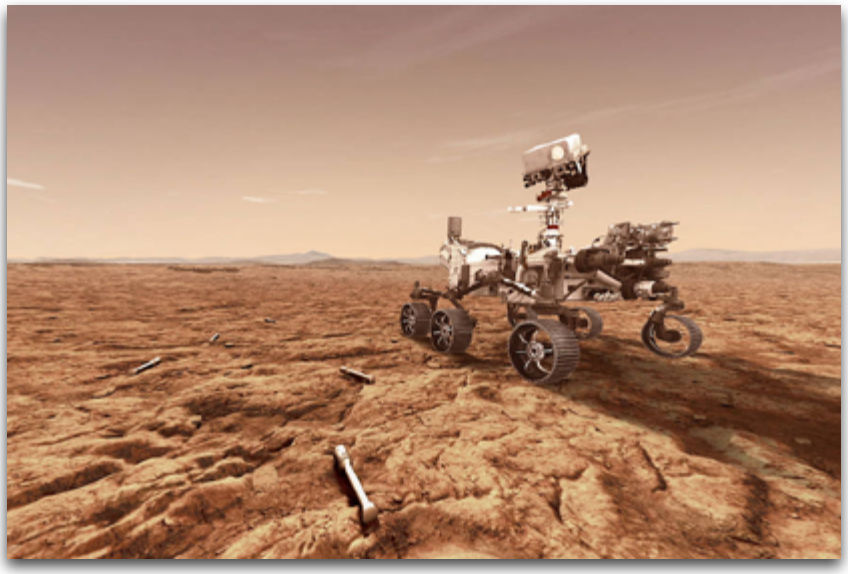
Astrobiology: Protecting the Solar System

We are all aware of how important it is to protect our own planet because we are surrounded by evidence of how humans have changed it.

The sun rising over the Earth

Every day, we take small steps to reduce our own impact on the Earth. From recycling to reducing single use plastic, using renewable energies to turning off the lights.

As humans explore parts of the Solar System that we haven't yet reached, it is important that we do not accidentally cause damage or change these untouched and unspoilt environments in any way.



Mars 2020 With Sample Tubes (Artist's Concept)
Image Credit: NASA/JPL-Caltech

Scientists also want to be sure that anything they may find definitely comes from that place and was not carried there from Earth, and that the data they collect is reliable.

This is especially important since many missions have the objective to search for life beyond the Earth. These missions target places where researchers think life may exist. We should not disrupt these potential habitats by introducing contamination or even life from Earth.

There are also missions that aim to return samples from other places in our Solar System. It is just as important that we don't bring samples back that could be a potential risk to the Earth.

