GRACE Education Curriculum Gravity	
Teachers	Grades 9-12
Biology	

Gravity and the Human Body

Background Information: As the human race sets their goals on space travel and on exploring other planets, we have to look at how long exposure to free-fall and microgravity affects the body. Space medicine is a new field that is growing fast as the International Space Station becomes a reality. NASA has ongoing studies on how the astronauts' health is affected by space travel.

Objectives: Students will do research on gravity and the human body.

Standards: Science: physical science; life science; earth & space science
Technology: effective use of computers as an aid to problem solving; integration of technology and curriculum to support learning
Language Arts: writing skills

Vocabulary: free-fall, microgravity, space medicine, ISS

Materials: Access to local library or Internet connections

Directions to the Teacher:

Since this is a current topic, there may be few books about the effects of microgravity on the human body. Students may find periodicals on the subject but the internet would be a valuable resource. Conduct a web quest for Internet sites to guide the students towards web sites on space medicine and affects of microgravity on the human body. Have the students:

1. Write a paper on one of the following topics.
   - How is the human body affected by long term "weightlessness"? This is also referred to as a state of free-fall.
   - Which of the human senses are affected by long-term space flight?
   - What type of health problems have astronauts had in the past?

- What other animals have traveled in space and how did they do as far as health concerns?

Include a bibliography of your sources.

Certain negative effects appear with every space flight on almost all crew members, such as headward fluid shift and muscle deconditioning. Other effects, however, are not very consistent and do not always occur. A few of these include nausea, headache, backache, congestion, and insomnia.

Astronauts take medicine to alleviate the pain or discomfort caused by the body's adaptation to space. Medications carried on Space Shuttle missions have varied from flight to flight, depending on the individual needs of crewmembers.

Before determining what measures are to be taken in space, it is first essential to define how exactly space effects the physiology of the systems of human beings. A fluid shift results as blood and other fluids move from the feet, legs, and lower trunk to the upper body, the upper trunk, and the head. This fluid shift causes at first the heart to enlarge in order to handle the increased blood flow. This "flooding" in the upper part of the body causing the body, through negative feedback, to correct this situation by getting rid of some of the "excess" fluid. The astronauts become much less thirsty than normal, and the kidneys increase the output of urine. Both these actions decrease the overall quantity of fluids and electrolytes. Once the fluid level decreases, the heart shrinks back to its normal shape and size.

Adaptation of the heart and the cardiovascular system to microgravity is rapid and effective. The adaptation is primarily a general response to a headward shift of body fluids. The concentration of red blood cells (or RBCs) stays about the same, surprisingly, even though plasma volume decreases in space. As humans are exposed to the microgravity of space, there is a loss of fluid. This suggests that the concentration of RBCs should increase. However, this does not happen. Thus, the concentration of RBCs must be somehow decreasing. This reduction of RBCs is known as "space anemia".This happens through negative feedback. As the concentration of fluid decreases, the kidney reduces the production of erythroprotein which in turn surpresses RBC formation. Thus the concentration of RBCs is maintained in the blood preventing any extremities.

Human muscles adapt to new situations. When we need our muscles, we can activate them almost immediately. When a person does not use his muscles for a period of time, the muscles begin to waste away or "atrophy". Astronauts, while in space do not require the use of their "anti-gravity" muscles and thus experience this natural atrophy.

When astronauts return to earth, these muscles can still cause problems. Thus, in microgravity, tension is reduced on muscles that support the body against gravity, resulting in a loss of muscle mass and an accompanying loss of muscle strength.

The main problem to be faced is that exposure to microgravity causes a reduction in the endurance capacity of skeletal muscle. A reduction in bone marrow also results due to the absence of gravitational force. In certain parts of the body (like the legs) this loss can amount to 1.5% per month, thus resulting in an unacceptable loss for a mission that takes approximately 2.5 years.

The awareness and perception of our body's orientation on Earth is attributed, in part, to the detection of gravity by the otolith organs, or the utricle and the saccule, and to the detection of the rotational movements by the semicircular canals, both of which are in the inner ear. Gravity sensors in the joints and the touch sensors in the skin are also involved, and the eyes contribute by sensing the body's relationship to other objects. However, the otolith organs are stimulated differently in the weightless environment of space where the resulting signals no longer correspond with the visual and other sensory signals sent to the brain. This signal conflict causes disorientation. For example, the brain may have difficulty making sense of the fact that although you see the floor and the ceiling, there is no other sense realism connected to the concept of "up" and "down". Once the astronaut returns home, the body responds again to a "new" environment. The body's goal is to reach an Earth-normal condition as soon as possible.

Numerous animals have survived in space including mice, a chimpanzee, a dog, etc. The Space Shuttle and the International Space Station provides a more suitable environment for animal research. To learn more about animals and spaceflight, visit: http://www.nal.usda.gov/awic/newsletters/v6n2/6n2borko.htm#living

The ability to conduct life sciences experimentation in space has been pivotal to our understanding of how biological processes are affected by microgravity. The early animal space explorers paved the way for humans to venture into space. A variety of animal models have been used to evaluate an assortment of flight issues that have included propellant systems, radiation exposure, life support systems, and recovery procedures. In

the absence of animal models, this work would have progressed much more slowly and with far greater human risk.

Extensions:

- Read a book written by an astronaut about their time in space.
- Research the time astronauts or cosmonauts have spent in space and do a timeline.
- What research is NASA conducting for long-duration spaceflight?

References / Resources:

http://www-sci.lib.uci.edu/SEP/CTS98/
http://www.edhelper.com/
http://quest.arc.nasa.gov/