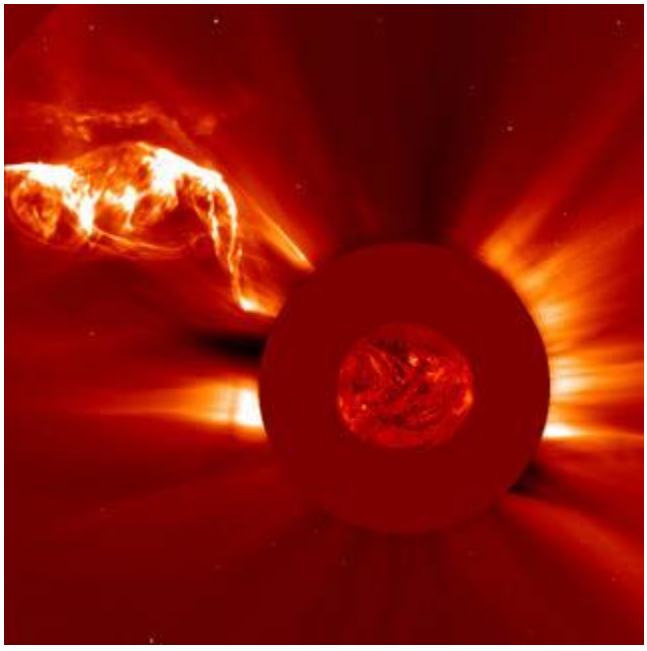
RESEARCH STATION #1 - Radiation Shielding

The Sun constantly produces a great deal of energy, called **radiation**, that can be harmful for humans. If that energy gets into the body, it can cause DNA to change, leading to significant health issues, such as cancer or radiation sickness. Fortunately, on Earth, the magnetosphere protects us from much of this radiation. However, Mars does not have a magnetosphere, so it is important that the astronauts have proper shielding from the radiation. There are a few ways to combat the radiation, but each has its drawbacks. It's important to balance the pros with the cons when designing a Mars habitat.

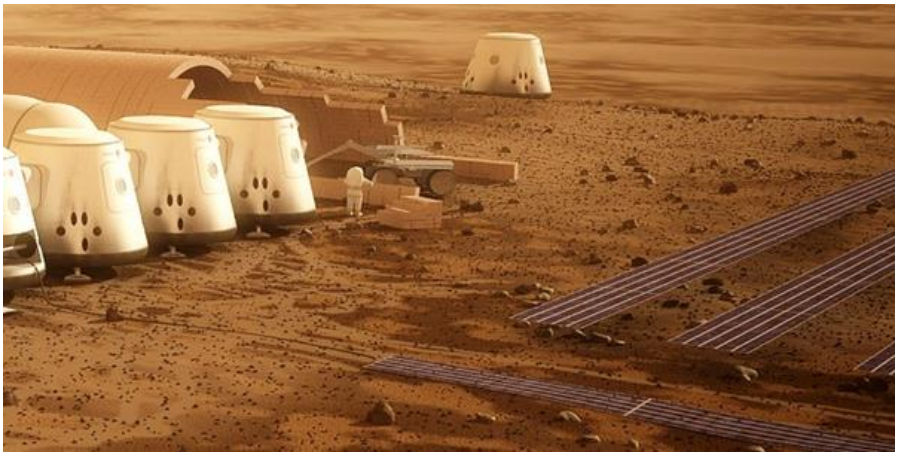
First is using sheer bulk to protect the crew; the heavier and thicker the material, like lead, the more protective. However, this can make it more expensive and less fuel-efficient to launch. Second, they could protect with a more efficient material made from hydrogen, which is very abundant in space, like water or a plastic called polyethylene (commonly found in water bottles). With water, it would need to be used and recycled out regularly, which could be challenging. With polyethylene, it is not strong enough to build an entire support structure and, on its own, cannot withstand the high heat and force required to launch. Finally, Mars itself could be used as a shield. Putting the habitat in a cave or rock wall on Mars could help protect the crew from the radiation.



A coronal mass ejection that can be harmful on Mars without shielding.

RESEARCH STATION #2 - In Situ Resource Utilization (ISRU)

When traveling in space, astronauts and spacecraft can only carry a limited payload with them, which can make extended missions more difficult. For example, food and water for a two-year trip or orbit would be double that of a one-year trip. Additionally, a return trip from Mars would require twice the fuel as just getting there. To facilitate an extended trip to Mars, or to set up a colony there, you will need to learn to use resources available in space to help supplement what astronauts can bring in the original payload. Scientists refer to this gathering and reutilization of materials from the environment as **in situ resource utilization**, or **ISRU** for short.