Planetary Protection

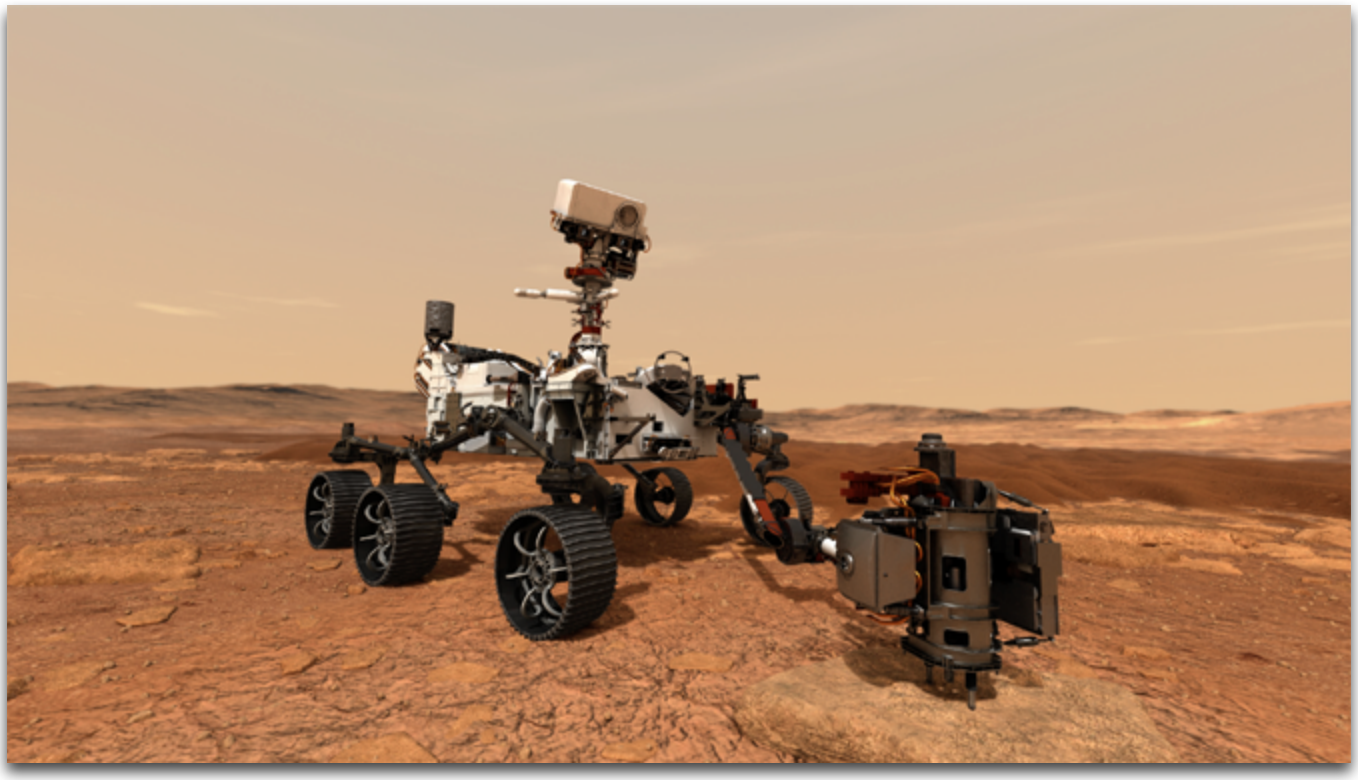
There are two main challenges faced by exploration missions: forward contamination and backward contamination. Forward contamination happens when a mission to another planet, moon or other body in our Solar System carries unwanted contamination that could pose a risk to its destination. Backward contamination is when anything brought back to Earth, for example a rock collected from Mars, might carry something that could put our planet at risk.

To manage these challenges, there are a set of guidelines that help space agencies, such as NASA and ESA, to plan missions and build spacecraft.

This 'Planetary Protection Policy' was developed by a panel of scientists as part of the Committee on Space Research (COSPAR) and it is updated as we learn more about the potential for life beyond the Earth.

For the planned Mars Sample Return missions, samples of rocks and soils will be collected by NASA's Perseverance rover, which landed on Mars in February 2021. A future mission, some time in the 2030s, will collect these samples and bring them back to Earth for scientists to analyse in more detail. To reduce the risk of backward contamination, samples bought back to Earth would be stored in special facilities preventing any material from entering the outside world until it was proven to be safe.

But how do we reduce the risk of forward contamination?

