known as the Combined Operational Load Bearing External Resistance Treadmill (COLBERT), aboard the ISS.

What happens to your body in a spaceship?

There are several side effects of life in a microgravity environment, ranging from the curious—astronauts can gain up to 3 percent in height—to troublesome. For instance, astronauts' muscles, without working against gravity, begin to lose mass. Without exercise to counteract this, astronauts would find themselves quite weak upon returning to Earth. Astronauts can also lose up to 1 percent of bone density, but this, like dwindling muscle mass, is helped by exercising while in space. Another curious problem faced by astronauts is difficulty sleeping. While in space, without the protection of Earth's atmosphere or magnetic field, cosmic rays zip through the station, causing flashes of light in the closed eyes of resting astronauts, interrupting their sleep. And you don't need to be an astronaut to understand the dangers of sleep deprivation.

Activity:

Modeling the Solar System

Space, as Douglas Adams said in *The Hitchhiker's Guide to the Galaxy*, "is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is."

This activity demonstrates just how big our solar system is, even though it is itself only a tiny speck compared to our galaxy, the Milky Way (not to even mention the rest of the known universe). There are two parts to this activity, on two different scales.

Materials needed:

paper, markers, scissors, drafting compass, tape, ruler

The Planets

This part models the planets in scale to one another. Students will be able to easily compare just how big—or small—Earth is compared to the rest of the planets. (Plus the dwarf planet Pluto!) Use a ruler to mark the scale size on paper, then a compass to draw a circle around that diameter. For tiny Mercury and Pluto it might be easier to draw the circle by hand. Label your planets and cut them out. We're not making the sun; that circle would be nine feet wide!

The Orbits

The second part demonstrates the vast distances encompassed by the orbits of the planets within the solar system based on an Astronomical Unit, which is derived from an approximation of the distance of the Earth from the sun, about 92,955,807 miles. Ten students will need to represent the sun, the planets, and dwarf planet Pluto. Everyone else can be asteroids! Now comes the measuring. This will need to be done outside or on a basketball court inside to have enough room. Hand out the planet and dwarf planet circles. Place the sun first, then measure out the planets. Pluto has an off-center orbit, so its distance from the sun varies wildly. Put Pluto at its closest distance to the sun if you're inside. If outside, put it all the way out to the farthest distance! Everyone else can spread themselves out in a circle as the asteroid belt. Note how close together the inner four planets are compared to the outer planets.

This activity is accessible for all ages, although younger students will probably have more fun playing planets in orbit.

▼ Planet Measurements

Planet	Diameter in Miles	Ratio to Earth	Scale Size in Inches
Mercury	3,032	.383	3/8
Venus	7,543	.952	15/16
Earth	7,926	1.00	1
Mars	4,217	.532	1/2
Jupiter	88,732	11.2	11 1/4
Saturn	74,898	9.45	9 1/2
Uranus	31,763	4.01	4
Neptune	30,775	3.88	3 7/8
Pluto	1,429	.180	3/16

▼ Orbit Measurements

Planet	Distance from Sun in AU	Scale Distance
Mercury	.38	13 1/2 in.
Venus	.72	26 in.
Earth	1.0	3 ft.
Mars	1.5	4 ft. 6 in.
Asteroid Belt	2.7 (average)	8 ft.
Jupiter	5.2	15 ft. 6 in.
Saturn	9.5	28 ft. 6 in.
Uranus	19.2	57 ft. 6 in.
Neptune	30.1	90 ft. 4 in.
Pluto	29.6–48.8 (closest to farthest)	89–146 ft.

Keep in mind that the planets are in scale to each other, and the orbits are in scale to each other, but the planets are not in scale to the orbits. Remember, if we'd made the sun in scale to the planets, it would have been nine feet across, which would swallow up the inner four planets on the orbit scale. If we sized the planets in scale to those orbits, they'd be too tiny to make! Space is big. Really big.

Mining in Space

Asteroid mining might be science fiction for now, but NASA is planning for the possibility of harvesting the minerals—and water!—in these giant rocks tumbling through space. The OSIRIS-Rex mission, planned to launch in 2016, will make a two-year journey to the asteroid Bennu, study Bennu's composition, and eventually return samples to Earth. The information gathered could yield clues about the formation of the solar system as well as strategies for asteroid deflection and techniques for mining.

