MATH AND SCIENCE @ WORK

AP* BIOLOGY Student Edition

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MICROGRAVITY EFFECTS ON HUMAN PHYSIOLOGY: IMMUNE SYSTEM

Background

From the beginning of the human space flight era, NASA has been mindful of the need to monitor the health and well-being of its astronauts. Keeping astronauts healthy in space, while researching the effects of microgravity on the human body, became a key priority. The Immunology Laboratory at the NASA Johnson Space Center investigates the effects of spaceflight on various aspects of human physiology. One of the primary areas of research conducted by the Immunology Laboratory is the effect of spaceflight on the human immune system.

The human immune system is a complicated network of different cell types (granulocytes, lymphocytes, monocytes, etc.), that reside in various tissues throughout the body. Immune cells primarily reside in the blood and lymph nodes, and migrate to any tissue where disease or injury may occur. Research suggests that immune system suppression occurs during spaceflight; however, the magnitude and specific nature of the suppression are unknown. Should the immune system remain compromised for the duration of an exploration-class space mission (such as to the Moon or Mars), this would result in greater crew risk for contracting illnesses. NASA researchers are currently conducting studies on Earth and onboard the International Space Station (ISS) to investigate potential countermeasures (or interventions) for immune system suppression during future human space exploration missions.

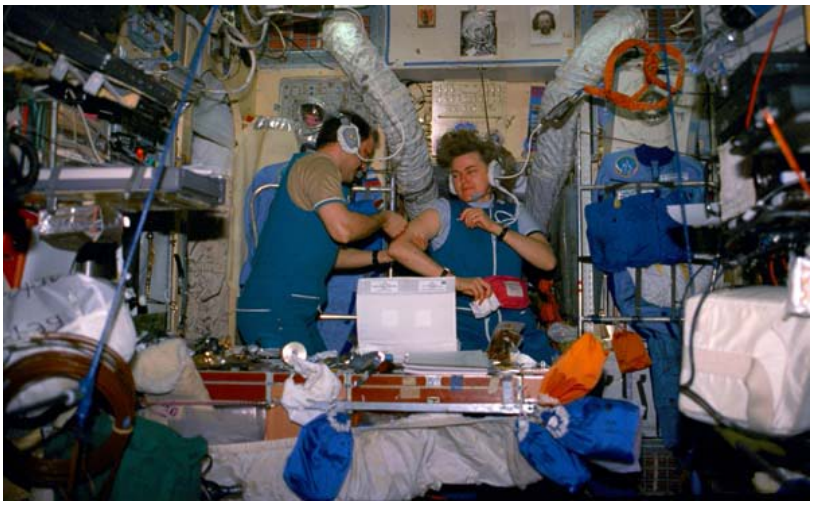

Figure 1: Astronaut Shannon Lucid receives an immunization from Cosmonaut Yury Usachev in-flight as part of a NASA-Mir experiment designed to examine the effects of long-duration spaceflight on the humoral (antibody producing) arm of the immune system.

Problem

Our complex immune system consists essentially of disease-fighting cells that can travel throughout the body. It is a highly regulated system that has multiple cell types that use chemical signals (cytokines) to communicate and respond. Research suggests that our immune system functions different in space than on Earth. NASA scientists are working to determine which parts of the immune response are affected by microgravity.

A. The immune system protects organisms from infection using a series of layered defenses against invading pathogens. The first line of defense consists of surface barriers that prevent pathogens from entering the body.

   I. Identify one mechanical, one chemical, and one biological surface barrier and explain how each one protects the body from invading pathogens.

   II. Identify at least two of the four types of leukocytes (white blood cells) that are activated as part of the innate immune response and discuss the role of each.

   III. Two of the most important cells found in the adaptive immune response are B cells and T cells. Describe the origin and specific functions of B cells and T cells in the human immune system.

B. NASA scientists believe that astronauts may experience certain factors during spaceflight that can cause suppression of the immune system. These factors include physiological stress, isolation, fatigue caused by heavy in-flight work, demanding exercise schedules, disruptions in sleep patterns and circadian rhythms, and radiation exposure.

   I. Identify the three major hormones involved in the 'fight or flight' response that can be activated as a result of physiological or psychological stress.

   II. Evaluate how chronic stress and sustained 'fight or flight' responses over time would have a negative impact on the human immune system.

C. Discuss two observed effects on T-cell function during spaceflight seen in astronauts or in cell culture simulations of microgravity.

D. Gaining an understanding of how spaceflight affects an astronaut's immune system would enable scientists to develop countermeasures to correct or alleviate this problem. Potential countermeasures might include medicines, improved diet, altered work schedules, and radiation shielding. This same research could potentially provide countermeasures for diseases on Earth resulting from reduced immune function.

   Based on spaceflight research of the immune system, evaluate the impact of T-cell response control and the effects that it could have on cancer patients.