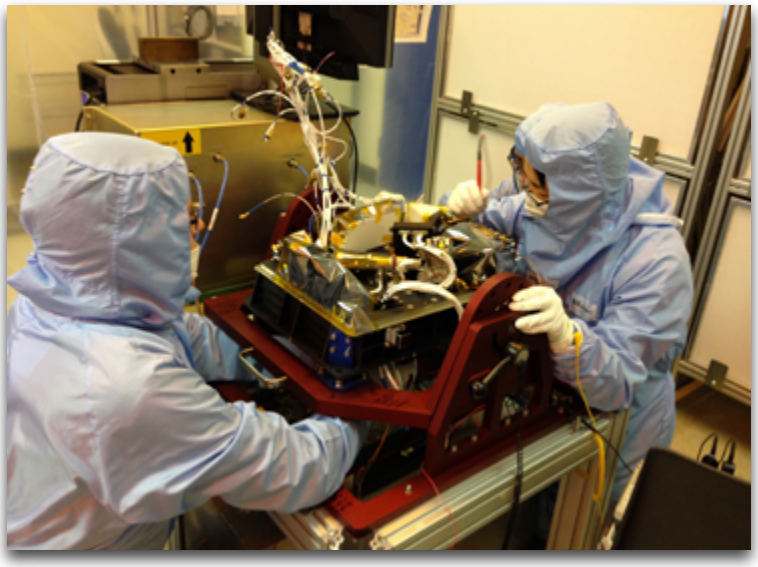


NASA Perseverance Rover
Image Credit: NASA/JPL-Caltech

Keeping it clean

It is important that space missions do not leave the Earth carrying anything that might be harmful to the place that it is going. This means that the scientists and engineers building the spacecraft need to ensure that it is clean and free from as many bacteria as possible.

To do this, spacecraft are built in `clean rooms', which are specially designed facilities in which the environment is carefully controlled. Their temperature, pressure, humidity and air particles are monitored and the air that enters the room is filtered. Only necessary people, items and equipment enter the room.



Specialised gowns, masks, hoods and shoes are worn to work on a spacecraft in a clean room

A clean room air shower
Image Credit: ESA-Guus Schoonewille

Anyone who enters a clean room wears specialised gowns, masks, hoods and shoes because humans are the main source of contamination. In fact, they lose 5 billion skin cells a day! So before someone puts on their clean room suit they may even need to change all of their own clothing, and use an `air shower'.

Hoods prevent the loss of skin and hair

Masks stop saliva and droplets being released through breathing, sneezing, and coughing

Gloves stop skin cells and bacteria from contaminating surfaces

Gowns go over the top of other clothes to stop the loss of clothing fibres

Clean room **shoes** prevent dirt and dust from the ground being walked in to the room

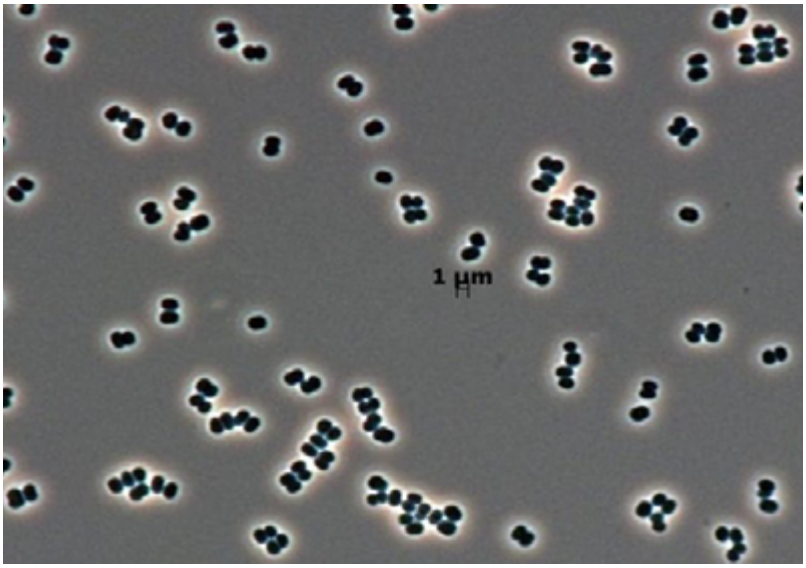
For those missions that might be going to look for life, their clean rooms are also monitored for the presence of any microorganisms. The number of microorganisms allowed into space is carefully controlled.

