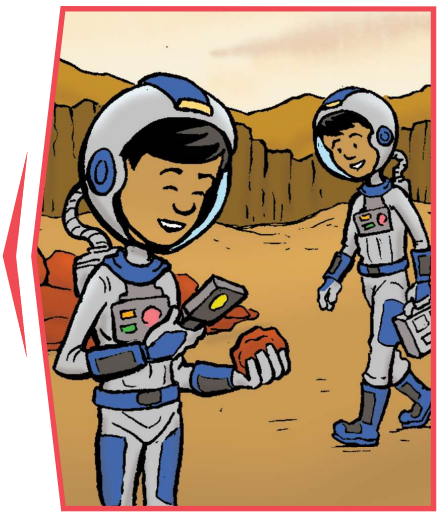
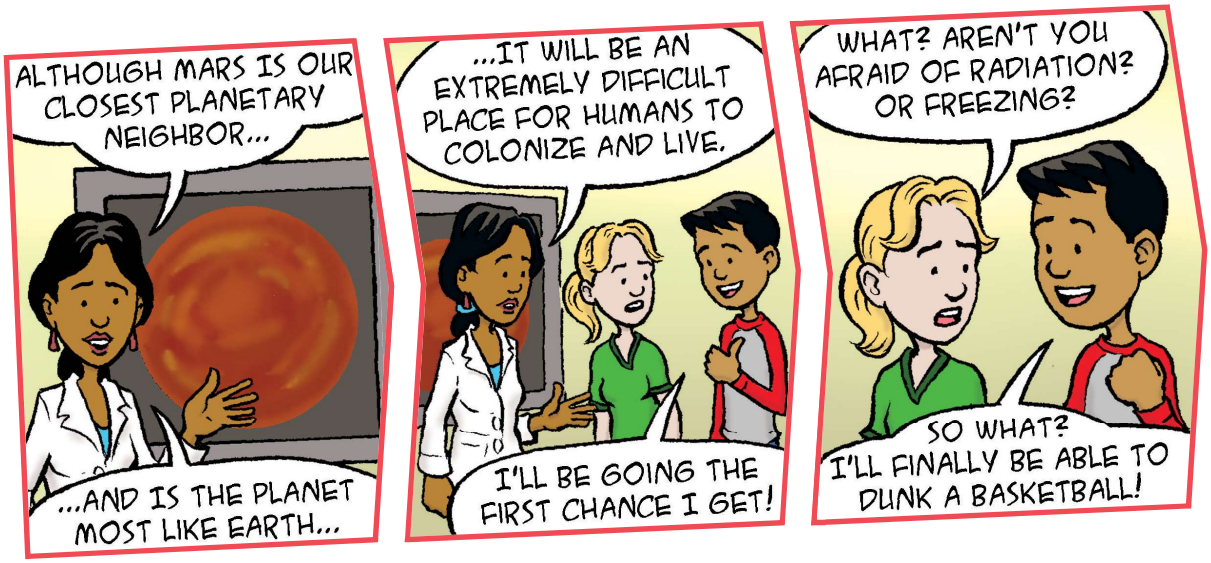
Chapter 3

Living on Mars



Why are humans interested in living on the Red Planet?



Inhabiting another planet has long been a human dream, and Mars is the planet that has the most potential of being habitable.

Science fiction makes living on other planets look easy. Most books and movies present alien worlds as Earth-like, though they might host exotic life forms, have weaker gravity, or orbit two suns. Even Mars is usually shown as much more Earth-like than it really is. But the movie *The Martian* is a little different from most stories about Mars. It shows the planet as a hostile, difficult place for humans to live, especially if you're a botanist stranded alone with little hope of being rescued.

The Martian is among the most realistic examples of just how hard getting to and living on Mars will be for future astronauts. The story uses a lot of real science and technology that isn't too futuristic. Right now, scientists and engineers are working to develop the necessary technologies to get humans to Mars in the 2030s. Many agree this is just the first step toward making humanity a truly multi-planetary species.

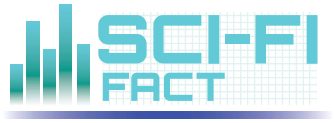
THE EARTH AND MARS

Earth is a special place. From microbes and mosquitos to whooping cranes and whales, it's the only planet we know of that can support life. Everything that thrives on Earth has evolved and adapted to this planet, with its thick, oxygen-rich atmosphere, plenty of water, and sunlight. Life is protected from deadly radiation by the planet's strong magnetic field and atmosphere. Earth orbits at just the right distance from the sun to have an average surface temperature of 57 degrees Fahrenheit. The conditions on Earth are perfect.

