Careers in Science

Careers in Bioengineering

Bioengineering includes a variety of fields, such as biomedical engineering, cellular engineering, molecular engineering, and others. Bioengineers use engineering methods and biological science to design and manufacture equipment, computer systems, and new materials used in the field of biology.

Biomedical Engineering

Devices made by biomedical engineers include artificial joints and organs, prosthetics, corrective lenses, and dental implants. Biomedical engineers still use the engineering design process to help them develop and optimize medical technologies. In this field, engineers must always consider how a design will interact with the different systems of the human body.

FIGURE 12: Biomedical engineers design devices, such as prosthetic limbs. This prosthetic limb is designed to interpret messages from the user's nervous system.

A bionic hand, as shown in Figure 12, might interact with the nervous system to interpret signals to grasp an item. However, implanting such a device could cause a stress on the immune system, causing the body to reject the device. Biomedical engineers must consider all potential health risks when designing solutions.

Imagine that a company wants to develop prosthetics for competitive swimmers who have had one of their legs amputated at the knee. The company needs a working design within six months and wants each prosthetic to cost less than $30,000. The prosthetic must last a swimmer at least five years before any parts need to be replaced. How would an engineering team solve this problem?

First, the engineering team must define and delimit the problem. The constraints were given by the company: The design must cost less than $30,000; it needs to be completed in half a year; and all components need to last at least five years. The criteria for this problem may include weight, hydrodynamics in the water, and safety of use.

Once the problem is defined, engineers will begin brainstorming possible designs. Each proposed design will be evaluated, and the solutions that meet all constraints and the most important criteria will be chosen for testing. When developing prosthetics, engineers may run computer simulations and use other types of models to help evaluate each solution. The team may realize that traditional prosthetic materials are too heavy to be used for an aquatic prosthetic. Instead, they may research more lightweight materials.

The engineering team will then begin testing and optimizing their designs. They will build prototypes and may even fit their prototype to swimmers to get feedback and data on the design. At this stage, engineers may realize their design generates too much drag in the water and needs to be redesigned to be more streamlined.

Even when the client approves a solution, engineering teams may continue to review designs and make improvements. As technology changes, there are new opportunities for improved design concepts.

Working with a team, develop your own design of an aquatic prosthetic leg. Imagine you are working with the same constraints outlined in this example. With your group:

Define and delimit the problem In your group, outline the criteria and constraints and then clearly define the problem.

Design a solution Each individual in your group should propose a potential solution. Assign weights to the criteria your group outlined, and make a decision matrix to evaluate each design. Choose the highest-rated design, or brainstorm additional ideas until you find a solution that solves the problem your group outlined. Remember, you may need to redefine the problem if the design solutions do not meet the criteria or constraints. When your final design has been chosen, make a model, such as a drawing, of that design and have your teacher approve it before moving to the next stage of the process.

Develop a prototype Using common household and classroom items, develop a prototype of your approved design. You may use items such as paper towel rolls, PVC tubing, cardboard, tape, and any other items you may need. Remember, a prototype does not need to be a replica of the final product. Your prototype may not be made to scale or it may not be waterproof. The prototype should be able to demonstrate how the design will work, but it does not need to function completely.

Optimize the design After building your prototype, review your design and identify areas where the design could be improved. Review the criteria and constraints again to ensure your design is solving the problem. If you feel your design did not work, brainstorm new designs or ways to change aspects of your designs. You may wish to build an additional prototype to test your modifications.

Language Arts Connection With your group, research other designs for prosthetics that help people swim. Then, make a presentation to share with the class. In your presentation:

- Include a summary of your research and the prosthetic designs you discovered.
- Present a diagram of your final design to the class.
- Explain the most important criteria considered in designing your solution.
- Finally, present your prototype and explain how your design will solve the problem.

Cellular Engineering

Cellular engineering is a field of bioengineering that combines an understanding of cellular functions, biological systems, and engineering practices to develop technologies that help improve people's lives. For example, cellular engineers may study ways that stem cells can be used to improve the lives of people with medical conditions, such as Parkinson's disease or diabetes.

Tissue engineering uses aspects of cellular engineering to develop biological tissues. Whole tissues or portions of tissues can be made from cells and then used to repair damaged areas of the body. Scientists in this field are even trying to make entire organs using their understanding of cellular function, engineering, and biological systems.

FIGURE 13: Bioengineers develop technologies, like MRI machines, to help scientists learn more about living systems.

Molecular Engineering

Molecular engineering is a highly integrated field of study combining knowledge from biology, chemistry, mechanics, and materials science. Molecular engineers study ways to build better materials and systems by studying the molecular properties of those materials.

In the field of biology, molecular engineers are studying immunotherapy. Immunotherapy is the treatment of disease by amplifying or minimizing the body's immune response. Molecular engineers are developing vaccines to increase patients' immune responses.

Molecular engineers also are researching ways to edit and manipulate an organism's genetic material. This may allow them to treat or cure genetic disorders, modify metabolic rates, and modify the structure of proteins to make new functions. To make changes to the genetic material of an organism, molecular engineers are developing new technologies to help further their research.

Language Arts Connection Write a short newspaper-style article comparing and contrasting the different fields of bioengineering.

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