

## Bioengineering

### Introduction

In previous newsletters, we have discovered environmental engineering, industrial engineering, and computer engineering. This week, we are going to learn about bioengineering, which is a type of engineering that applies the engineering principles that we learned in past weeks to biological systems and technologies. Okay, so what is a biological system? A biological system is a network of body parts all working together to serve a greater good. For example, when you eat an apple, the apple is first mechanically and chemically digested in your mouth -- mechanically by your teeth and chemically by your saliva. It then travels down the esophagus to the stomach and through the intestines until it eventually excreted out (that's your poop). All the parts in this process work together to ensure the apple is fully digested.



Bioengineering is typically split into a few concentrations, or areas of interest. At Northeastern, Bioengineering is split up into the following: cell and tissue engineering, medical devices and signal processing, and biomechanics. Cell and tissue engineering focuses on the microscopic events happening in your body and stopping them from failing. An example of this is the [Vacanti Mouse](#), which is an experiment in which a toddler's ear was grown on the back of a mouse. In medical devices, the engineers often focus on prosthetics and other devices, such as incubators and heart valves, which either increase patient comfort or help in emergent situations. Lastly, biomechanics focuses on the physics and math behind biological processes to better understand what needs to be done in order to improve them. This subsection tends to be similar to mechanical engineering!

## Northeastern Connections

### Faculty Connection

This week's faculty connection is Professor Sandra Shefelbine, who is associated with Bioengineering as well as Mechanical engineering. Prof. Shefelbine was recently awarded a \$650K National Science Foundation (NSF) grant for her work in "Manipulating Fluid Flow Mechanoadaptation of Bone." This falls under the "biomechanics" concentration. Prof. Shefelbine plans to research the effects of mechanical loads (different weights and forces) on bone. She will look at the signaling that is produced from these loads in order to optimize the signaling via changing the load conditions (speed, amount). She was also awarded the prestigious [Fulbright](#) Futures Scholarship to work on this research!



Along with her groundbreaking research, Sandra Shefelbine is an American Institute for Medical and Biological Engineering (AIMBE) Fellow in recognition for "her distinguished and continuing achievements in medical and biological engineering." She also teaches 3 upper-level courses here at Northeastern.

### Student Connection



This week's student connection is Nathalie Leger, a 5th year Bioengineering student here at Northeastern University and also a Center for STEM Education student employee. Nathalie initially came to Northeastern to study Health Sciences but she decided she "wanted a better understanding of the science behind the body and a way to fundamentally fix issues instead of temporarily stopping them." Nathalie is part of the cell and tissue concentration. Her favorite class was tissue engineering, where she learned about the difficulties in creating organs to implant in humans. She wrote a paper detailing the history of heart valves and why a new solution is needed in the near future. Nathalie would enjoy ultimately working on tissue engineering in the heart.

Nathalie has completed 2 co-ops, or internships, here at Northeastern. Her first one was at Novartis in Cambridge, MA where she researched the outcome of "degrading," or eliminating, proteins from cancer cells. She continued there for an additional 4 months to research what

would happen in stem cells, or self-regenerating cells. Her second co-op was in Belgium! She went abroad for 6 months and worked in a brain lab where she trained mice to perform a simulation task and then imaged their brains to see the connections! She will begin her third co-op in July at Visterra Inc. in Waltham, MA, where she will research [antibody based therapy](#).

Nathalie is a part of [NU BMES](#), [Society for Biomaterials](#), and [Phi Sigma Rho National Sorority for Engineers](#) here on campus.

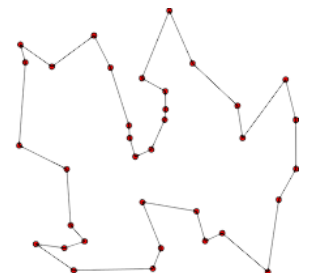
## Do Now



Bioengineers must be able to apply the principles of engineering to the concepts of biological systems. This activity will demonstrate how this field can engineer products for certain health-related needs. **For this activity, you will design a prosthetic limb using some household items.** A *prosthetic* device is essentially an artificial device that replaces a missing body part, such as a limb. Another word you may hear is *bionics*, which are similar to prosthetics, but are electronically or mechanically powered.

For this activity, you will need measuring instruments, such as a tape measure, scissors, tape, a cylindrical item to mimic the structure of the limb (like a plastic pipe or paper towel tube), string/rope, and various materials to create the prototype. Some suggestions include bubble wrap, cardboard, towels - feel free to get creative with the materials! Keep in mind that the goal is to create a device that essentially mimics a limb, so get a feel for how your own limbs feel and work. Then test the prototype either on yourself or another person.

Now here are some questions to consider when designing your prosthetic limb. What material will make the prosthetic the strongest and durable? The most comfortable? What about shock absorption? Or how life-like it is? These are all questions bioengineers must consider when developing these types of



products. Materials most often used by bioengineers include carbon fibers and silicon, as they are lightweight and long-lasting. The goal is to make a product that can mimic the original structure and function of the body part as much as possible, which highlights influences of biology on this type of engineering!