Asteroids range in size from a few yards to hundreds of miles in diameter, and there are three broad categories: C-type, S-type, and X-type. The latter two are what people think of when traditional mining is being discussed. S-type asteroids are largely composed of iron, cobalt, and nickel, with trace amounts of rare metals such as gold and platinum. X-type asteroids are rare, but contain ten times more metal than S-type, making them quite a find for future space miners. Whether mined in the asteroid belt or captured and pulled back to lunar orbit, these rocks could provide valuable metals for Earth-based production and minimize the need for invasive mining on the Earth's surface.

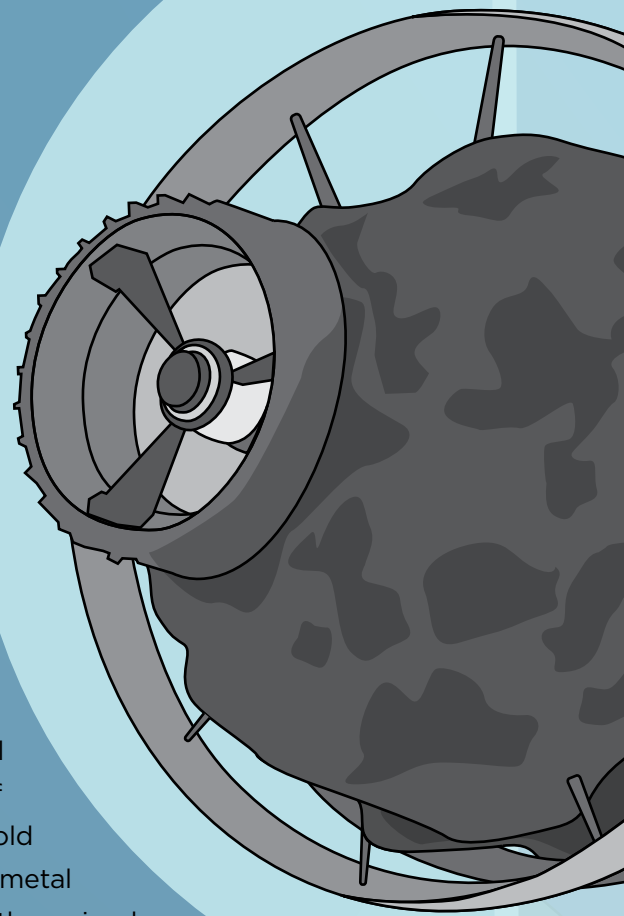
C-type asteroids, however, are not the destination for astronauts interested in panning for gold. The C-types hold water and organic carbon, which would be great resources for humans living in space. Instead of shipping Earth water into orbit—when there are already high demands on our water supply—the water could be extracted from asteroids. Water can also be broken down into hydrogen and oxygen to provide rocket fuel. Carbon, phosphorous, and other elements in these asteroids could be used as fertilizer in extraterrestrial gardens, helping space colonies become self-sufficient. *Space Next* dramatizes large-scale mining missions in a high-tech future.

Who will mine the asteroids?

In the growing entrepreneurial spirit of commercial use of space, two companies have started developing plans for asteroid mining.

Both Deep Space Industries and Planetary Resources have long-range plans for space mining, and both have partnered with NASA on asteroid-related projects. The companies are building and testing hardware to achieve their goals.

The next decade could be a turning point in space infrastructure. If asteroid mining can move toward profitability, it will have a domino effect on the space industry, inspiring and making possible further advancements for humans in space.



Activity:

Mining Meteorites from Your Lawn

Meteoroids are small solid natural objects moving through space. A meteor is what is often called a shooting star, a meteoroid that has entered the atmosphere and is seen burning across the sky. If a meteoroid survives all the way to the ground, it becomes a **meteorite**.

Materials needed:

strong magnet, plastic wrap or bags, magnifying glass or microscope, internet access

Meteors are much more common than most people realize. Since only the rare large ones captured on video make the news, it's easy to forget that Earth is pelted by smaller ones around the clock. Perhaps as much as 100 tons of meteorites hit the Earth every day, but most are little specks, just space dust settling quietly to the ground . . . perhaps right in your backyard.