Mars is both similar and very different. Orbiting about 1.5 times as far from the sun, a year on Mars lasts 687 Earth days. A Martian day, or sol, is only 37 minutes longer than a day on Earth. Both planets have icecaps, mountains, canyons, and volcanoes.

> Mars is the most Earth-like planet we know, but there are differences between Earth and Mars that are more important for life on these planets.

Being farther from the sun, Mars receives less solar energy. It's cold! The average surface temperature is -51 degrees Fahrenheit, quite a bit colder than most places on Earth. Mars also lacks a protective magnetic field, allowing radiation from space to reach the ground. What little atmosphere remains on Mars is about 100 times thinner than ours and is made mostly of carbon dioxide.



Scientists and meteorite hunters sometimes find meteorites from Mars here on Earth!

GRAVITY ON MARS

With a diameter of just 2,110 miles, Mars is only half as wide as Earth. It's also only 15 percent as massive, meaning the pull of gravity is much weaker. Standing on the surface of Mars, you would weigh only about one-third of your weight on Earth!

All of these factors mean there are no oceans, lakes, or rivers on the surface of Mars. Even so, it's possible for humans to live there, if we have the right technology. But before we can think of living on Mars, we have to get there.

THE PATH TO MARS

The trip to Mars will be a long and dangerous one. So far, human exploration of space has relied on chemical propulsion, which is powerful enough to lift people and supplies off Earth but not very good at letting us travel between planets. In 1968, it took three days for *Apollo 8* to travel to the moon and another three days for the crew to get back home—a 480,000-mile round trip took nearly a week.

Mars, at its closest, is about 40 million miles away. A voyage there will take months using even our most powerful rocket engines.

> To make the trip to Mars even more difficult, there are no straight lines when traveling from one planet to another.

All the planets in the solar system orbit the sun, and any spacecraft that travels between planets will do the same. To travel from Earth to Mars, a spacecraft needs to plan its trajectory so that its orbit intercepts the orbit of Mars at just the right place and time.

Because the distances between Earth and Mars are always changing, planning the shortest path to Mars is important. The longer the voyage, the more the astronauts are exposed to the dangers of space.

SCI-FI FACT

The amount of time and energy needed to travel from Earth to Mars is at its lowest every 26 months. This is called a launch window.

In the next chapter, we'll look at how the speed of light will further affect our ability to travel to Mars.

SPACE TRAVEL CHALLENGES

Science fiction stories often describe large and roomy ships. These come with private rooms, fresh food, running water, large viewing windows, and Earth-like gravity.

The reality of space travel is very different. Spacecraft designed to lift astronauts to the International Space Station tend to be compact, with just enough room to give astronauts a safe ride to orbit. Any craft designed to take humans from Earth to Mars will need to be larger, more comfortable, and capable of protecting passengers from the dangers of deep space.

One of the greatest dangers to people in space is radiation. The radiation in space is different from the radiation we experience here at home. Earth's magnetic field and substantial atmosphere help block most harmful radiation rays from reaching the surface. For astronauts, cosmic radiation, also called cosmic rays, are extremely harmful and difficult to protect against.

Some cosmic rays come from our sun as particles emitted during solar flares. These particles move at extremely high speeds and have enough energy to easily penetrate the thin metal walls of space habitats. They have an impact on astronauts' bodies. When cosmic particles enter cells in the body, they can damage them. This can lead to problems such as cataracts and cancer.

Other cosmic rays, called galactic cosmic rays, come from outside the solar system. They zip through the galaxy at nearly the speed of light and cause the same kind of damage.

Scientists are studying ways to shield astronauts from this deadly radiation. Certain materials, such as water and even human waste, can absorb or deflect these harmful rays. But radiation isn't the only challenge.

The most common forms of harmful radiation we experience on Earth are ultraviolet rays and X-rays. Ultraviolet rays are emitted by the sun and are what cause sunburns. Most of our exposure to X-rays is from visits to the doctor!

THE GRAVITY OF THE SITUATION

The longer the journey, the more important it is for astronauts to stay strong.

On Earth, we are held to the ground by the force of gravity. Our bones and muscles fight against this force to stand, jump, and move around, keeping us in good shape. In space, astronauts are in a microgravity environment, or weightlessness, for long periods of time.

When our bodies are no longer fighting the force of gravity, strange things begin to happen. Muscles don't need to work as hard, so they shrink from disuse, leaving them weaker. Bones lose density, making them more brittle. Even the fluids in our bodies behave differently in microgravity. On Earth, blood, water, and other fluids are pumped upwards to the heart and brain against gravity's pull. Without this force, astronaut's bodies overcompensate, giving them a puffy or bloated look. This can be uncomfortable!

