Read the article and answer the questions at the end in as much detail as you can.

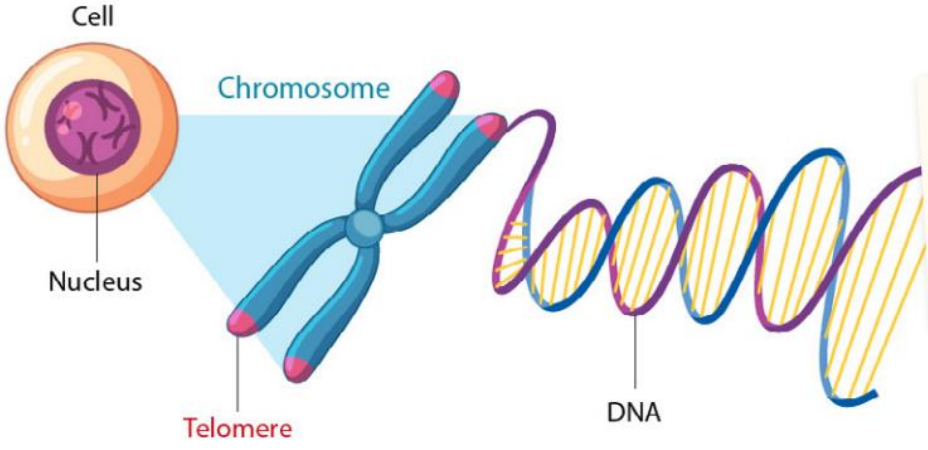
Abstract

Space is a really cool place. It is even becoming popular as a tourist destination! But space is also a dangerous place. Floating around sounds fun, right? But weightlessness can have negative impacts on human health. Think muscle and bone loss or vision problems. And exposure to cosmic radiation can actually damage our DNA. So, it is important to better understand how the human body responds to being in space.

We studied DNA from the 2021 SpaceX Inspiration4 mission crew. We looked at it before, during, and after their 3-day trip to space. We were particularly interested in telomeres – the "end-parts" of chromosomes that protect the DNA. Telomere length relates to aging and the risk of other diseases. We found that telomeres got longer while the crew was in space. When the astronauts returned to Earth, telomeres quickly shortened. Exposure to cosmic radiation might have triggered this dynamic response. Keeping people safe from cosmic radiation is essential for any long-duration spaceflight. In the future we can use this information to help keep people healthy as we explore the cosmos.

Introduction

Have you ever wondered what it is like to be an astronaut? They have to deal with an extreme environment very different than any on Earth. There is no gravity. It's really cold. And astronauts are exposed to **cosmic radiation**. Researchers already know that astronauts lose muscle and bone in space. Their vision changes and their immune



DNA is coiled into chromosomes within the **nucleus** of each cell. The ends of the chromosomes are called telomeres. They protect the DNA from fraying or getting tangled.

systems don't work as well. These become huge problems during longer trips to space.

An astronaut's genome, or **DNA**, can determine how they respond to space. Changes to their DNA may lead to adverse health effects. But researchers don't have a good understanding of what actually happens to DNA in space. Studying **telomeres** may help. They are the "end-parts" of **chromosomes** that protect the ends of the DNA. Like the plastic tips on the ends of shoelaces! They keep the laces from getting tangled or frayed.

Researchers know that telomeres get shorter as people get older. This is related to normal **cell division**. Things like stress and smoking make telomeres shorter, too. Unhealthy environments can also cause telomeres to shorten. For example, places with air pollution or radiation exposure. The length of telomeres is linked to the risk of dementia, heart disease, and cancer. This makes them important to study for human health effects.

In 2015 NASA did a study on the twin astronauts Scott and Mark Kelly. Scott Kelly spent a year on the International Space Station while Mark Kelly stayed on Earth. Researchers studied the twins' telomeres. Scott's telomeres increased in length while in space. His telomeres then quickly shortened when he returned to Earth. In fact, Scott's telomeres were shorter after the 1-year mission than before he went into space. We will have to wait to see what impact this has on his health in the future.

The NASA Twins Study gave researchers a lot of new information about astronaut health. But there were also limitations. To date, most astronauts have spent less than 20 days in space. Also, Scott and Mark Kelly are middle-aged white men. Spaceflight is becoming more common. So more people of different ages, sexes, ethnicities, and starting health will travel to space. There will also be more **civilians** instead of highly-trained astronauts. Some will be on short-duration trips, but some will be on longer missions. Some may even stay!

We wanted to know if telomere length changes occur in a more diverse population. And does telomere length change during a shorter trip into space? This information is important to ensure the future health and safety of humans in space.

Methods

We used the 2021 SpaceX Inspiration4 mission for our study. The mission was only 3 days long. The four crew members were all civilians and first-time flyers. And they were of different ages and sexes. We collected blood from each crew member 92 days, 44 days, and 3 days before their trip. We also collected blood during each of the days they were in space. Lastly, we collected blood again 1 day, 45 days, and 82 days after they returned to Earth.

