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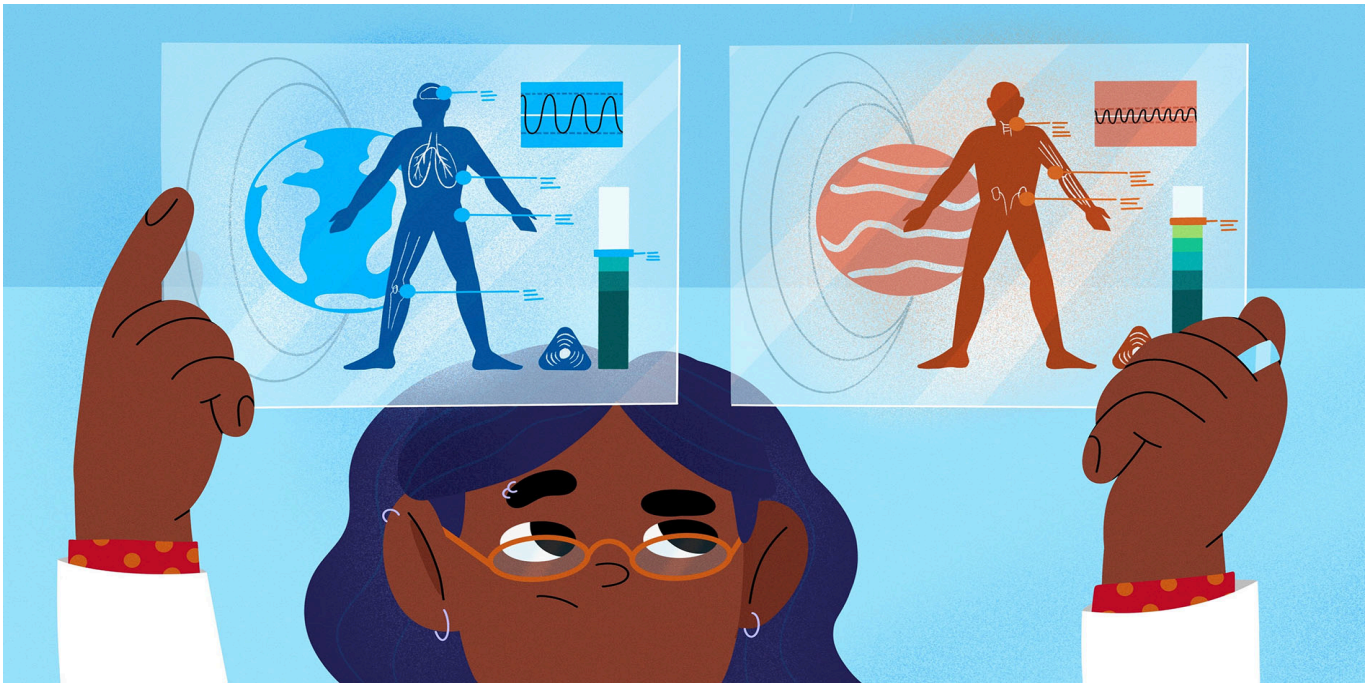

RADIATION EPIDEMIOLOGY: KEEPING SPACE TRAVELERS SAFE

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YOUNG REVIEWERS:

ELLOUISE
AGE: 12

KAJ
AGE: 10

STANFORD ONLINE HIGH SCHOOL
AGES: 13–18

Did you know that millions of people are exposed to radiation on Earth as part of their jobs or during helpful medical procedures? The branch of medicine that studies the health effects of radiation exposure on large groups of people is called radiation epidemiology. Radiation also exists in space! But how do we study the ways that radiation impacts the body in space when there are so few space travelers? In this article, we will define radiation epidemiology, give some examples of studies that evaluate how radiation on Earth effects people's health, and explain how we use the information from studies on Earth to better understand the health effects of radiation in space.

Radiation epidemiology is a branch of medicine that studies the health effects of radiation exposure on large groups of people. Millions of people are exposed to radiation on Earth as part of their jobs or during certain medical procedures. Radiation also exists in space. As space

travelers go on longer missions further away from Earth, they will be exposed to increasing amounts of radiation. To understand how radiation impacts the body *in space*, it is important to understand how radiation impacts the body *on Earth*. In this article, we will define radiation epidemiology, give some examples of studies that evaluate how radiation on Earth effects people's health, and tell you how the information from Earth-based studies is used to better understand the health effects of radiation in space.

WHAT IS IONIZING RADIATION?

Radiation is energy that can travel through space or a material. It can be in the form of energy waves or energized particles. We cannot feel, see, or smell radiation. Sometimes radiation can have so much energy that it can excite molecules and break their chemical bonds. When radiation breaks the chemical bonds of molecules, it is called **ionizing radiation**. Ionizing radiation can damage DNA, the molecules that contain the instructions to build our cells and bodies and to help them function properly (Figure 1). Normally, our bodies can repair broken DNA. However, sometimes the DNA cannot be repaired or is not repaired correctly. This can lead to health problems. A small amount of ionizing radiation exposure is not harmful but too much ionizing radiation exposure may lead to health effects such as cancer and changes to heart tissues.