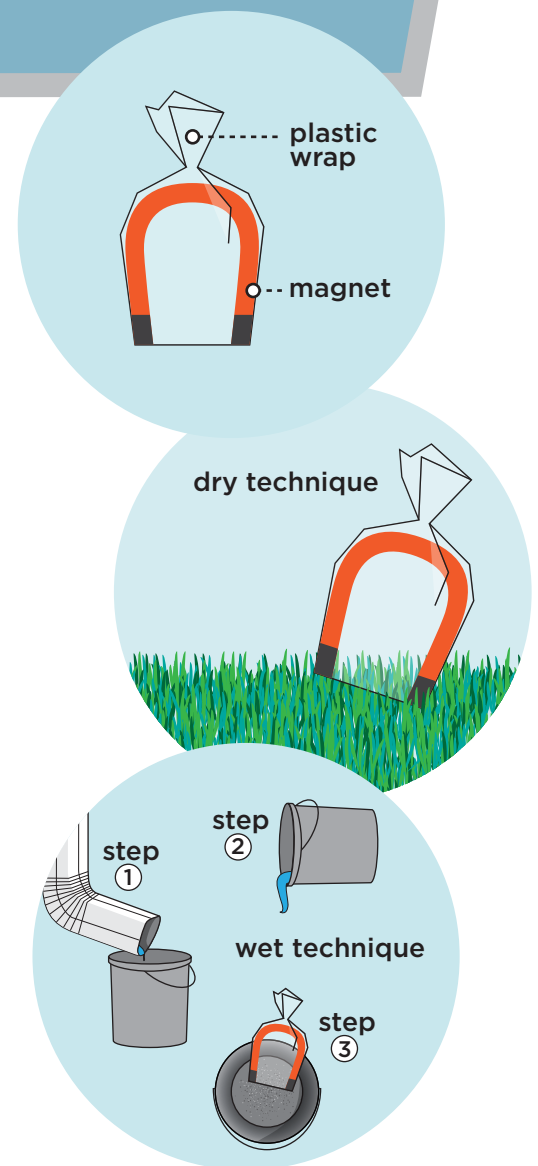
A large percentage of meteorites contain iron, which means they can be picked up with a magnet. This is how you can mine for the micrometeorites that may be right under your feet. There are two techniques you can try: dry or wet.

The dry approach is to simply drag a magnet—a strong magnet, not just something that was holding a grocery list to your fridge—through the grass.

The wet technique involves rain water. Set out a bucket or pan when it's raining, beneath a down spout from your house's gutters if possible. When it's done raining, carefully pour off the clear water, leaving the sediment at the bottom. Let this dry out. If it dries into big clumps, crush it into finer grains. Then it's time to get out your magnet.

For both techniques, put some plastic wrap around the magnet before you use it. Be careful not to rip the plastic while dragging it around. Soon, with some luck, the magnet will have attracted various particles. Slowly pull the plastic off the magnet, trapping the magnetic particles in the plastic. Now you can examine these particles with a magnifying glass or microscope. Some of them might be from outer space!

It's hard to tell the difference between a micrometeorite and other tiny metallic pieces that might originate from the exhaust of engines or factories. If you live in the city or close to a factory, there's a better chance of finding those sorts of pollutants. But if you live in the country, there could be a higher ratio of meteorites to other little bits of metal. Research micrometeorite pictures on the internet, and see if you can find close matches.



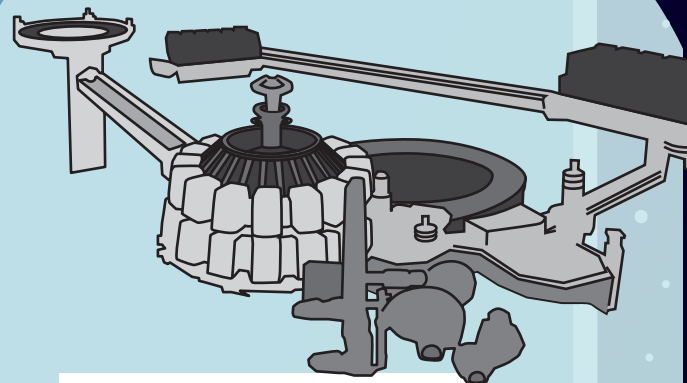
Going to Mars

Mars has long fascinated the people of Earth. Unlike cloudy Venus, basic surface features could be discerned with telescopes by the late 1800s. The low resolution of early telescopes along with the mistranslation of the Italian word for channels, *canali*, as canals led to imaginative misinterpretations of those features. H. G. Wells's novel *The War of the Worlds* and Edgar Rice Burroughs's series of Barsoom novels featuring John Carter both capitalized on and reinforced the idea of advanced Martians.

