# Engineering the Body

Lesson Type: Modular, Demonstration, Construction
Target: Elementary
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## Overview

The purpose of this lesson is to further mentees' understanding of (or expose them to) the concept of surgical implants. The focus of this lesson is on some of the common technological devices that are implanted in people's bodies to replace or assist malfunctioning biological systems. Mentees will gain insight into the process of designing and creating technological devices to perform certain functions inside a person's body through a modular lesson that includes hands on construction activities as well as demonstrations.

## Objectives

By the end of the lesson, the mentees should have a solid understanding of the following concepts:

1. Many of the biological processes and functions of the body can be replicated by technological devices, and those devices are regularly used in modern science to replace or assist faulty biological systems in the human body.
2. In order to find a solution to a given problem, engineers must first identify the exact cause of the problem and then design something that directly corrects that problem. They can then build their solution and test it to see if it works. This is fundamental to the engineering design process.
3. How the heart, lungs, and joints work in the body.

## Background

**For Mentors:**

Implants:

An implant is a medical device manufactured to replace a missing biological structure, support a damaged biological structure, or enhance an existing biological structure. Medical implants are man-made devices, in contrast to a transplant, which is a transplanted biomedical tissue. The surface of implants that contact the body might be made of a biomedical material such as titanium, silicone or apatite depending on what is the most functional. In some cases implants contain electronics e.g. artificial pacemaker and cochlear implants. Some implants are bioactive, such as subcutaneous drug delivery devices in the form of implantable pills or drug-eluting stents.

Among the most common types of medical implants are the pins, rods, screws and plates used to anchor fractured bones while they heal.

The process of implantation of medical devices is subject to the same complications as any other invasive medical procedure, including infection, inflammation, and pain. Implants also run the risk of rejection if they elicit a reaction from the host immune system.
(source: http://en.wikipedia.org/wiki/Implant_(medicine))

Human Joints:

There are lots of different joints in the body, but the ones discussed in the lesson are the ball-and-socket and hinge joint. Detailed info on these two types is available at:
http://www.innerbody.com/image/skel07.html)

Heart Valves:

Aortic valve replacement is a cardiac surgery procedure in which a patient's failing aortic valve is replaced with an alternate healthy valve. The aortic valve can be affected by a range of diseases; the valve can either become leaky (aortic insufficiency / regurgitation) or partially blocked (aortic stenosis). Aortic valve replacement is open heart surgery.
Mechanical valves are designed to outlast the patient, and have typically been stress-tested to last several hundred years. Although mechanical valves are long-lasting and generally present a one-surgery solution, there is an increased risk of blood clots forming with mechanical valves. As a result, mechanical valve recipients must take anticoagulant (blood thinning) drugs such as warfarin for the rest of their lives, making the patient more prone to bleeding.
The risk of death or serious complications from aortic valve replacement is typically quoted as being between 1-3%, depending on the health and age of the patient, as well as the skill of the surgeon.
(source: http://en.wikipedia.org/wiki/Aortic_valve_replacement)
More on the different types of valves: http://en.wikipedia.org/wiki/Artificial_heart_valve

Lungs:

The lungs are a pair of spongy, air-filled organs located on either side of the chest (thorax). The trachea (windpipe) conducts inhaled air into the lungs through its tubular branches,

called bronchi. The bronchi then divide into smaller and smaller branches (bronchioles), finally becoming microscopic.
The bronchioles eventually end in clusters of microscopic air sacs called alveoli. In the alveoli, oxygen from the air is absorbed into the blood. Carbon dioxide, a waste product of metabolism, travels from the blood to the alveoli, where it can be exhaled.
(source: http://www.webmd.com/lung/picture-of-the-lungs)

**For Mentees:**

Implants:

Surgical implants are technological devices that are used to replace or repair/help organs and bones. Implants are man-made devices, as opposed to transplants which are from other people. Implants are used when a some part of a person stops working the way it's supposed to, so a doctor has to either remove the faulty part of the person and put in an implant in place of it, or add the implant next to the faulty system to make it work again. Since implants can help our body work better than it naturally does, they can also be used to improve human abilities.