To counteract the effects of muscle and bone loss, astronauts spend hours every day exercising on special machines. On the International Space Station (ISS), they have a treadmill with straps to hold runners in place, simulating the force of gravity. These are important tools to keep bodies healthy so astronauts can walk when they return to Earth. The same kinds of measures will be used to make sure astronauts will be strong enough to move around on Mars.

Some science fiction stories solve the weightlessness problem by creating artificial gravity, holding space travelers firmly in place with special gravity plating or gravity fields. Is there a way to create gravity within a spacecraft? There is, but not the way it's done on television.

SCI-FI FACT

Watch NASA astronaut Karen Nyberg demonstrate the fitness machines in use aboard the International Space Station.

PS

space station treadmill

Try holding a can of soda in each hand with your arms outstretched, and then pull them in to your chest. Now try the same thing, but while spinning very fast.

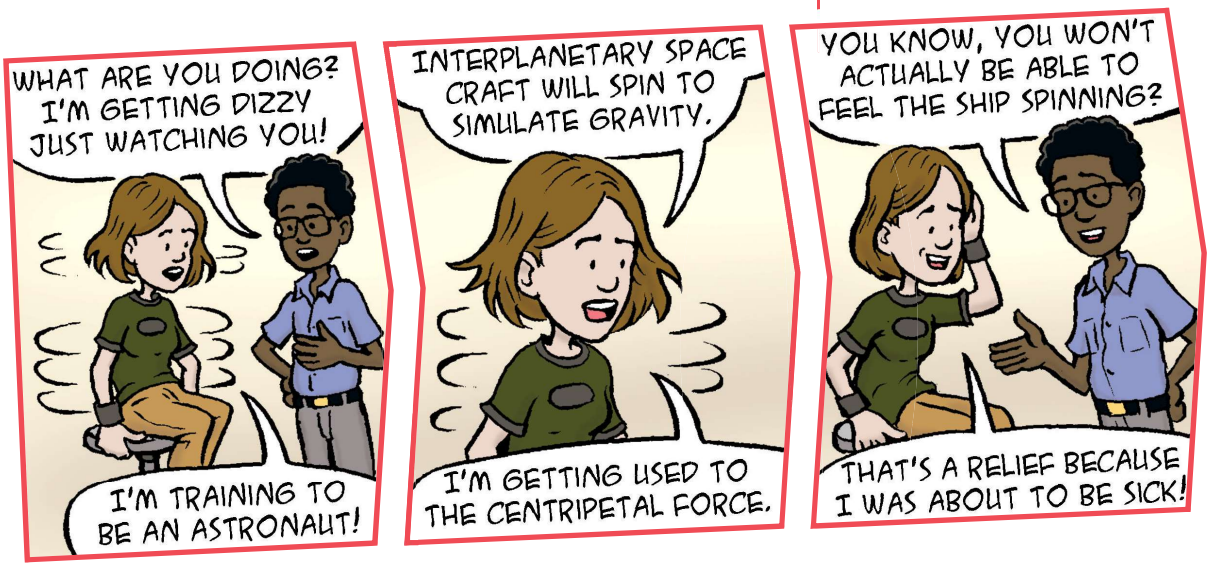
Was it harder to pull the cans to your chest while spinning or standing still? When you're spinning, your arms experience centripetal force, which pushes your arms away from your body as you turn. Anything inside a spinning object would feel a force away from the center of rotation, and this can simulate the pull of gravity.

> If astronauts could experience centripetal force in a rotating space ship, it would feel like gravity holding them to the floor of the ship.

In the 1968 movie *2001: A Space Odyssey*, the inside of Space Station V looked a lot like a nice hotel on Earth. Travelers experienced gravity because of its spinning wheel shape. However, producing this kind of artificial gravity is not easy.

SCI-FI FACT

Exercise isn't the only thing astronauts will need on a trip to Mars. In addition to keeping bones and muscles in good form, astronauts will need to eat a balanced diet.



SCI-FI FACT

Astronauts on the ISS have grown and eaten a variety of red romaine lettuce called Outredgeous. Scientists hope that this will lead to growing even more fresh food on the ISS and maybe even Mars.

On the International Space Station, even some urine is recycled.