While those dreams came to an end with modern telescopes and space probes, the fascination with Mars continues. Evidence collected by NASA's Mars rovers brings science full circle: while there were no water channels, much less canals, in recent history, Mars may have been quite wet millions of years ago. Some theorize an ocean spreading across the northern hemisphere of the planet. There could still be pockets of frozen water underground that, under the right seasonal conditions, melts and flows to the surface. And where there's water, there could be life, even if only microscopic.

Although Mars landers and rovers have done amazing jobs, humans on Mars could try to get to the bottom of these issues more quickly. A crewed mission to Mars would, like the Apollo missions, capture the attention of the entire world. Unlike Apollo, however, such a vast undertaking would necessarily be an international venture. The first people on Mars would likely only stay for a few weeks, but a different scenario would have them there for a year. The latter seems more like a colony than just a landing! Either way, it would be a first step toward a permanent habitation of the Red Planet. With the new optimism of private space companies working together with NASA, humans living on Mars seems inevitable, a question of when, not if.

Space Next takes Mars to the next step beyond space station-like Martian habitats to terraforming: the large-scale manipulation of a planet's ecosystem to create human-friendly living conditions in its surface. Such a project would likely take hundreds of years, but would result in an environment where humans would no longer need special suits or habitats to live on Mars.



A concept for a permanent structure on Mars as seen on *Space Next*.

How long does it take to get to Mars?

Current technology gets rovers to Mars within eight months. It's hoped that advances over the next decade will get that down to six months or so. That would still make a minimum Mars mission a year long, with just a few weeks on the surface. Among the many challenges such a long mission would face is protecting astronauts from the radiation exposure of space. Another is simply keeping the crew occupied for six months of travel both there and back. Work and research on the International Space Station, especially the One-Year Mission, will be instrumental in overcoming these issues.

Activity:

Beating Gravity Coming Down

Safely landing rovers and landers on the surface of various planets, moons, comets, and asteroids has required a variety of approaches, as shown in *Space Next*.

The goal of this activity is the successful touchdown of a lander—represented by a raw egg—by building a protective carrier that will prevent it from cracking when dropped to the floor. The project can be done individually, but a teamwork approach is more like NASA and provides opportunities for cooperative brainstorming.

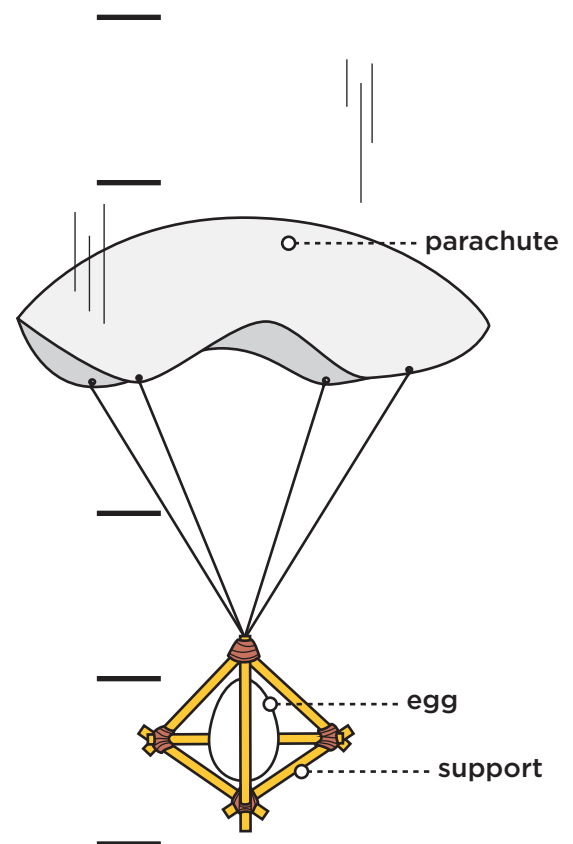
Materials needed:

eggs, yard stick or measuring tape, various items for padding and building, glue, tape, plastic drop cloth

After designing and building the protective carrier, students will test their design by dropping the lander from increasing heights and noting the results. If the egg breaks, students can adjust their design and try again.

