Letting Our Cells Do the Fighting

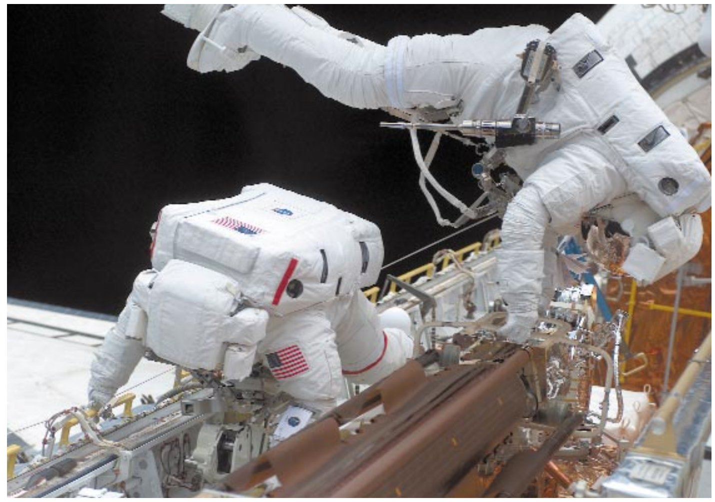
Flight-Induced Changes in the Immune Response

The organisms that make us ill, such as bacteria, viruses, and fungi, are like attacking armies. We now know a great deal more about this unseen world of microscopic invaders. Fortunately for us, the human immune system is ever vigilant against them.

Microorganisms such as bacteria, viruses, and fungi occupy almost every corner of the Earth, and even parts of the human body. Some organisms are beneficial to us, helping to produce milk, cheese or yogurt. Others are potentially harmful, yet we don't always develop illnesses from them; they are kept in check by the sentinels of our immune system. Our immune system is routinely challenged by these organisms every day. When the immune response is diminished, our ability to fight off these "bugs" is lowered. And that's when we become ill.

Space flight presents a challenge to the immune system. Scientists believe that the stressful conditions of space flight — launch into orbit, adapting to microgravity, heavy workloads, and isolation from family and friends, to name but a few — reduce the astronauts' immunity. This immune suppression makes them more susceptible to common illnesses from bacteria and to re-infections from latent viruses in the body. In addition, risk of spreading illness in the confined environment of the Space Shuttle is high. Understanding changes in immune function will help scientists develop ways to keep astronauts healthy in space. This knowledge can also benefit earthbound populations.

This experiment will give scientists insight into the immune system by comparing how certain cells of astronauts' innate immune system — the first line of defense against invaders — function after flight compared to before flight.



Astronauts John Grunsfeld (left) and Richard Linnehan participate in a space walk on STS–109 to work on the Hubble Space Telescope. Space walks can present significant physical and psychological stress on astronauts, possibly challenging their immune systems.

Earth Benefits and Applications

With greater understanding of the immune system in space, we can:

- Prevent impaired immunity for humans in confined conditions on Earth, such as polar stations, submarines, hospitals, and nursing homes
- Develop better vaccines
- Develop more precise treatments and drugs for illnesses
- Prevent emerging diseases.

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Background Information

Science

To minimize the health risk during flight, astronauts undergo preventive measures (such as immunization and physical exams) before flight. In order to understand the changes the immune system undergoes in microgravity and upon return to Earth, scientists must learn how immune cells behave before and after flight — measured as the response to invaders or the intensity of that response.

The body's immune system actually consists of two types of systems — the adaptive immune system and the innate immune system; they complement each other to provide effective protection. The adaptive arm responds to a foreign invader to destroy it and then retains a memory, an antibody against that specific invader should it ever attack again. This system is at work when you are vaccinated. Vaccination exposes you to a small, non-virulent dose of the foreign microorganism, which will not make you ill but allows your adaptive immune cells to respond and know what to look for in the future.

The innate arm of the immune system is the first line of defense, so its cells do not focus on specific invaders. In this way, it is non-specific and attacks cells recognized as foreign to eliminate them quickly. Innate cells destroy mainly through an action called phagocytosis, by which the foreign microorganism is engulfed and destroyed. They can also work with the adaptive immune system to destroy invaders.

The cells of interest in this experiment are three types of white blood cells of the innate immune system — specifically, neutrophils, monocytes, and a special set of lymphocytes called natural killer cells; all of these play important roles in warding off infection and illness. However, like any military force, these soldiers have different methods of attack.

Neutrophils, ready as the first line of defense, circulate in the bloodstream. They move out of the blood and into infected tissue to destroy infected cells. The results of their action can be seen in everyday life; for example, the pus from a boil is mostly a collection of dead neutrophils that have destroyed the microbial invaders.

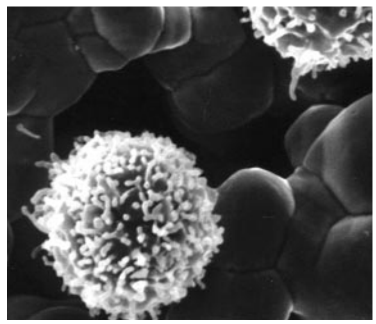
Monocytes also circulate in the bloodstream. These cells are important not only for their defense in the bloodstream, but also because they mature and migrate into tissues where they become potent macrophages. These macrophages have the ability to engulf foreign antigens and destroy them with certain enzymes. Macrophages can also break down the microorganism into smaller pieces and present these to other immune cells for antibody production.

Natural killer (NK) cells are the last type of white blood cell to be studied. They belong to a subset of white blood cells known as lymphocytes. NK cells recognize foreign targets in a non-specific manner and destroy them. They play key roles in fighting tumor cells and cells infected with viruses or bacteria.

The data for this experiment will come from blood samples taken before and after flight. Three blood samples will be taken — 10 days before flight, on the day of return to Earth, and 23 days after return. The only restriction given to the astronauts is that they must record any medication taken. Once isolated from blood samples, these cells will be tested for any alteration in function.

Earlier Studies

Similar studies performed before and after shorter missions (lasting 5 to 11 days) have shown a decrease in the function of neutrophils and monocytes immediately before and after space flight when compared to non-astronauts. This suggests that astronauts are stressed before launch and after flight when returning back to Earth. These effects may also be dependent on mission length.



Immune cells in action: one kind of a human white blood cell, the lymphocyte, is shown here.

Previous studies performed on Apollo, *Skylab*, and Shuttle missions have studied the adaptive arm of the immune system. While NK cells were previously studied by Russian investigators, this is the first study to investigate the neutrophils and monocytes of the innate immune system.

This STS–107 study examines how the complex space flight environment affects the functions of immune cells before and after the mission. This contributes to our ever-maturing understanding of the immune system as it performs on Earth and in microgravity.

Operations