Imagine a spacecraft as a giant spinning wheel, with inhabitants working and living on the outer rim. The amount of centripetal force depends on the diameter of the wheel and its rate of spin. The smaller the wheel, the faster it has to spin to generate the same force as a large wheel spinning more slowly. But a wheel with a small diameter could be very disorienting to astronauts. Because centripetal force increases the farther you are from the center of the wheel, the astronaut's feet could experience a greater force than their head, drawing blood away from their brains. This might cause them to lose consciousness!

The bigger the wheel, the less difference in force between an astronaut's head and their feet, making it a more comfortable situation. A large spinning structure on a spaceship would be very complicated and heavy, though. These are two things to avoid on a spacecraft traveling millions of miles from Earth to Mars.

NASA has experimented with centrifuges to see if small amounts of centripetal force can help astronauts counter some effects of microgravity. Because the first humans to journey to Mars will want to be able to walk on the surface when they arrive, it will be extremely important that they stay fit and healthy on the journey.

PACKING FOR A TRIP TO MARS

Astronauts on the ISS rely on regular resupply missions from Earth for meals, including some fresh food. Astronauts going to Mars will have to take everything with them.

The food of the early space programs was mostly unappetizing freeze-dried or dehydrated packages. One of the main reasons for this was to eliminate crumbs that could clog instruments or ruin experiments. Modern space meals have gotten much better.

Astronauts today have dozens of choices on a typical space station menu.

On a voyage to Mars, astronauts will need to use both prepackaged and grown food. However, food and water can be very heavy things to carry. Careful use and recycling of water will be essential to keeping a crew alive and healthy during the months-long trip. Explorers will need more than just drinking water—they'll also need water to conduct experiments and grow food on the way. Once they reach Mars, they might have more options.

> Mars has plenty of water, but getting to it and making it potable won't be easy.

Most of the water on Mars lies frozen deep underground. To use it, astronauts will need to bring it to the surface. However, the water on Mars is thought to be much saltier than Earth's oceans, so astronauts will need to remove the salt to make it drinkable. On Earth, this is done to turn seawater into fresh drinking water. It takes a lot of time and energy, but it's possible. Having fresh Martian water would make living on the planet much easier.

FARMING ON MARS

Based on what scientists have learned about Martian soil from previous missions, growing plants on Mars is possible with a little help from Earth. NASA has developed a simulated Mars soil to test different growing techniques, and scientists have found that adding just a little organic material from Earth can provide enough of a boost to get plants growing. Plants would need to be grown inside a greenhouse to provide Earth-like pressures and temperatures.

ONE YEAR IN SPACE

On March 1, 2016, astronaut Scott Kelly and cosmonaut Mikhail Kornienko returned to Earth after spending a year on the International Space Station. Their mission was to help scientists understand what happens to the human body in space for long periods of time—just the kind of information needed to prepare for a trip to Mars. The astronauts performed tasks and experiments designed to determine how helpful different types of exercise can be, how sleep cycles affect how crews live and work together, and how the body changes during long periods of microgravity. You can see Kelly's Instagram feed, filled with photos of his year in space.

PS

Scott Kelly Instagram

Children could be born and raised on Mars—they might consider themselves the first true Martians!

> Giving plants close to the same conditions they have on Earth will increase the likelihood of them growing well and feeding hungry astronauts.

The surface of Mars might be used for more than farming. Scientists and engineers are investigating ways of using Martian dirt to create habitats and protect astronauts from radiation. It might even be used to make fuel to help with a return trip to Earth.

MARS ON EARTH

To prepare for a long stay on a hostile world, humans need to practice all aspects of living on Mars. This includes growing food and finding water to living with others in a small, confined space. And we can do that much closer to home. The Mauna Loa volcano of Hawaii is a good substitute for Mars. At an altitude of 8,000 feet and with little vegetation, the slope of the giant active volcano does look a lot like the red planet.

Since opening in 2013, the HI-SEAS Mars simulation has provided researchers with important information on what it's like to live in an isolated environment for a long time.

HI-SEAS tests involve crews of six who live and work together on a year-long simulated Mars mission. Just as they would on Mars, the crew spends most of their time living in a small dome that contains living quarters, workspaces, and an airlock.

Participants are only allowed out of the dome to perform experiments on the volcanic slope, and only if they're wearing a spacesuit. These kinds of simulations allow scientists to test new spacesuits and rovers, and also learn what psychological challenges a crew living on Mars might face.

Just like real astronauts, these crews don't get to go home to their families after a long day. They have to live and work with very little personal space and privacy with the same five people for a full year!