The carrier should be tested from heights of two feet to six feet, increasing by one foot for each test. Students can take notes and photographs to document the series of experiments. Students should try to explain what worked—or didn't work—and why.

This activity can be adjusted for various grade levels. Lower grades can keep simpler records or just give oral descriptions of their experiments. The building of the carriers can also be adjusted to age-appropriate levels. K-3 can be limited to the use of simple padding of various types. Grades 4-6 can build protective frameworks from various materials. Grades 7-9 can experiment with parachutes in addition to the protective structures. Grades 10-12 can use an uneven landing surface for an addition level of difficulty.



NASA Travel Plans

NASA is actively developing new technologies and spacecraft with a goal of putting humans on Mars in the 2030s. Orion is the new crew module, designed for a crew of up to four astronauts. For its first test flight (uncrewed), it was launched with a Delta IV Heavy rocket in December 2014, but it will eventually be paired with NASA's Space Launch System, currently under development. NASA also plans to send astronauts to an asteroid by 2025. Here are highlights of NASA's plans for the next twenty years, as currently scheduled:

2016

InSight, the next Mars lander, launches. The lander will feature a seismic sensor for detecting Marsquakes as well as a drill capable of digging as deep as 16 feet into the Martian soil.

InSight lands on Mars.

Juno orbiter (launched in 2011) begins studying Jupiter's massive magnetic field.

OSIRIS-REx, an asteroid sample return mission, launches.

2018

Space Launch System takes first test flight; Orion (uncrewed) launched for a flight around the Moon followed by return to Earth for splashdown. Following Orion's deployment, SLS will launch a group of solar sail CubeSats to orbit the Moon and head toward an asteroid.

OSIRIS-REx begins survey of asteroid Bennu.

Solar Probe Plus launches. During several orbits the probe will fly closer to the sun than any other spacecraft.

James Webb Space Telescope launches. The infrared telescope will be able to see further back in time than any previous telescope.

2019

OSIRIS-REx collects sample from surface of Bennu.

2020

Launch of **Mars 2020 rover**. The rover will collect samples that will eventually be returned to Earth.

Early
2020's

Launch of **Asteroid Redirect Mission**, which will capture a boulder up to thirteen feet in diameter from the surface of a near-Earth asteroid and bring it to lunar orbit.

2021

Astronauts launch on first crewed Orion test flight.

OSIRIS-REx leaves Bennu and heads home.

2023

OSIRIS-REx returns Bennu sample to Earth

2025

Astronauts launch in Orion on a mission to inspect the captured asteroid boulder in lunar orbit.

Late
2020's

Europa orbiter launches to Jupiter to study the moon which may have a large ocean of water beneath its icy crust.

2030's

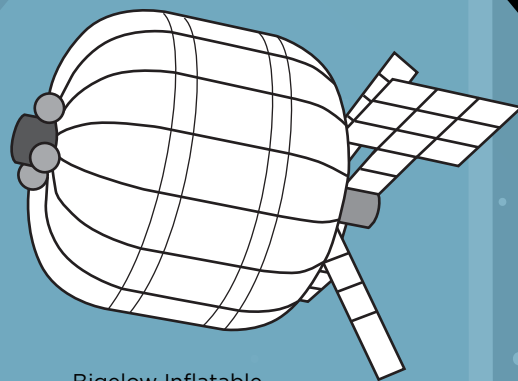
Astronauts launch in Orion on first mission to Mars.

Space Companies

The new model of space exploration features a strong partnership between NASA and the private sector. By yielding low Earth orbit transportation to such companies, NASA can devote its resources to not-for-profit science, like probes, landers, and rovers, and larger efforts like crewed Mars missions. It can also let bold private firms tackle long-term risky ventures such as asteroid mining. Here's a sampling of private companies that are making a run for profits in outer space.

