"Living outside the Earth is a huge challenge"

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Credit: NASA

Susana Zanello is an expert of human adaptation to life in space. Invited as an academic guest at EPFL, this renowned scientist agreed to share her views on her research, exploration, future trips to Mars and much more.

Space trips affect the human body in many more ways than we think. Susana Zanello specializes in these effects. Trained as a biologist, she works for the Division of Space Life Sciences (DSLS) in Houston, an institution supporting the work of NASA. Her mission is to investigate the human adaptation to life in space, identify the risks involved and develop countermeasures to preserve the health of the astronauts as they go on space exploration missions. For a few months, she has been at

EPFL as an academic guest at Prof. Phillipe Renaud's Microsystems Laboratory 4.

How did this stay at EPFL help you in your research?

I came here to learn more about miniaturization and gather some ideas. In space medicine, we need low-volume devices that allow in-flight analysis and real time health monitoring to measure parameters such as heart rate, blood pressure, respiration rate, and the temperature of the astronauts. Plus, it has to be possible to cross-reference data collected by the devices to obtain the health status of the whole crew. This is a crucial point, because we have a lot of limitations in space: the available space, the crew time, and the weight of the objects we take up there. Therefore, we are looking for new micro- and nanotechnologies to build better and smaller devices.

What are the most important effects of space flight on the body?

It's a huge challenge to live outside the Earth. Through evolution, life has really adapted to being on this planet. In space, one of the main risks comes from microgravity - or the absence of gravity. A very clear consequence is the loss of bone mineral density. Up there, you simply don't have to constantly fight the force of gravity, the way we do naturally on Earth. Thus, there is no more need for a skeleton to sustain us! The human body starts adapting by reducing bone matrix density and processing calcium differently. This leads to a loss of strength in your bones that increases your risk of fractures when you are back on Earth, as well as that of developing kidney stones.

Cosmic radiation is another critical risk of space exploration. Earth's magnetic field is a very effective protection, preventing most of the high-energy particles from reaching the surface of our planet. Outside the Van Allen belts, or also on other planets, we are constantly bombarded by strong solar protons and galactic cosmic rays. There is abundant evidence that these can traverse our entire body and interfere with our DNA. So, in the long term, all the risks associated to those DNA alterations, such as cancer, really have to be carefully studied.

Your research also focuses on changes in the astronauts' vision…

In the early 2000s, we began to observe a degradation of the astronauts' near visual acuity after they spent time in the ISS, the International Space Station. Upon further investigation, we noticed a change in the shape of their eyes, called globe flattening, and a thickening of the back part of the eye, at the beginning of the optic nerve. About 60% of astronauts experience vision loss, which can be irreversible in some cases. This is why it is considered as a high priority health risk by NASA.

What causes this loss of vision?

We think it happens because of a shift of the fluids inside the body. On Earth, liquids tend to go down into our legs. Their movement and valves in our leg veins then help pump the blood back up to our heart. In microgravity, this system is no longer needed, and you fluid is pumped towards the head instead. This leads to the typical puffy face and chicken legs that astronauts have, but also possibly to increased intracranial pressure. Scientists postulate that when the pressure in the cerebral spinal fluid increases, it alters the pressure behind the eyes, impacting visual acuity.

In which direction will you focus your research in the

future?

There are physiological signs of adaptation that we can observe, but also underlying ones at a molecular level. Genes may be expressed differently in space, leading to specific physiological changes. The studies that I am conducting right now already seek to answer these questions. But again, there are a lot of limitations to performing experiments in space. Commonly, astronauts live up there for six months, and now two of them are participating in a one-year mission. But when we are talking about going to further destinations, like Mars, this means much longer missions. To know what could happen on such trips, we have to perform experiments not only using the ISS but also ground analogs, which are platforms simulating, to a certain extent, space conditions.

Precisely, what are the main challenges of a trip to Mars?

Such a mission is estimated to take three years. The first risk is psychological. And to measure it, we have to take into account the duration, the remoteness, the isolation, the confinement with a limited number of persons, the stress of a high workload and the pressure of being successful. Now, once you arrive on Mars, there is one good thing: you have partial gravity. Your bones will immediately be stimulated and reduce the rate of density loss. But once again, on the surface, astronauts will be confronted to the risks of high-energy radiation. Not to mention a harsh climate, dust, and the need for good nutrition, among others.

What about other planets?

Of course, we are beginning to consider more remote objects, like Jupiter's satellite Europa, where water has been found. But that's much farther away! Plus, believe it or not, even though Mars sounds inhospitable, it is quite a friendly planet, compared to others. Its size and rotation pattern are similar to that of the Earth. Therefore, a day is almost 24 hours long. And that's a big thing for humans, as life evolved to fit such conditions. Living on a planet with a 10-hour day, for example, would trigger many more other adverse effects in the body.

Aren't we too adapted to Earth's conditions to survive elsewhere in space?

Experience shows that we are able to adapt at least to some extent to new environments. Of course, there are risks and there always will be. The most important thing is to define very precisely the acceptable levels of those risks. Moreover, we cannot ignore the human greed for exploration. Even with a high level of risk, I bet there will always be somebody ready to push and take it.

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