LIVING AND DYING ON MARS

While NASA and other space agencies are focused on just getting to Mars and back, others are looking farther into the future. For a longer or permanent stay on Mars, astronauts will have to set up a colony. This would be a way for scientists to study Mars in far more detail. Elon Musk, the founder of the rocket company Space Exploration Technologies (SpaceX), founded his company with the goal of making humanity a two-planet species. He envisions large cities on Mars that will eventually function with no help from Earth. This reality is very far in the future, but it's exciting to think about!

For many, the drive to become a two-planet species comes from the knowledge that we live on a fragile world. Is it possible that humans could face extinction at some point, just as the dinosaurs did millions of years ago? Having a second place to call home could greatly increase humanity's chance of survival.

SCI-FI FACT

NASA plans for the first crewed mission to Mars sometime after 2030. Would you want to go? Would you want to live on Mars? What if you couldn't come back?

CLIMATE CHANGE

One reason scientists are interested in finding ways to live on Mars is because climate change is altering the environment on our home planet. Check out the link to learn more about climate change.

PS

climate change

RED TO GREEN(ISH)

Studies of Mars have shown us that the planet was once much more like Earth. Could Mars be made more like Earth today? For Mars to truly be a second home, we'd need to live on the surface as we do on Earth, moving around outside without the need for a spacesuit. To do this, we'd need to engineer the entire planet through a process called terraforming.

At about 1.5 AUs from the sun, Mars receives only about 42 percent of the solar energy received by Earth. Most of this solar energy is lost because the thin atmosphere on Mars can't hold onto it. To start terraforming, we would need to thicken the atmosphere, raising both the temperature and pressure on the surface. There are a few interesting ways to do this.

The first would be to create climate change. A few proposals to make this happen sound more like science fiction than real science. Some scientists suggest painting the poles of Mars with a dark substance, such as charcoal. Since the color black absorbs more energy from the sun than bright white ice, it should be capable of thawing the frozen carbon dioxide, which would move into the atmosphere and thicken it. Others have suggested exploding nuclear bombs above the poles, thawing the carbon dioxide ice and melting the water ice all at once, though this would spread a lot of deadly radiation in the process. A third option is to crash a comet into the surface of the planet, which would make a big mess, but provide water and heat all at once.

These are extreme ideas. There might be a better solution right here on Earth. Scientists have found that releasing greenhouse gases such as carbon dioxide into Earth's atmosphere causes a measurable increase in the average surface temperature.

TERRAFORMING MARS IN SCIENCE FICTION

The Red Mars series by Kim Stanley Robinson details the effort to change Mars from a cold, dry world into a more Earth-like environment, and all the struggles that could come with it. In the first book, Kim writes: "In games there are rules, but in life the rules keep changing." What do you think this means?

SCI-FI FACT

An AU, or astronomical unit, is the average distance from Earth to the sun, about 93 million miles.

> Although excess carbon dioxide gas is not a good thing for our planet, it could be just what Mars needs.

These initial steps toward terraforming would make Mars's surface pressure and temperature slowly increase, so water could exist on the surface as a liquid. Some studies show that once surface pressure reaches a certain level, both the temperature and pressure would be high enough to keep water flowing in many places on Mars during the long summers. At that point, a full spacesuit would no longer be necessary for people on the surface.

AIR TO BREATHE

Making the atmosphere breathable needs a different approach. On Earth, most of the oxygen we breathe is created when plants take in carbon dioxide and produce oxygen. To get to this point on Mars, we need to take a few steps first.

With a thicker, warmer atmosphere, biologists and botanists could start introducing genetically engineered organisms that help condition the Martian soil by removing nitrogen from the atmosphere and putting it into the soil. When the soil is more Earth-like, larger forms of life, such as lichen, mosses, and eventually trees, could be planted. Once established, massive forests could start the process of taking in carbon dioxide and producing oxygen, just as they do on Earth. Imagine what a Martian forest might look like!

Once we colonize Mars, where might we go next? To explore worlds beyond our solar system, we'd need to travel very, very fast to cover the huge distances between stars. Is that even possible?

NEW EARTH

Terraforming Mars can't be done overnight. Scientists estimate it could take anywhere from 100 to 100,000 million years to make Mars as Earth-like as possible, and it still wouldn't be exactly like Earth.

Martian gravity is only one-third the gravity of Earth. Nobody knows what living your whole life in Martian gravity would be like. People born and raised on Mars might never be able to travel to Earth. Their bodies might not be able to adapt to Earth's greater gravity. Martians might eventually evolve into a separate species!

KEY QUESTIONS

- **Why is living on Mars such a difficult problem to solve?**
- **Why is it useful to train in certain places on Earth that are similar to Mars?**