One of the hardest parts of making implants is making sure the body accepts them, since using an implant means putting something in the human body that naturally doesn't belong there. A lot of the time, the body recognizes foreign objects as a threat to the its health and safety, and slowly works to remove it from the body.

Joints:

Joints are the places in your body where bones meet. Two important types of joints in the body are the ball-and-socket joint and the hinge joint. A ball-and-socket joint involves a spherical ball on the end of one bone fitting into a spherical socket on the other. Since the ball can rotate freely inside the socket, the bone attached to the ball has a wide range of motion. This type of joint occurs in the shoulder and the hip. A hinge joint is a joint that only allows one direction of motion, like a hinge. The attached bones can only move from close together to far apart. This occurs at the elbow and in the finger.

Heart Valve:

The heart has 4 different chambers. When blood flows through the heart, it goes through each chamber in a set order. The valves of the heart are the entrance to each chamber. The function of blood in human is to act as the medium to transfer nutrients and oxygen to, and wastes from the body parts. A back flow of blood would make this whole communication very inefficient and difficult. Because of this, the valves are designed to only let blood through in one direction, so once blood flows through the valve it can't go back the other way. Sometimes, a valve can stop working because of a disease or other condition, so the valve needs to be repaired or replaced. Since the valves are made out of tissue, doctors usually try to replace it with tissue

from another animal; if the valve is too damaged, the doctor may need to remove the faulty valve and put in a metallic valve in its place.

Lungs:

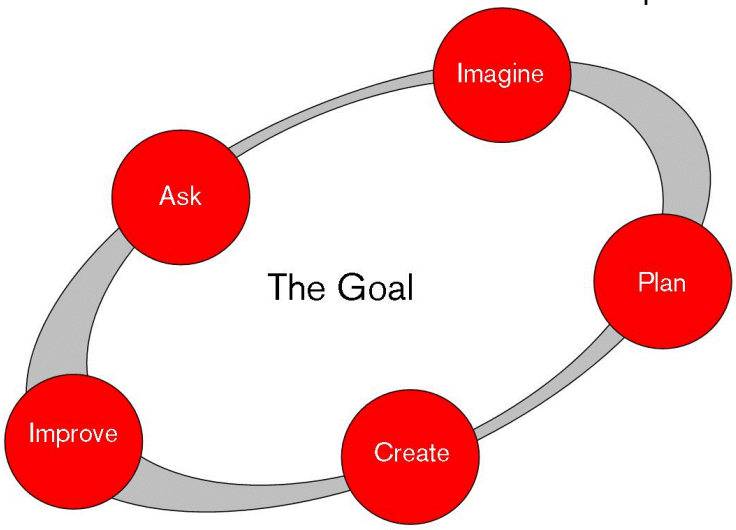
The lungs allow people to breath. When you inhale, the air goes through a tube in your neck that's connected to your lungs. When the lungs fill with air, the oxygen is absorbed through the surface of the lungs and into the bloodstream, while carbon dioxide in your bloodstream is passed through the surface of the lungs and into the air. When you exhale, the carbon dioxide is then released from your body by way of the air in your lungs. Instead of the lungs being made up of one giant chamber, they're instead made up of a large amount of very small bubble-like sacs. When you inhale, the air is distributed to each of the small bubbles where the transfer of oxygen and carbon dioxide takes place.