Bigelow Aerospace

Bigelow Aerospace is developing inflatable space modules suitable for space stations or bases on the Moon or Mars. Space stations could be configured for scientific use or as orbital hotels for space tourism. The narrow profile of the uninflated modules allows for the launch of a module that, once inflated in space, provides substantially more internal volume than any existing module of the International Space Station. Two test modules, Genesis I and II, were successfully placed in orbit by 2007. The Bigelow Expandable Activity Module is slated for testing on the International Space Station from 2015 through 2017.



Bigelow Inflatable Space Hotel

Deep Space Industries

The second of two companies to announce intentions to mine asteroids has said it plans to launch a fleet of small probes in 2015 to begin prospecting. The company wants to begin mining operations by 2025.

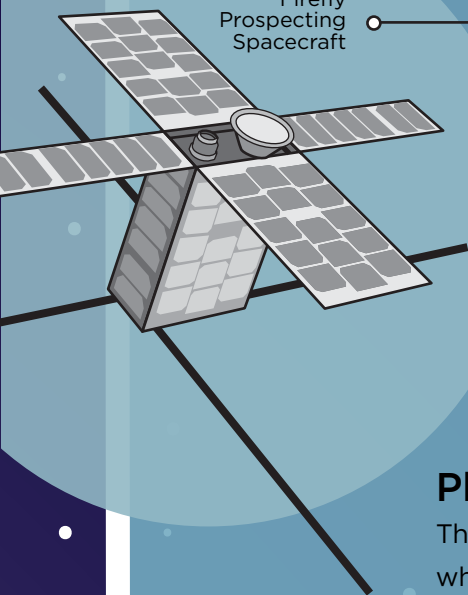
Orbital ATK, Inc.

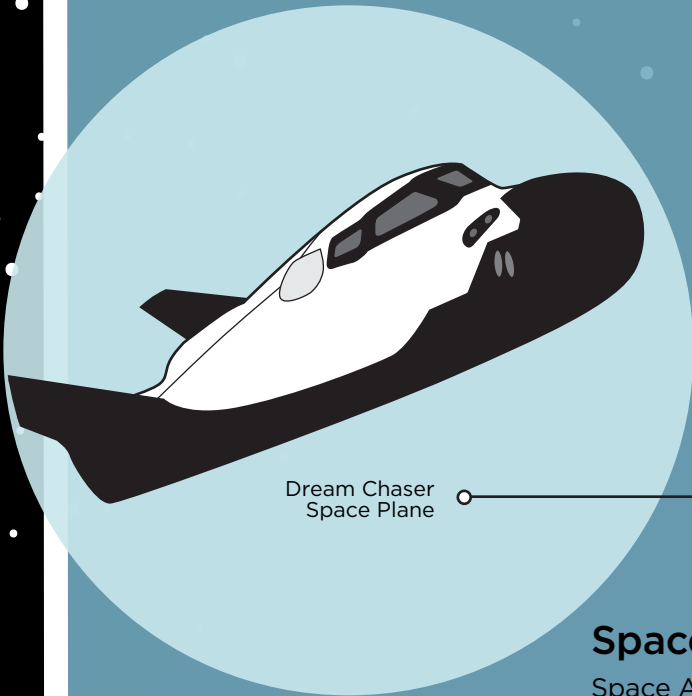
Orbital has manufactured launch systems, satellites, and other spacecraft. Its Antares rockets have launched its Cygnus cargo modules to ISS. Orbital contributed to the building of NASA's *Dawn* probe currently orbiting the dwarf planet Ceres.

Planetary Resources

The first company founded to mine asteroids lost its first test prospecting satellite when the Antares rocket it was on failed and exploded on launch. Their next test satellite launched in April 2015 aboard a SpaceX Dragon to ISS. The small satellite was then sent into orbit from a launch system aboard ISS.

Firefly Prospecting Spacecraft





Dream Chaser
Space Plane

Sierra Nevada Corporation's Space Systems

Known as SpaceDev before its acquisition by SNC, SpaceDev worked with Scaled Composites to build rocket engines for SpaceShipOne. Space Systems is building rockets for SpaceShipTwo. They are also continuing development of the Dream Chaser spaceplane, essentially a mini-Space Shuttle, for carrying astronauts to and from ISS. A test flight is planned for November 2016.