For example, the European Space Agency's Rosalind Franklin rover (due to launch in 2022) is allowed to have no more than 9800 bacterial spores over the whole vehicle. The rover has a surface area of 150 m2 - that's about half the size of a tennis court and that many spores would fit on the size of a pin head (1.5 mm across). Imagine how clean that rover needs to be!

Rosalind Franklin rover
Image Credit: ESA

But even clean rooms are not entirely clean.

In 2013, a completely new type of bacteria was found in two clean rooms, one in Florida and one in French Guiana (4000 km apart). This bacterium has not been found anywhere else on Earth!



The 'clean room' bacteria
Image Credit: NASA JPL-Caltech CC-BY

Activity - how clean is clean?

Here is an experiment you can do at home to understand that, although things may look clean, they might not be.

You will need:

- 300 g plain white flour
- 150 ml warm water
- 1 sachet dried yeast
- Large mixing bowl
- Clean tongs
- 4 resealable plastic sandwich bags
- Hand wash/soap
- Antibacterial hand sanitiser/gel
- Pen

Method - what do to:

First you need to make a *growth media* - something for the bacteria to grow on. For this experiment, this is bread. Ask an adult to help you if you need to.

1. Pre-heat the oven to 180°C
2. Mix the flour, yeast and water in a large mixing bowl until it forms a ball
3. Cover the bowl and let it rest in a warm room for 30 minutes
4. Kneed the dough for 2 minutes
5. Re-shape the dough into a ball and place it on a baking tray
6. Place in the centre of the oven for 20 minutes (or until it is light brown)
7. Remove bread from the oven and place on a rack until completely cool
8. Cut the small loaf into 4 slices.

Now you will use the bread (growth media) for the experiment

9. Using the pen, label your resealable sandwich bags "Control", "Not Cleaned", "Soapy" and "Sanitised" then lay them out on the table or worktop.
10. Using clean tongs, place 1 slice of bread into the bag labelled "Control" and seal it
11. Wash your hand with hand soap for at least 20 seconds and dry them on a clean towel.
12. Take another piece of bread and press your hands onto both sides. Place the bread in the bag labelled "Soapy" and seal it.
13. For 20 minutes do things around your home.
14. Take another piece of bread and press your hands onto both sides. Place the bread in the bag labelled "Not Cleaned" and seal it.
15. Clean your hands with the hand sanitiser and wait until they have fully dried.
16. Take the final piece of bread and press your hands onto both sides. Place the bread in the bag labelled "Sanitised" and seal it.
17. Place all four bags in a dark cupboard.
18. Check on them each day and write down what you see (your observations). You could record your observations in a table (see below)

Type	Observations				
	Day 1	Day 2	Day 3	Day 4	Day 5
Control					
Not Cleaned					
Soapy					
Sanitised					

Results - what you saw:

You will see that mould has grown on the bread inside the bags.
Can you see different colours, shapes or sizes of mould? Do you see a difference in the mould that has grown in each of the different bags?

Conclusions - what this means:

Something can look clean, but it might not be as clean as you think.
A single bacteria is so small it can only been seen with a microscope. What you see on the bread, as mould, is a group of bacteria. In fact, if the whole slice of bread was covered there could be more than 100 thousand million bacteria. Which is more than the number stars that astronomers estimate are in the Milky Way.

Why do we care?

