**Web Activity: Homeostasis and Space Travel**

On April 12, 1961, a 108-minute Earth orbit by Cosmonaut Yuri Gagarin signaled the beginning of manned-space flight. Gagarin proved that the human body was able to adapt to the rigor of lift-off, re-entry, and microgravity, and still perform tasks required for spaceflight. By the time Valeri Polyakov climbed from his Soyuz capsule on March 22, 1995, after a world-record 438 days on the Mir space station, scientists had gained a better understanding of physiological adjustments of the human body to the micro-gravity conditions found in orbiting space vehicles.

The human body is adapted to the gravitational forces on the surface of Earth. Approximately 60 % of a person's mass is composed of water, found in intracellular fluids (within the cells of the body), in the blood plasma, and in extracellular fluids (fluids in spaces between the cells). In response to the force of gravity, these body fluids are pulled toward the feet, abdominal cavity, and lower extremities. Our physiological systems counteract the gravitational force, and so prevent excess pooling of body fluids in these areas. The lymph system returns fluids and proteins to the circulatory system. Muscles that surround veins push fluids back up toward the heart. In addition, any time we change the position of our body relative to the force of gravity, such as by lying down, also assists in redistributing fluids.

Hydrostatic pressure is the force exerted by a stationary (static) column of water (hydro). Hydrostatic pressure is determined by the height of the column of water and the force of gravity acting on the water. In a standing human body, hydrostatic pressure increases with the distance below the heart (**Figure 1**). The hydrostatic pressure above the heart is much lower, because gravity pulls the fluids downward. While lying down (prone), a person is in a condition similar to microgravity. The hydrostatic pressure between feet and head are similar to that found in the heart.

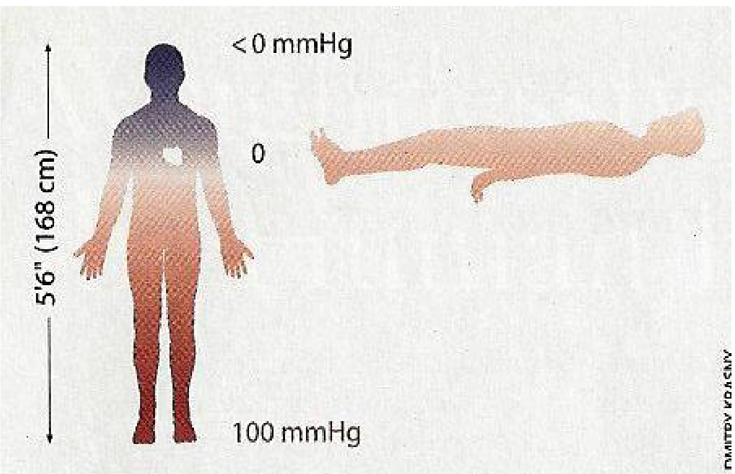


**Figure 1**
The hydrostatic pressure of fluids at various places in the human body varies with the position relative to Earth's surface.

During space travel, the hydrostatic pressure decreases rapidly, as it does for a person in the prone position. Within minutes of reduced gravitational force, any body fluids that pooled in the lower extremities are redistributed. The neck of the space traveler begins to bulge, the sinuses fill and the face begins to appear puffy (**Figure 2**), a condition that is sometimes called "Moon face). The legs also become very thin from a lack of fluids.

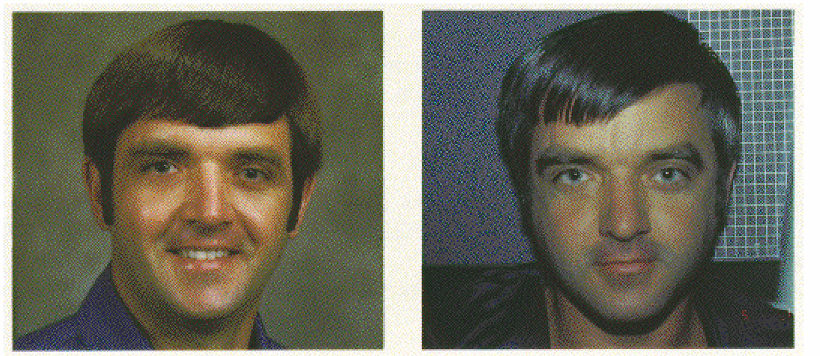

**Figure 2**
(**a**) Prior to space flight; (**b**) space flight

Under normal conditions, homeostasis of body fluid volume is maintained or restored by the adjustment of fluid intake and by the physiological mechanisms that regulate fluid output by urine formation. The more fluid that is consumed, the greater the volume of urine produced to maintain fluid balance. The function of the kidney is affected by two hormones, ADH (antidiurectic hormone) and aldosterone.

**Table 1** summarizes the changes in the body that occur in microgravity.When a person enters microgravity, the redistribution of fluids from the feet and abdominal cavity fools the body into thinking that fluid balance it too high. The kidneys therefore begin to eliminate excess fluids. The filtration rate increases by nearly 20 % and will remain at a high level for nearly one week. As a result, astronauts have to rehydrate prior to entry.

**Table 1**

| **Body area** | **Change** |
|---|---|
| Legs | • Loss of 1 L of fluids<br>• a 10% loss of fluids causes legs to appear thinner |
| Extracellular fluids | • fluids from the legs and abdomen are redistributed<br>• more extracellular fluids surround tissues of the head and are found above the heart |
| Kidney | • increased filtration rate by 20 %<br>• decreased ADH production<br>• increased urine production<br>• body fluid volume decreases as more urine is excreted<br>• increased aldosterone production<br>• increased electrolytes in the blood |
| Cardiovascular | • increased heart rate.<br>• reduced blood pressure in some astronauts |
| Skeletal system. | • bones breakdown faster than they build<br>• a release of calcium into the blood<br>• increased calcium levels in the blood may cause the formation of kidney stones and the calcification of soft tissues |

 

**Case Study Questions**

1. Explain why filtration rates increase.
2. Using the data provided, infer the function of ADH.
3. Why do levels of ADH decrease when fluid intake does not increase?
4. Draw a feedback loop showing adjustments with ADH.
5. How would a decrease in blood pressure affect aldosterone levels?
6. Using the data provided, infer the function of aldosterone from the data provided.
7. Draw a feedback loop showing adjustments with aldosterone.