**Materials**
(for 15 students)

- computer paper (200 sheets)
- pencils (15)
- rubber bands (50)
- paper clips (100)
- scotch tape (6 rolls)
- scissors (6 pairs)
- balloons (30)

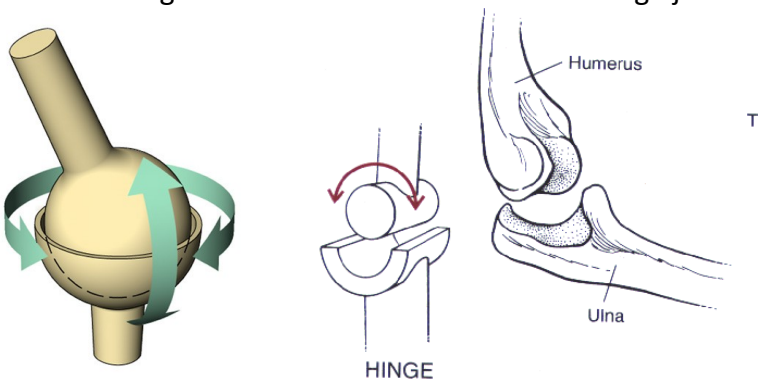
**Agenda**

1. Introduce lesson and concepts behind surgical implants (5-10 min)
    - Draw diagram of the engineering design process on the board and explain its steps, and how the mentees should think of these steps when building their own projects



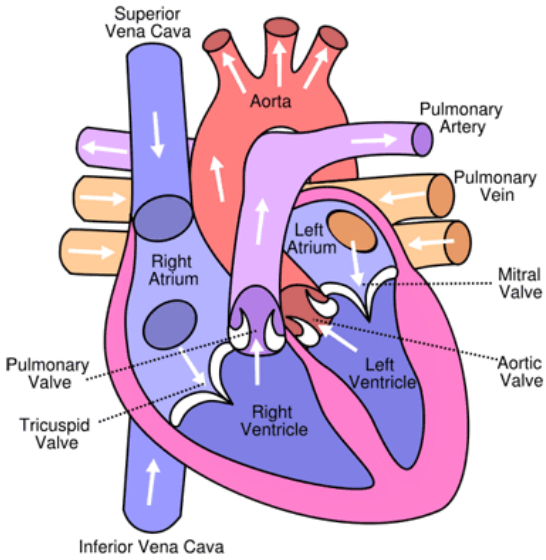
- Explain the functionality and risks of surgical implants

2. Module 1 - Joints (5-10 min)
   - Draw diagrams of the ball-and-socket and hinge joint on the board

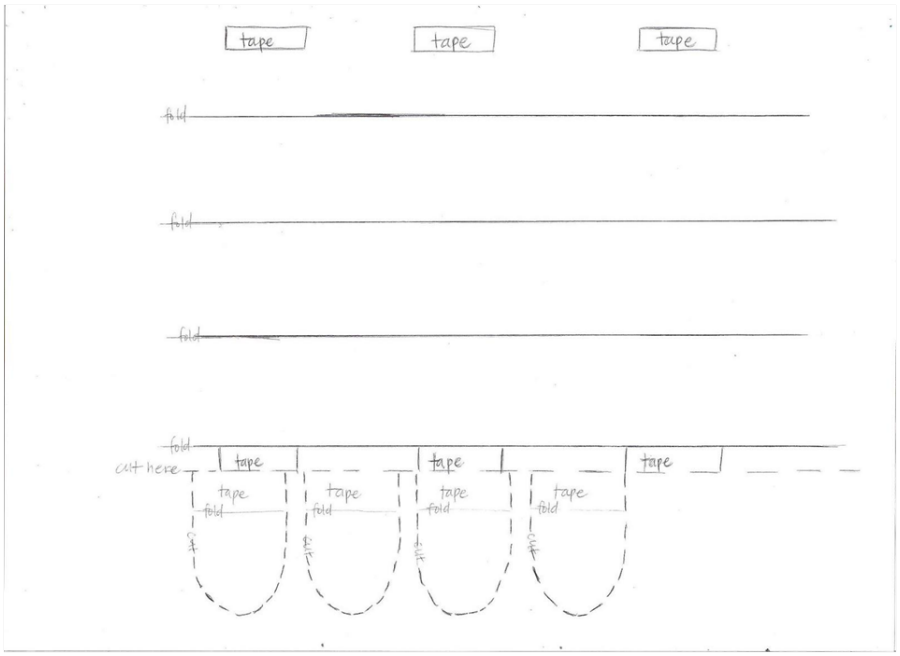



   - Explain how ball-and-socket and hinge joints work and the range of motion each provides
   - Discuss how a joint can be replaced by a prosthetic that imitates the movement of the joint