We **extracted** DNA from all the blood samples. Then we measured the average telomere length.

Results

We saw that telomeres were longer during spaceflight (Fig. 1). This happened for all four crew members. We also saw that telomeres shortened quickly when they returned to Earth. This happened for three of the four crew members. At 45 and 82 days post-trip, we saw all four crew members' telomeres gradually return to near normal length.

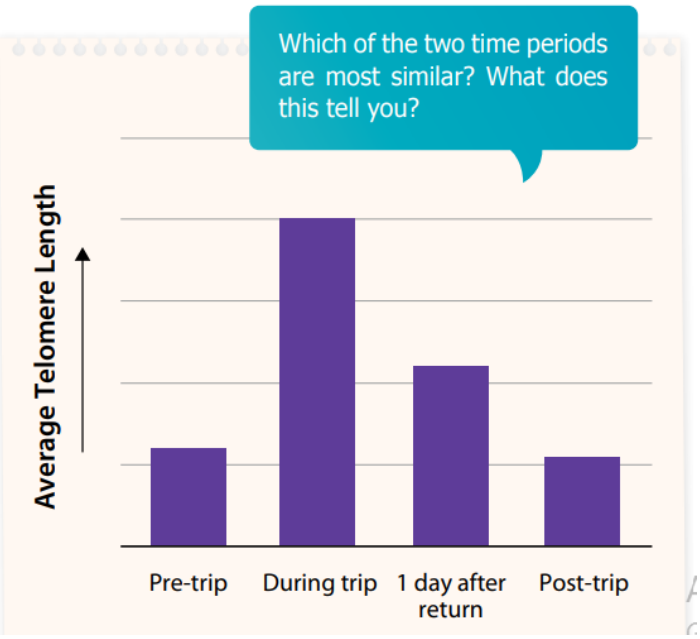


Figure 1:
Telomere lengths of the Inspiration4 crew.

Discussion

The changes in telomere length for the Inspiration4 crew were like those seen in the NASA Twins Study. It is important to know that even short trips into space can change telomere length. And that it can happen in a more diverse group of people. We wanted to learn more about these changes. This will help us understand how they might cause problems for astronauts when they come back to Earth.

We think that telomere length changes because of cosmic radiation exposure. Radiation damages DNA. And it is everywhere in space. Spending more time in space also means more exposure. The International Space Station has shielding in frequently used areas. This helps protect the astronauts from some radiation. But what if humans want to travel to and/or stay on other planets someday? We need a better solution to reduce radiation damage.

Conclusion

Space is an extreme and dangerous environment. We don't know a lot about how it can impact people's health long-term, especially their DNA. The more we know, the better we will be able to keep our astronauts healthy.

There are several things you can do to stay healthy down here on Earth:

- Eat healthy food with plenty of fruits and vegetables.
- Get enough sleep.
- Limit your stress. You can try meditation, do relaxing activities, and stay in touch with loved ones.
- Reduce your exposure to **toxicants** like smoke, pesticides, and pollution.

Glossary of Key Terms

Cell division - the process by which a cell makes a copy of its DNA and then splits into two cells. Each of the cells is an identical copy of the original cell. Making new cells through cell division is how you grow.

Chromosomes - the organized structure that DNA forms when it is coiled up. Organisms have different numbers of chromosomes. For example, humans have 23 pairs of chromosomes. Dogs have 39 pairs.

Civilian - a person who is not a member of the armed forces or actively engaged in a military conflict. In this case, it also means someone who is not associated with NASA or another government space agency.

Cosmic radiation - high energy particles produced by stars. This includes radiation from the Sun. The energy travels through space. Some examples are x-rays and gamma rays.

DNA - the molecule that contains genetic information. It is found in every cell.

Extraction (of DNA) - a process that removes DNA from cells. This involves several steps. First the cells are broken open. Then the DNA is separated from all the other stuff in the cell. Then the DNA is concentrated.

Nucleus - the structure in a cell that contains the chromosomes. It is surrounded by a membrane.

Telomere - a section of DNA at the end of a chromosome. It protects the chromosome from fraying or getting tangled.

Toxicant - a harmful chemical that is not natural. Toxicants are put into the environment by people. Some examples are pesticides, car exhaust fumes, and industrial waste.

Check your understanding

1. What are telomeres and why are they important to DNA?

2. Why do we care about studying telomeres? Why might they be extra important to study in astronauts?

3. What are three differences between this study and the NASA Twins Study? Were the results similar or different?

4. What do we think caused the change in telomere length while in space? Why do you think this doesn't happen on Earth?

5. Knowing how dangerous it is to travel in space, would you still do it? Why or why not?