MATH AND SCIENCE @ WORK

AP* BIOLOGY Student Edition

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PHYSIOLOGY OF THE CIRCULATORY SYSTEM

TI-Nspire™ Lab Activity

Background

The International Space Station (ISS) is a research laboratory being assembled in low Earth orbit by five international partners. Construction of the ISS began in 1998 and is scheduled for completion in 2011. Crews aboard the ISS conduct experiments in biology, chemistry, physics, medicine, and physiology as well as astronomical and meteorological observations. The microgravity environment of space makes the ISS a unique laboratory for the testing of spacecraft systems that will be required for future exploration missions beyond low Earth orbit.

Figure 1: The ISS orbiting the Earth as observed by Space Shuttle Discovery on March 26, 2009

The ISS travels in orbit around the Earth at an average speed of 27,743.8 km/h (17,239.2 mph) completing 15.7 orbits per day. An international crew, of typically six members, resides on the ISS for approximately six months. As they orbit the Earth, the crew experiences close to zero gravity. Shifting from Earth's gravity to microgravity causes changes in an astronaut's body. One of these changes can be seen in the circulatory system.

The circulatory system is responsible for carrying oxygen, carbon dioxide, nutrients, hormones and many other substances throughout the body. The body's cells rely on the circulatory system for a continuous supply of essential materials and waste removal. The heart is the driving force behind the workings of the circulatory system. The ventricles are the pumping chambers of the heart that push blood out of the heart with tremendous force then refill with blood. This process continues nonstop for many decades – billions of times during your lifetime.

Figure 2: A picture of astronaut Sunita Williams on Earth (left) is contrasted with a picture of her in microgravity (right).

On Earth, gravity affects how blood and other fluids flow in the body. Gravity pulls most of the body fluid to parts of the body that are below the heart. Natural muscular tension in the legs helps pump body fluids to the upper body. In space, the force of gravity is absent, but muscular tension continues to exert a force that moves the fluids toward the head. This fluid shift that astronauts experience while in space is characterized by nasal congestion, swelling in the face, and bulging blood vessels in the neck. This is a similar sensation as one would experience by hanging upside down here on Earth. While in space, these symptoms decrease somewhat after about three days, but are noticeable during the entire duration of a spaceflight mission.

A change in appearance is not the only side-effect of this fluid shift. Research has shown that spaceflight can have a dramatic effect on the human cardiovascular system. Even brief periods of exposure to reduced gravity environments can result in cardiovascular anomalies. One anomaly is a reduction in total blood volume. Up to 20% of circulating blood volume can be excreted by the kidneys as well as through the skin and lungs during the first 24-36 hours in space. When spaceflight crewmembers return to Earth's gravity, symptoms such as difficulty standing, low blood pressure, and even fainting have been observed. The risk of some of these symptoms is reduced by fluid loading just before landing and by wearing G-suits during landing. A G-suit is a specially designed suit that applies pressure to the abdomen and legs to restrict the draining of blood from the brain during periods of high acceleration.

Lab Procedure

On your TI-Nspire handheld, open the file, *Circulatory System*. Read the provided information and answer the Pre-Lab questions that follow (TI-Nspire pages 1.1-1.15). You will then be ready to start the Lab Activity (TI-Nspire pages 2.1-2.21). Work with a lab partner through the activity and answer the questions. Following the lab activity, proceed to the Lab Extension (TI-Nspire pages 3.1-3.9) and the Lab Analysis (TI-Nspire pages 4.1- 4.3).

Pre-Lab Questions (embedded within the TI-Nspire document)

1.8 The pulmonary artery takes blood from the right ventricle to which body organs?

1.9 The aorta, which is the largest artery in your body, takes blood from the left ventricle. What is the destination of this blood?

1.10 Which of the two values in a BP reading is always greater?

1.11 What is a "sphygmomanometer"?

1.12 An example of a BP reading is 120/70. What does this reading represent?

1.13 In which of the following locations would you expect the diastolic pressure to be the highest?

- O In your feet
- O In your fingers
- O In your aorta, near the heart
- O In the veins that enter the heart

1.15 What do you think are some contributing factors to a person having HBP?

1.16 What are some ways that a person with HBP could lower their blood pressure?

Lab Questions (embedded within the TI-Nspire document)

2.9 Explain why your pulse rate is lower when you are at rest.

2.10 Why might you feel dizzy when you stand up quickly from a lying down position?

2.11 Why does your pulse rate increase so much right after you stand up from a lying down position?

2.18 Describe the trend you see in the data for both you and your partner.

2.19 Why does your heart rate increase during exercise?

2.20 What other physiological changes do you notice during exercise?

2.21 What factors could contribute to a lower heart rate during exercise and a faster recovery after exercise?

Lab Extension: Endothermic vs. Ectothermic Heart Rates
(embedded within the TI-Nspire document)

3.3 With respect to the environmental temperature, what trends do you see with the heart rates of the two animals?

3.4 Explain the trends.

3.7 Based on your graph, are ectotherms or endotherms more affected by changes in the environmental temperature?

3.8 Based on the data and the graph, when do you think ectotherms would need to eat more food?

3.9 When would endotherms need to eat more?

Lab Analysis (embedded within the TI-Nspire document)

4.2 Hypothesize how the human circulatory system would be affected during long duration missions on the Moon (16.5% of Earth's gravity) and Mars (38% of Earth's gravity).

4.3 Propose two countermeasures or interventions that could be used to maintain cardiovascular health on the missions referred to on page 4.2.