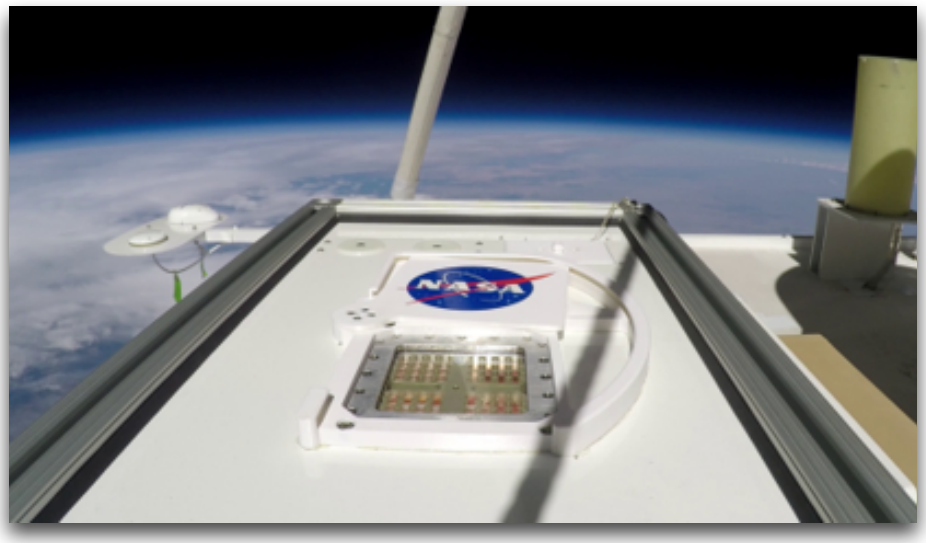
From the experiment on the previous pages you should have seen that even if something appears clean, it may not be. So even if every effort has been made to reduce the chances, a spacecraft could still leave Earth carrying life. But if it did, could that life survive in space?

A Tardigrade
Image Credit: Pailly CC BY 4.0

Some organisms can survive the radiation and cold temperatures of space. For example, tardigrades are microorganisms that survive harsh conditions on Earth by drying out and slowing down their life support processes. When conditions improve, they become active again.

In 2007, the European Space Agency's FOTON-M3 mission carried tardigrades into space. When the mission returned to Earth after orbiting the planet for 10 days, most of the tardigrades became active and were even able to lay eggs.

ESA and Roscosmos' BIOMEX experiment, positioned on the outside of the International Space Station, exposes microorganisms to space conditions for much longer periods of time to understand how they might survive. Some bacteria and fungi were able to survive and even grow in these conditions.



The Microbes in Atmosphere for Radiation, Survival and Biological Outcomes Experiment, or MARSBOx
Image Credit: NASA

NASA's MARSBOx mission used a balloon in the Earth's stratosphere, 38 km above the planet's surface, to expose bacteria and fungi to ultraviolet radiation similar to that on the surface of Mars. When the balloon came back down to Earth, the samples were tested and some of the fungi had survived. This means they could survive if they were accidentally carried to Mars by a spacecraft.

For these reasons, it's important that the rules are followed and that Planetary Protection is taken seriously by everyone launching a spacecraft.

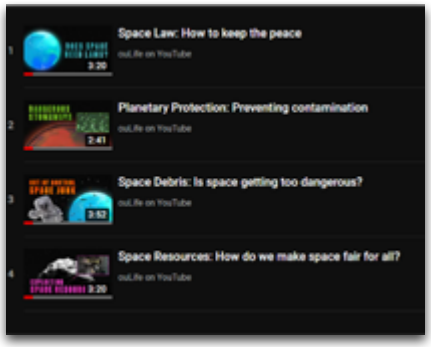
Taking it further…

Can you think of ways you could take the experiment further? You could:

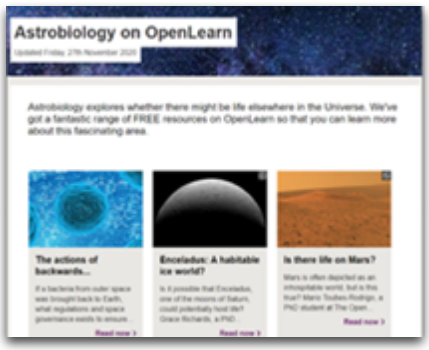
- Use items around the house to test how clean they are (e.g., a mobile phone, tv remote etc) - just press the item into a piece of the bread and pop them in a bag as before.
- Test the cleanliness of the hands of other members of your home.

Remember to record your observations!

Find out more…



Find out more by watching our Space Governance Explained series on YouTube



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