IONIZING RADIATION

A form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue.

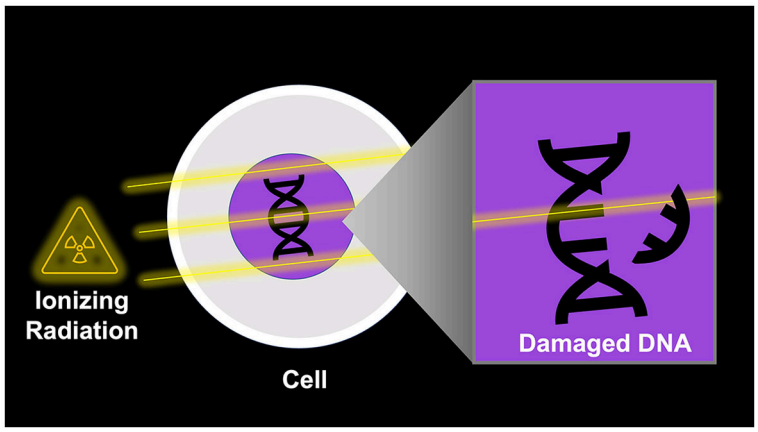

Figure 1

Ionizing radiation can damage DNA within cells. The body can repair damaged DNA. However, if there is too much damage or if the damage is not repaired correctly, health effects like cancer can result.

Figure 1

Ionizing radiation is present on Earth and in space. On Earth, people can be exposed to ionizing radiation for their jobs (nuclear energy workers or some medical technicians) or during medical procedures (X-rays, CT scans, or some cancer treatments). There is also ionizing radiation in space. **Space radiation** comes from the sun and from distant galaxies. Various types of shields made of many different materials can be used on spacecraft to block some of the ionizing radiation from the sun, for example, but not all types of space radiation can be blocked by a shield. For example, radiation coming from

SPACE RADIATION

The spread of energy through space or matter in the form of waves or particles.

distant galaxies, called **galactic cosmic rays**, cannot be blocked by a shield.

GALACTIC COSMIC RAYS

A type of ionizing radiation found in space that comes from distant galaxies. They cannot be blocked by a shield.

WHAT DO RADIATION EPIDEMIOLOGISTS STUDY?

Epidemiology is a branch of medicine that studies patterns of diseases in groups of people. Radiation epidemiology examines the health of groups of people who have been exposed to ionizing radiation. It also examines actions that can be taken to help reduce risks of getting injured or sick from radiation. Understanding the health impacts of ionizing radiation is important so that policy makers can create laws and regulations that set limits of ionizing radiation exposure, to keep workers and the public safe.

Through their research, radiation epidemiologists have learned about the health risks of large doses of ionizing radiation that happen all at once. These studies have shown that large amounts of ionizing radiation can cause cancer and other tissue damage. However, researchers still have some questions. For example, what are the long-term impacts of radiation exposure, both on Earth and in space? What are the impacts of a little bit of radiation exposure over a long period of time? Does ionizing radiation exposure increase the risk of heart or brain disease? Does exposure to ionizing radiation affect a person's unborn children or grandchildren? Radiation epidemiologists are still working hard to answer these questions.

WHAT MAKES A HIGH-QUALITY RADIATION EPIDEMIOLOGY RESEARCH STUDY?

COHORT STUDY

A study that follows a group of people over time. The people in the group share something in common such as their occupation or where they live.

There are several types of epidemiology studies. To study radiation effects on the human body, **cohort studies** are generally the best. A cohort study starts with a group of people who share some things in common, such as their occupation or where they live, and follows them for the rest of their lives. These studies measure the types of diseases or cancers that develop in the group over time, and determine which diseases are from ionizing radiation exposure. High-quality radiation epidemiology research includes many components such as: (1) having good measurements of the amount of radiation each individual received; (2) including as many relevant people in the research study as possible; (3) working to reduce any biases, or unfair judgments that may not be accurate; (4) minimizing other factors that may have caused the disease, such as smoking; and (5) following the people in the study for as long as possible, preferably over their lifespan [1].

EXAMPLE OF EPIDEMIOLOGY RESEARCH ON RADIATION

One example of epidemiological research on radiation is the Life Span Study (LSS) [2]. The LSS investigates life-long health effects of Japanese atomic bomb survivors, to understand long-term radiation effects, including death and cancer. Since 1950, 94,000 atomic bomb survivors and 27,000 unexposed individuals have been followed in a cohort study. A periodic check of people who have died from cancer, which is called a **mortality rate**, and those who have been diagnosed with cancers, called an **incidence rate**, is conducted to continuously update the data. The results of this study suggest that individuals who were exposed to the ionizing radiation have a greater risk for developing some cancers and other deteriorating diseases. There have also been studies on their children and grandchildren, and there is currently no evidence of radiation effects on that are passed down through the genes. This cohort of individuals will continue to be evaluated throughout their lives.

