Life in Space – Teacher Notes

Gravity is one of the most fundamental forces in the universe. We know its effects on Earth, we know that it holds the moon in orbit about the Earth and the Earth about the sun. It is responsible for tidal movement of the Earth's oceans and even for the formation of the Earth itself. In fact without gravity life would not exist.

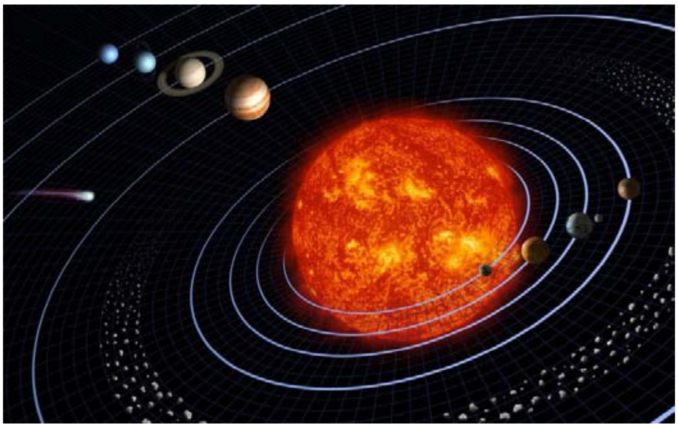

Figure 1: Gravity holds the planets in orbit about the sun

The strength of a gravitational field is measured as the acceleration of an object under its influence. The acceleration due to gravity on the surface of the Earth is equal to approximately 9.8 m/s^2 this is known as 1 'g'.

Figure 2: Astronauts can train for weightlessness in an aircraft that experiences free fall

Gravity has a major effect on biological life and its development, but this is only noticeable when gravity is removed. Once in orbit around the Earth, the Space Shuttle and the International Space Station (ISS) are microgravity environments. This is sometimes called zero-g, but this is in fact incorrect as astronauts in the Space Shuttle or aboard the ISS are still affected by the Earth's gravitational field, how else do they remain in orbit? However orbiting astronauts experience weightlessness due to their freefall around the Earth.

Science in Micro-gravity

Micro-gravity is approximately one millionth of the gravity experienced on the surface of the Earth, and many physical and biological processes work differently in a micro-gravity environment. In space, researchers can isolate the effect of gravity and undertake experiments impossible in the presence of gravity. The ISS and even the Space Shuttle provide laboratories within the space environment to perform experiments that are not possible on Earth.

The Effect of Micro-gravity and the Space Environment on the Human Body

When exposed to a micro-gravity environment the first thing humans undergo is 'headward fluid shift'. The absence of gravity allows blood to move from the lower body to the heart and head. This causes the heart to temporarily enlarge until the body begins to decrease total blood volume. Red blood cell mass also decreases during space flight. After a few days in space the heart has shrunk to compensate for the now smaller than normal amount of blood being pumped around the body. Complications can occur once the astronauts return to Earth as their weaker heart struggles to pump blood around the body against the force of gravity.

Over time the micro-gravity environment also causes a loss of bone density which increases the risk of broken bones when the astronauts return to Earth. The reason for this is still not well understood, but it is believed that gravity plays some part in the generation of a hormone involved in regulating bone growth. Muscles also undergo weakening in a micro-gravity environment. In the absence of gravity, leg and back muscles are no longer required to support an astronaut's weight and the muscles atrophy. The decrease in muscle strength is again a problem when the astronauts return to Earth, and may result in them being unable to walk or even lift their arms. In order to counteract the effect of micro-gravity on the muscular, bone and cardiovascular health of astronauts they must undergo a strict exercise regime while in space.

Figure 3: An Astronaut undertaking an echocardiogram in micro-gravity

As well as the effect of micro-gravity, the closed environment of a spacecraft can suppress immune function, while stress may have dramatic effects for long duration space missions. The cause of these and many other changes to biological function that occur during space flight are still the focus of much ongoing study. In order for astronauts to take long duration space missions to Mars, or other locations, the impact of space travel on human physiology must be well understood to avoid serious health problems.

Effects of the Space Environment on the Brain and Nervous System

The effect of micro-gravity on the brain and central nervous system, and the effect of the space environment on the body's biological and sleep patterns are important areas of study currently being undertaken by scientists. The vestibular system (the inner ear) maintains balance by sending information to the brain on the position and movement of the head, based on sensing gravity. In a micro-gravity environment astronauts undergo various different reactions that include dizziness and space motion sickness.

Figure 4: In space there is no up or down

Space Motion Sickness (SMS) is experienced by more than 50% of astronauts during their first few days of exposure to micro-gravity. It is essentially the same as motion sickness on Earth, resulting in symptoms including nausea and vomiting. Understanding the physical cause of SMS is an important area of research because of the effect it can have on crew well-being and productivity.

Astronauts also suffer from severe disorientation when they first enter the micro-gravity environment. There is a conflict between the signals being received from the vestibular system and the visual information sent to the brain. There is no longer any physical concept of up or down. However, this disorientation disappears relatively quickly as astronauts adapt to the micro-gravity environment and begin to rely on their visual sensory input as a reference.

Closed Environment

Spacecraft, including the space station, are closed environments that must provide everything the astronauts need to survive, including a pressurised environment, safe air to breath and safe drinking water. The environment must be monitored and filtered to avoid microbial contamination. Water and air will be recycled from onboard and treated for crew consumption.

Radiation

During their time in space astronauts are exposed to radiation, consisting of photons and heavier charged particles. The effect of radiation on astronauts can be separated into two categories, acute and long term. Acute effects include skin-reddening, nausea, vomiting and dehydration, which can cause a disruption to the performance of the astronauts. Because only moderate doses of radiation are generally encountered, the acute effects of radiation exposure are low risk. The long term effect of radiation on astronauts is a more important consideration. The passage of a charged particle through a cell causes ionization within the cellular structure. This can cause damage to DNA molecules, which can lead to cell death. Even more dangerous is the non-lethal mutation of DNA molecules which can lead to cancer.

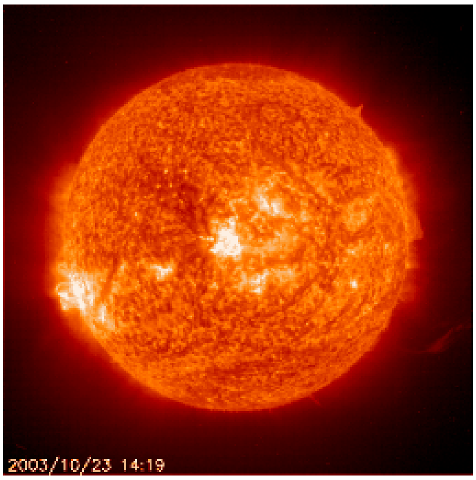

Figure 5: Radiation from the sun is a major concern for astronauts

Studying the Effect of the Space Environment

As human space flight moves from the relatively short term into longer duration stays aboard the ISS, and the eventual 3 year trips to Mars, understanding the effects of long term exposure to the space environment is becoming increasingly important. In order to study the effects of space on biological functions, scientists are studying both plants and animals. This is important not only to understand biological effects, but also to study the possibility of using plants for food and environmental functions on long duration space travel.