3. Module 2 - Heart Valves (20-25 min)
   - Draw a basic diagram of the heart and label the location of the valves




   - Explain how how heart valves replicate the function of a tissue valve, and why this is an important function in the heart
   - Show a sample of a paper heart valve model
   - Explain the construction process and assist mentees in their step by step construction of their own valves

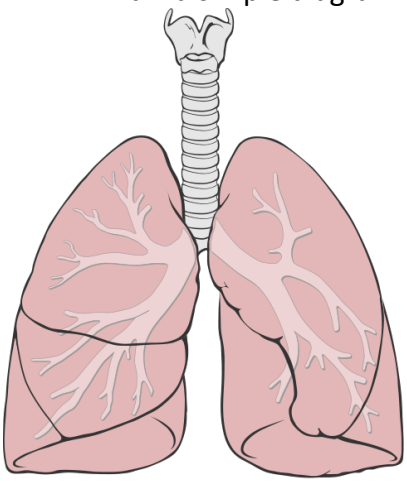



Heart valve assembly instructions:

- Cut out flaps at bottom by cutting along dashed line
- Fold flaps along “fold” line
- Tape flaps in straight line with “tape” portion facing the same way for each, one flap between each solid line
- Fold sheet along solid lines and tape box-like contraption where edges meet

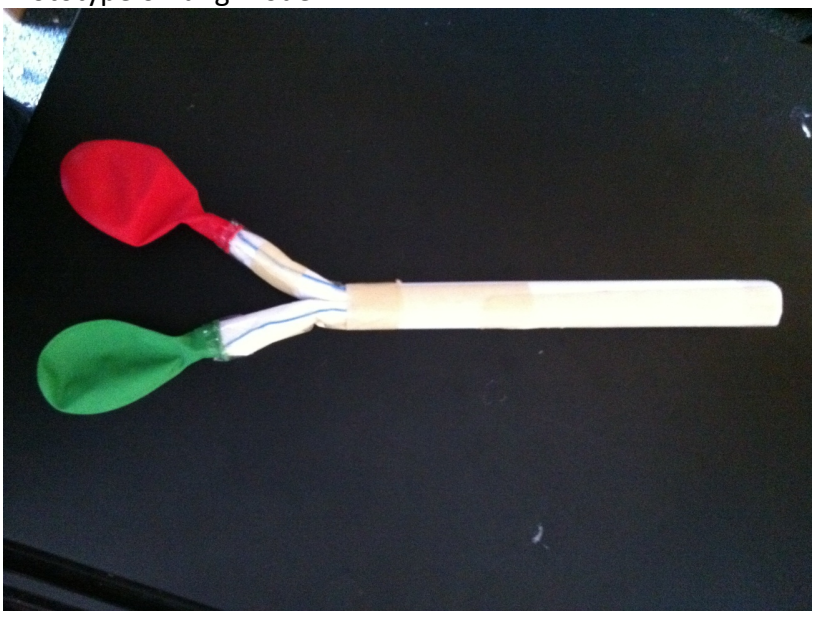
4. Module 3 - Lungs (25-35 min)

- Draw a simple diagram of the shape of the lungs



- Explain how lungs work
- Present the challenge to the mentees of designing their own replacement for a set of lungs out of paper, paper clips, rubber bands, and tape
- Mentees should brainstorm and plan their design by drawing it (5 min)
- Once the mentees are ready to build, they can get the materials they need and begin construction

Prototype of lung model:



5. Debrief (5-10 min)

- Possible follow up questions:
    - What's the most difficult part of making an implant? Designing it? Building it? Testing it to make sure it works?
    - Can implants replace other parts of the body that weren't mentioned in the lesson? What other parts, and how?