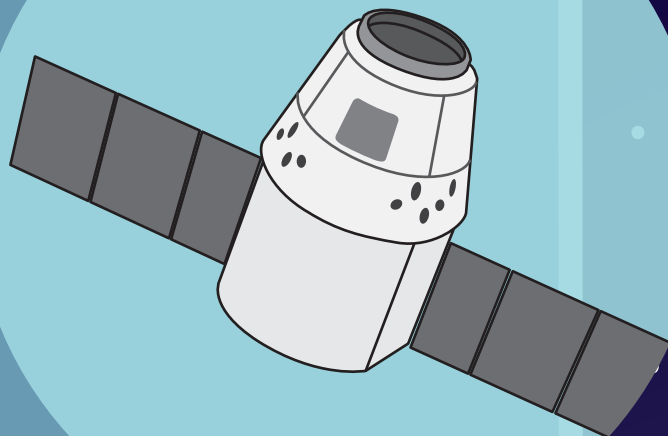
Space Adventures

Space Adventures arranges trips for space tourists. Their first client was Dennis Tito, who became the first space tourist in 2001. They have since sent six additional clients to ISS. By 2018 they hope to launch their first circumlunar trip, sending two tourists and a cosmonaut around the Moon.

SpaceX

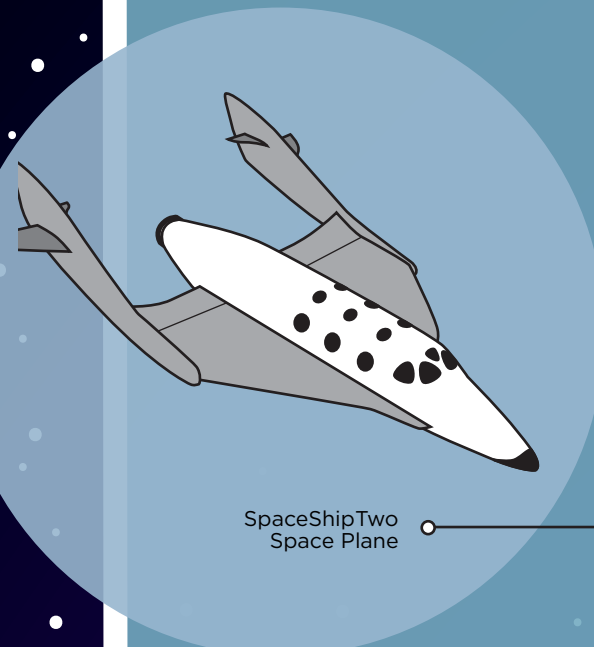
SpaceX has developed the Falcon launch system and the Dragon cargo module. The Dragon made the first commercial cargo delivery to ISS. They are developing a crew version of the Dragon and larger versions of the Falcon. SpaceX has begun tests of a reusable first stage for Falcon; the stage would land vertically after separating from the upper stages.

Dragon cargo
module



Virgin Galactic

Virgin Galactic has already sold hundreds of tickets for its planned suborbital flights aboard the SpaceShipTwo spaceplane, which is launched in air from beneath the carrier aircraft White Knight Two. They are still in the testing stage after suffering a setback in 2014 with the loss of VSS *Enterprise* during a powered test flight. The copilot lost his life, while the pilot survived with serious injuries. The next spaceplane, VSS *Voyager*, will be completed in 2015.



SpaceShipTwo
Space Plane

Next Generation Science Standards

The historical and hypothetical space exploration portrayed in *Space Next*, along with the related science activities suggested in the *Space Next Educator's Guide*, can be used to stimulate classroom discussion and projects that support Next Generation Science Standards. Examples of grade-appropriate class work, organized by Disciplinary Core Ideas relevant to subjects covered in *Space Next*, are provided below.

Kindergarten—Motion and Stability: Forces and Interactions

- K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

Kindergarten through Second Grade—Engineering Design

- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Third Grade—Motion and Stability: Forces and Interactions

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

Fifth Grade—Motion and Stability: Forces and Interactions

- 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed downward.

Middle School—Earth’s Place in the Universe

- MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.

High School—Motion and Stability: Forces and Interactions

- HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
- HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
- HS-PS2-4. Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects.

