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The presentation tonight will provide a brief overview of some of the hazards that humans face when engaged in exo-atmospheric activities as well as the future challenges to be faced as humans venture beyond Low Earth Orbit (LEO).

The presentation will cover effects due to:

- Space environment: radiation effects
- Physiological effects: fluid redistribution, skeletal degradation, sleep disorders
- External hazards: fire

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The modern Extra Vehicular Activity Mobility unit (EMU) provides protection against many of the hazards of the space environment. Without it, exposure to space would:

- Cause the blood to boil due to extremely low temperature and pressure
- Cause the internal organs to expand and then freeze due to the blood boiling
- Cause suffocation due to a lack of oxygen

Therefore, the space suit provides protection not only to exposure to space but in many other different ways:

- Layering: the multiple layers of the space suit protect against decompression due to micrometeoroids as well as providing protection against the extremely low temperature of space.
- Polarised visor: Protects the astronaut's eyes from the intensity of solar radiation
- Self contained environment: the suit's Life Support System (LSS) provides oxygen to allow for a maximum Extra Vehicular Activity (EVA) duration of 7 hours. It also removes expelled carbon dioxide.

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On the ground, most of the body's blood volume is contained in the lower body (i.e. legs and lower torso) but in microgravity, the blood redistributes to the head and upper body due to the elastic expansion of blood vessels. For the first few days of space flight, this gives the face a bloated or puffy appearance. The body readjusts by expelling, what it thinks are, excess fluids. This causes a significant reduction in the size of the upper legs, as this is where a large amount of blood resides. These effects can be lessened by periodic stints in the Lower Body Negative Pressure (LBNP) suit, which is a suit that fits over the lower half of the body and pulls the blood towards the legs and feet.

Another issue in microgravity is the fluid shift in the inner ear. Small particles in the inner ear called "otoliths" that are central to our balance, no longer provide accurate information on the linear acceleration of the body along the x, y, and z axes. This causes a conflict between what the eyes see and the body senses. This conflict tends to result in nausea and vomiting and persists for a few days even after astronauts return to earth.

Upon returning to earth, astronauts ensure that their movements are very slight and planned. Many report that when they turn their head too quickly, they get the sensation that they are

about to go flying off into the next room! This is directly attributable to the conflict between what they see and what they sense.

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This diagram demonstrates the process of fluid redistribution in the body before, during and after spaceflight as well as the general sensations and feelings of the astronaut during these periods.

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Once the astronaut is in microgravity, there is a reduced load placed on the skeletal system to support the body against the force of gravity. Because of this, calcium begins to be expelled by the body and over long periods, bone integrity can be significantly reduced. Another side-effect is the decrease in muscle volume, most prominent in the legs. This gives astronauts what is known as “chicken legs”. This effect can be reduced somewhat by exercise and its inclusion forms part of an astronaut's daily routine. Long term missions on Mir have shown that at this stage, there is no way to remove completely the effects of microgravity on calcium loss.

Any potential manned mission to Mars will need to address this issue of bone and muscle degradation. An astronaut on a journey to Mars, even with a daily exercise regime, would be suffering from the effects of Osteoporosis and may not even have the muscle condition and strength in the legs to support their own weight (body and space suit) and step onto the martian surface.

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Sleeping in microgravity brings with it its own set of problems and issues. You obviously can't sleep on a bed as on earth because you'd be constantly floating above it. Due to circulating air currents, you'd probably drift away and end up against an air-vent somewhere. Astronauts on the space shuttle have a series of sleeping compartments (four of them, like self contained bunk beds) with 'sleeping bags' that have velcro straps to keep the occupant in and the sleeping bag fixed to a surface to prevent it from floating around.

Many astronauts have described problems with sleeping in microgravity. Some have described the sound of blood pounding in their ears to be more prominent than usual and others have experienced discomfort caused by back aches (due to expansion of the spinal discs, making astronauts almost an inch taller in space!). Related to the previous discussion of balance in space, some astronauts have reported a sensation of spinning whenever they close their eyes such that they were constantly being woken up and couldn't go to sleep.

To understand these and other effects in microgravity, sleep studies are done on earth. The patient reclines at 30 degrees past the horizontal as it's been found that this body position provides results similar to those experienced by astronauts. Patients spend anywhere from 4-6 weeks in bed with all manner of readings taken to determine effects and possible counter effects of long term existence in microgravity.

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On earth, fire burns from a base source and the flames progress upwards from the source under the effects of gravity. Fire extinguishers work on the principle of removing one of the factors that enable combustion to occur: fuel, heat or oxygen.

In space, flames are unconstrained by gravity. The best way to fight fires in microgravity (and the primary way that the fire on board MIR was extinguished) is to turn off all of the air ventilation. In so doing, less oxygen is supplied to the fire and the by-products (smoke and other gases) act as a suffocating blanket, starving the fire of oxygen.

When using extinguishers in microgravity, astronauts must brace themselves to ensure that they are not sent spinning in the opposite direction to the expelled CO₂ due to Newtons 2nd law. The ISS fire fighting kit is shown in the middle picture.

On the ISS, for extreme fires that cannot be contained, certain modules can be evacuated of air in order to extinguish the fire.

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Cosmic background radiation, solar charged particles and coronal mass ejections all pervade space. Earth is protected from the majority of harmful radiation by its own atmosphere and magnetosphere. One area of the magnetosphere known as The Van-Allen belts, extends out into space (3000km and 16000km) and provides a shield against such rays and particles. Beyond Medium Earth Orbit (MEO) however, there is no shielding against such radiation. As the space shuttle and International Space Station orbit in LEO, they are exposed to very little extra radiation.

However, once we progress beyond MEO on any inter-planetary missions (say to Mars), there will be direct exposure to these harmful forms of radiation. These can be potentially overcome through the use of drugs, passive or bulk shielding or proposed advanced forms of electromagnetic shielding.

The problem with harmful radiation is that it causes mutations to occur in the cells of our bodies (see diagram) and after cell division and replication, can cause rise to benign or malignant cancers or tumours.

In the case of a manned Mars mission, this problem worsens because unlike on earth, Mars has virtually no atmosphere to speak. The surface of Mars is therefore saturated in Ultra-Violet (UV) light as well as bombarded by solar charged particles.

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All of the hazards to human space flight discussed previously will need to be overcome or at least accommodated if any of the above images are to be transformed from science fiction into science fact...