## Activity

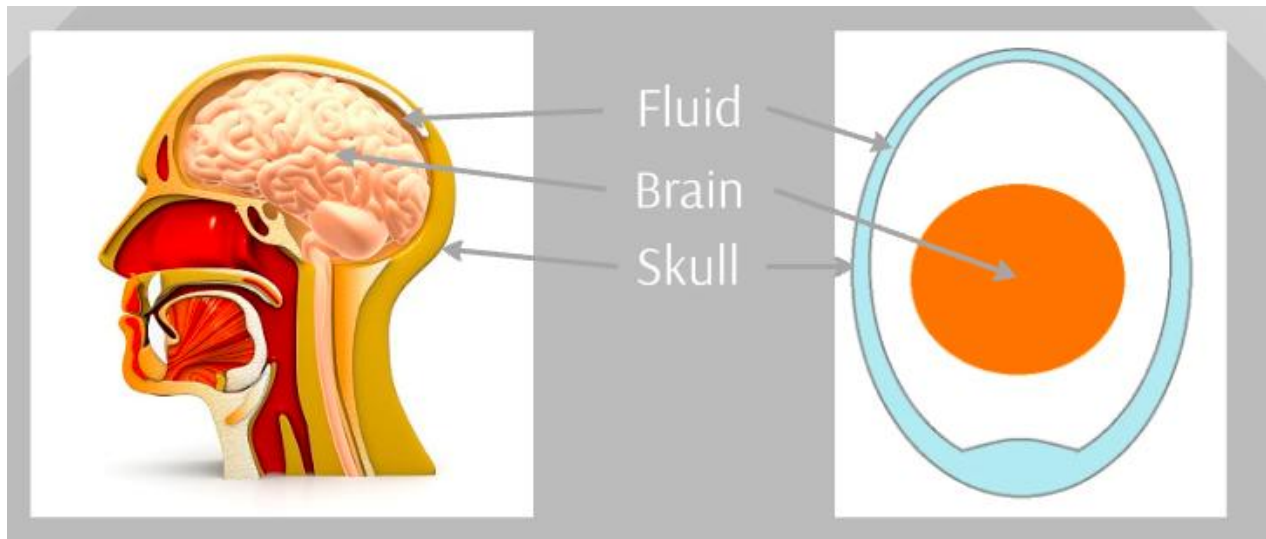
What would you say is the most important part of your body? Your brain? Your heart? How do you protect them?

Both of these organs have bones that protect them, your brain has your skull and your heart has your rib cage, yet we can still get injured. Biomedical Engineers work on creating things that can help fix brain damage, dysfunction, or even prevent it altogether. In this week's activity, we'll focus on the brain (although the heart is still important!) and just like Biomedical Engineers, we'll design things to protect it. In fact, a group of Biomedical Engineers (at Tufts University in Medford, MA) have created 3D, brain-like, tissue to study the changes that occur after brain injury, as well as the changes in response to their treatment.

For this activity, you are going to build a device that will keep an egg from breaking. The egg represents the human head, and as you can see in the image below, there are some similarities. We can imagine the yolk is the brain, the egg white is the **cerebrospinal fluid**, which allows our brains to move without hitting our skulls, and finally the shell can represent our skull. You must design a device that will prevent it from breaking when you drop the egg in it!

Here's a presentation you can look through before getting started:

<https://prezi.com/view/kcEQijvKEBjBmcNCED3L/>



### Materials Needed:

You can use any materials you want but here are some suggestions:

- Cotton balls
- Tape
- Paper
- Cardboard
- Scissors
- And anything else you want! Be creative and innovative!

### Steps:

1. Design a device that can catch your egg without it breaking. We do not want any brain injuries!
2. Place several newspapers on the ground (just in case the egg cracks)
3. Place the device you made on the newspapers and stand several feet above it (stand on a stool if needed)
4. Drop your egg into the device and see if it is successful!

### Discussion Questions:

- Did your device work? Why or why not?
- How could you improve it?

- Can you think of any real life examples we use to protect our brains?
- What do Biomedical Engineers do if our brain gets injured? What do they do to prevent injury?

## Share Your Results

We'd love to know how the activity and/or the "do now" turned out! What worked and what didn't work? Please share with us something you learned and/or send us pictures! Email us at [stem@northeastern.edu](mailto:stem@northeastern.edu).

## Related links/Extensions

- [Crash Course on Bioengineering](#)
- [Why Bioengineering?](#) A look at possible careers and the industry
- [eGFI: Bioengineering](#)
- [News in Bioengineering](#)
- [TEDxYouth: Big Questions of Biomedical Engineering](#)
- Rah: [Day in Life of Bioengineer](#) | [Choosing Biomedical Engineering](#)