Recommended Reading

Ages 6 through 8

Astronauts

Hannah Wilson

Solar System for Kids for Fun and School: Stage 1

Jamie Maslen

Stars and Planets Handbook

Anne Rooney

Ages 9 through 11

Apollo 13

Kathleen Weidner Zoehfeld

Eye on the Universe: The Incredible Hubble Space Telescope

Michael D. Cole

Welcome to Mars: Making a Home on the Red Planet

Buzz Aldrin and Marianne Dyson

Ages 12 through 14

Curiosity's Mission on Mars: Exploring the Red Planet

Kathleen Weidner Zoehfeld

Flying to the Moon: An Astronaut's Story

Michael Collins

What's so Mysterious about Meteorites?

O. Richard Norton and Dorothy Sigler

Ages 15 and Up

Interstellar Age: Inside the Forty-Year Voyager Mission

Jim Bell

New Space Frontiers: Venturing into Earth Orbit and Beyond

Piers Bizony

*You Are Here: Around the World in 92 Minutes:
Photographs from the International Space Station*

Chris Hadfield

Recommended Websites

Astronomy Picture of the Day
<http://apod.nasa.gov/apod/astropix.html>

Bradford Robotic Telescope
<http://www.telescope.org/>

Hubblesite (Hubble Space Telescope)
<http://hubblesite.org/>

International Space Station
https://www.nasa.gov/mission_pages/station/main/

Kennedy Space Center Visitor Complex
<https://www.kennedyspacecenter.com/>

Mars Science Laboratory: Curiosity Rover
<http://mars.nasa.gov/msl/>

The Planetary Society
<http://planetary.org/>

Glossary

Apollo—NASA program that placed first humans on the Moon

asteroid—a minor planet of the inner solar system, mostly located within the asteroid belt between Mars and Jupiter, ranging in size from 20 yards to 600 miles across

astronaut—originally a spacecraft crew member of a government-trained space program; now often used for any person who travels to space, such as space tourists

cosmonaut—Russian term for astronaut

CubeSat—a cube-shaped miniature satellite just 10 centimeters (about 4 inches) wide

dwarf planet—natural object orbiting the Sun that is larger than an asteroid but smaller than a planet; currently recognized dwarf planets range from about 500 to 1260 miles in diameter, including Pluto

International Space Station (ISS)—active and still expanding space station in low Earth orbit consisting of over a dozen connected modules

lander—a spacecraft designed to land on the surface of an astronomical body such as a planet, moon, or asteroid

launch system—rocket that carries spacecraft to orbit from the surface of the Earth

low Earth orbit—an Earth orbit between altitudes of approximately 100 and 1,200 miles

meteor—a meteoroid that has entered Earth's atmosphere

meteorite—any piece of a meteor (or other natural space object) that survives burning through the atmosphere and lands on the Earth's surface

meteoroid—a small metallic or rocky space object smaller than an asteroid

Mir—low Earth orbit Soviet/Russian space station active from 1986 to 2001

module—individual section of a spacecraft or space station

orbit—the curved path of a spacecraft or natural space object around a planet, star, or moon

orbiter—a spacecraft designed to orbit space objects without landing

payload—contents of a launch system, from passengers to cargo and other equipment

probe—a robotic spacecraft designed to explore space or space objects

rover—an exploratory vehicle designed to travel across the surface of a planet or moon; can be robotic or carry human crew

satellite—natural or artificial object in orbit around a planet, star, or moon

Skylab—low Earth orbit US space station in orbit from 1973 to 1979

Soyuz—Soviet/Russian crewed spacecraft consisting of orbital, reentry, and service modules

spaceplane—a reusable spacecraft designed to take off or land like an airplane

Space Shuttle—NASA spaceplane that flew from 1981 to 2011

space tourist—person who is not part of a traditional government space program and has traveled to space primarily for recreation or private corporate business

suborbital—trajectory of missile or vehicle that reaches space but does not have the velocity to achieve low Earth orbit

SPACE NEXT

A journey of mankind's pursuit to reach the stars. From the beginning of our earliest dreams that sparked the imagination to the machines that took us there, Space Next will present the history that inspired generations and inventions that have changed the world forever. The film will reveal the possibilities of what is to come next and will explore the exciting future of private space developments, national space programs, and the latest innovations. The result is a mesmerizing display of intergalactic excellence sure to inspire the next generation of dreamers and astronomers.

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