MORTALITY RATE

The measure of the frequency of death in a defined population during a specified timeframe.

INCIDENCE RATE

The occurrence, rate, or frequency of a disease.

Another large-scale study that examines the health effects of ionizing radiation is the Million Person Study (MPS) [3]. The MPS includes about 30 cohorts of American workers and Veterans from the 20th century who were exposed to radiation through a variety of environments and jobs. By including one million or more people, researchers can more accurately assess risks of radiation exposure, to keep workers and veterans safe.

WHY IS RADIATION EPIDEMIOLOGY IMPORTANT FOR SPACE TRAVELERS?

People who have been to space received some ionizing radiation exposure. It is difficult to measure the health effects of space radiation. Most people who have traveled in space have not gone very far away from the Earth and have been shielded from radiation by the Earth's **magnetosphere**. Therefore, they have been exposed to only small amounts of space radiation. In addition, there are many factors in space that can be hard on the body, including changes in the gravitational. Because of these factors, researchers must study many more people to understand the effects of ionizing space radiation on human health. That is where studies on Earth come in.

MAGNETOSPHERE

A magnetic field around Earth that protects against ionizing radiation.

Eventually humans want to travel to Mars and beyond. Longer missions further out into space will expose space travelers to greater amounts of ionizing radiation (Figure 2). These people will be outside of the protection of Earth's magnetosphere and will be exposed to more galactic cosmic rays, which cannot be blocked with a shield. Therefore, planning these missions in ways that will keep space travelers safe—both during and after their missions—will require understanding the risks of ionizing radiation on the human body. Even

though radiation in space is different than radiation on Earth, agencies interested in radiation studies, such as the National Aeronautics and Space Administration (NASA), periodically review the effects of ionizing radiation on human health to help them create their radiation policies. Someday, after many people have traveled in space, there may be a branch of radiation epidemiology that specifically studies space radiation cohorts. But for now, researchers use data from both Earth and space to understand potential risks and health consequences of space radiation exposure.

Figure 2

Ionizing radiation exists both on Earth and in space. A long trip to Mars will expose space travelers to more space radiation than will a trip to the Moon. This is because of the longer time spent in space and the greater exposure to galactic cosmic rays, which cannot be blocked by a shield.

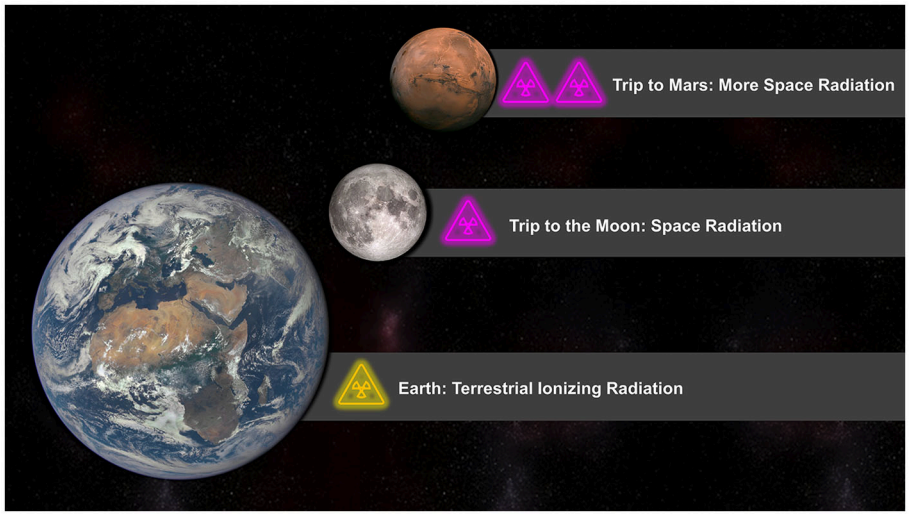

Figure 2

CONCLUSION

Radiation epidemiology is the study of how radiation exposure impacts human health. Exposure to ionizing radiation, which is radiation with enough energy to break the chemical bonds of molecules, can occur from a person's occupation, from the environment, from certain helpful medical procedures, and from space travel. Researchers are working to understand the health effects of exposure to ionizing radiation, and they know that large doses of ionizing radiation can increase the risk of developing cancer. However, the consequences of low doses are still being studied. As space travelers go further into space for longer missions, understanding the impact of ionizing radiation on human health is critical, so that scientists and policy makers can ensure safe space travel to Mars and beyond.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ELLOUISE, AGE: 12
She plays volleyball, chess, and is an avid reader & writer. Conversations are also very important to her. She loves music a lot and appreciates different genres. She particularly enjoys lasagna, despite being lactose intolerant.

KAJ, AGE: 10

A black playful boy who plays chess and football. He loves video games and his favorite actor is Kevin Hart. He also enjoys food quite a lot and cooks.

STANFORD ONLINE HIGH SCHOOL, AGES: 13–18

The Stanford Online High School Astrobiology class is a collection of young citizen scientists all over the world. Our Avatar is a picture of our school mascot (the pixel) on one of the high altitude balloons that we launched.

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