There are many examples of ISRU. At a basic level, solar panels help to turn energy from the sun into fuel and power for the ISS. To take that a step further, think about ISRU as mining the materials to build solar panels in space, and then having them operate by transforming the Sun's energy into useable energy for the crew. Another example is using a Sabatier Reactor to turn carbon dioxide and hydrogen, both of which readily available on Mars, into water for the astronauts to drink, to use for growing plants, and for personal hygiene. If you wanted to construct buildings on another planet, you certainly wouldn't be able to bring construction materials in your payload so would need to be able to repurpose found materials to use as building blocks. Lastly, you wouldn't be able to bring enough food to last for several years, so you would want to be able to grow your own. This could be done in a lab or in a greenhouse. ISRU developments will be crucial to making long term missions to Mars feasible, so it is important your habitat has evidence of at least 1-2 instances of ISRU.

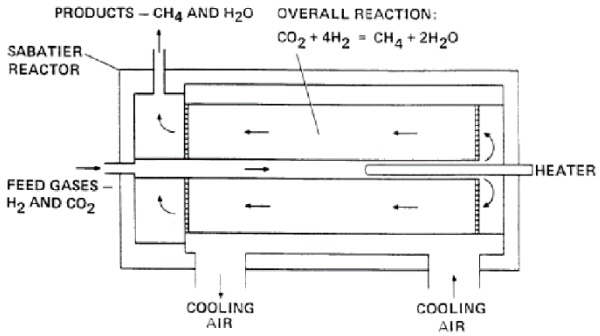
RESEARCH STATION #3 - Basic Needs

In any space habitat, it is important that all habitants have their basic needs met. Just as they do on Earth, the crew needs food and water.

Some **food** can be brought along with the crew. That food must be nonperishable, as it is a long journey and they do not want food spoiling. The food can either be eaten as is, or by adding water. They could also use a microwave or oven, but not a refrigerator (it is heavy and not particularly useful in space since they need food that won't go bad). In addition to the food they bring, during a prolonged mission such as this one, it is important that they can produce their own food. In fact, scientists have already grown lettuce on the International Space Station (ISS). However, there are a few challenges associated with growing their own food on Mars. First, Martian soil is devoid of many of the nutrients found in Earth's soil. Yet, some hardy plants, such as tomatoes, wheat, cress, and mustard leaves have been successfully grown in simulated Martian soil. Second, if crops were to be grown outside, they would need to be able to survive the significant changes in temperature, the solar wind, and the lack of a magnetosphere. A greenhouse could help with this problem.

A scientist grows lettuce on the ISS.

Water could be produced by the Sabatier Reaction, which produces water from carbon dioxide and hydrogen, which is prevalent at Mars. For this to happen, they would need a Sabatier Reactor. Additionally, on the International Space Station, the crew uses a Water Recovery System (WRS) to reclaim and filter any liquid used or produced to become drinkable water.



RESEARCH STATION #4 - Living Quarters & Entertainment

Astronauts **sleep** in sleeping bags in space. Each crew member has their own small pod that is big enough for one person.

Left - An astronaut in his sleeping bag.

Right- The crew of the International Space Station (ISS) in their sleeping pods.

Astronauts will also need **a restroom** in their habitat. With significantly less gravity on Mars, the toilets may look a little different. On the International Space Station (ISS), there is a hose that is used with suction, like a vacuum. Historically, solid waste has been dispelled from the habitat and burned in space; however, it has many nutrients that could be useful in growing plants, if recycled.

Imagine spending 24 hours a day, 7 days a week, 365 days a year, for several years far, far from home, with the same crew of six people. You are all living in close quarters without much privacy, which can be psychologically exhausting and challenging. It is important that the crew have free time and sources of **entertainment** to keep some normalcy from their life on Earth. For longer missions on the ISS, astronauts try to mirror similar schedules to ones they had on Earth, working a five-day week, with some time each day for free time. During that time, they can watch movies, listen to music, read, communicate with their family back home, play games, or other things that they might do for fun on Earth. It is incredibly important for astronauts to have the space and resources to keep them psychologically healthy.

RESEARCH STATION #5 - Exercise

While **exercise** on Earth is important to keep us in peak physical condition, it is imperative in outer space. Without the gravitational pull that normally exists here on Earth, astronauts' bone density and muscle mass can decrease dramatically during their time in space. To combat deterioration, NASA has developed a countermeasure exercise program that helps to keep astronauts as healthy as possible while on a mission with the International Space Station. Due to the complete lack of gravity on the International Space Station (ISS), astronauts spend at least two hours per day on exercise equipment that is designed to simulate cardiovascular and weight training machines, while relying on harnesses to keep athletes attached to the machines and vacuum cylinders to create force that resemble weights. The three machines currently in orbit are the **ARED**, which simulates weight lifting, the **CEVIS**, which is a modified stationary bike, and the **T2**, a treadmill designed for outer space. In the ISS, the weight lifting machine (ARED) is built into the ceiling, because without any gravity, working out upside down is no different than being right side up. While there is slightly more gravity on Mars than on the ISS, the length of any expeditions to Mars would certainly cause bone density loss and muscle atrophy (shrinking) in any astronauts. You will need to ensure that you designate space in your Mars habitat for these machines, as well as time in the astronauts' days.