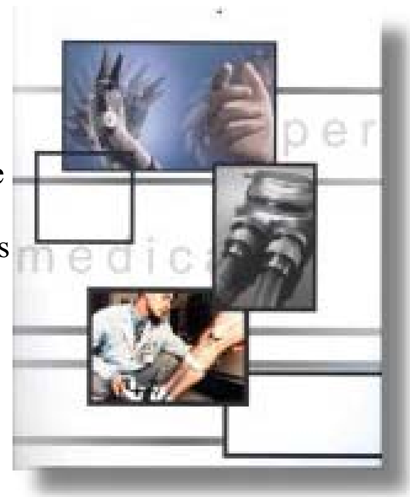
ACHIEVEMENT #9:

Bioengineering

Teacher's Guide

Introduction



In Bioengineering, engineering knowledge combines with scientific discovery. The result is a better, healthier quality of life for all of us.

The human body is the world's most complex machine. It is an intricate network of mechanics linked to a central super computer. Bioengineers have solved some of the body's greatest mysteries. Like good detectives they study, research and use state of the art materials to create artificial hearts and limbs. Working with new arms, hands, or legs, people can live normal lives, including all kinds of sports, from basketball to snowboarding.

When microchips were first developed, engineers wondered how many ways they could use them to help people. Soon they became the brains in the sensors of crib alarm systems, and the eyes and ears of intensive care units. They have made hearing aids nearly invisible. Engineers use computers to design and manufacture artificial limbs and joints that fit better – which means that injured and disabled people are more comfortable and have greater mobility.

Doctors have asked engineers to help them design machines that will diagnose diseases and other health problems -- and machines that will help them perform surgery and provide cures. By paying close attention to the clues in science, engineers have extended the average life span by 30 years.

Lesson Focus: Ergonomics

Lesson Synopsis: Students perform an ergonomic analysis of their use of computer workstations in the school and compare the traction of various types of shoes on different surfaces using spring scales. They also evaluate the design of school computer workstations.

Teacher's Guide (Continued)

Related National Science Education Standards:

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop Abilities of Technological Design, including the ability to Evaluate Completed Technological Designs and Products. As a result of activities in grades 5-8, all students should develop:

- Understandings About Science and Technology.

Fundamental concepts and principles that underlie this standard include:

- Scientists propose explanations for questions about the natural world, and Engineers propose solutions relating to human problems, needs, and aspirations.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, other constraints limit choices in the design, for example, human safety.

Related Benchmarks from Benchmarks for Science Literacy:

Section 3A (Technology and Science):

By the end of 8th grade, students should know that:

- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems, but they usually have to take human values and limitations into account as well.

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

- Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
- Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

By the end of 8th grade, students should know that:

- Technology … is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.

Section 12C (Manipulation and Observation):

By the end of 8th grade, students should be able to:

- Read analog and digital meters on instruments used to make direct measurements… and choose appropriate units fro reporting various magnitudes.

Related Standards for Technological Literacy:

Standard 9 (Engineering Design):

In order to comprehend engineering design, students in grades 6-8 should learn that:

- Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Teacher's Guide (Continued)

Glossary:

bioengineering A term that is used in several different ways:

1. The use of engineering principles of analysis and design to solve problems in medicine and biology. This broad use of the term includes both **biotechnology** (see definition 2) and **biomedical engineering**.
2. The use of recombinant DNA or other specific molecular gene transfer or exchange techniques to add desirable traits to plants, animals, or other organisms, or to enhance biological processes. (Also referred to as **biotechnology** and genetic engineering.)
3. A method of construction using living plants, or plants in combination with dead or inorganic materials. The practice brings together biological, ecological, and engineering concepts to produce living, functioning systems to prevent erosion, to control sedimentation, and/or to provide habitat.

biomedical engineering Application of engineering to solve problems in medicine and biology, including cell and tissue engineering and the development of artificial organs. As broadly used, it includes **biomechanical engineering** (see definition below).

biomechanical engineering Basic and applied studies on biomechanics, development of mechanical prostheses for medical and dental use, and development of mechanical equipment for medical and dental use.

ergonomic design The application of knowledge about human abilities, human limitations, and human characteristics to the design of products, tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.

newton (N) The newton is the SI unit of force. One newton is the force required to give a mass of 1 kilogram an acceleration of 1 meter per second per second. It is named after the English mathematician and physicist Sir Isaac Newton (1642-1727). **Spring scales are often marked in grams (actually "grams of force"), force should be recorded in newtons. To convert from grams to newtons, multiply by 0.0098.**

traction Resistance to lateral movement between two surfaces that are in contact with one another. Slipperiness is the result of too little traction.

Important Concepts:

- Bioengineering is the application of engineering to the solution of problems in biology and medicine.
- The field of ergonomics applies knowledge about human abilities, human limitations, and human characteristics to the design of products, tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.

Materials for Each Inquiry Team:

- Shoes with different types of soles
- Variety of test surfaces
- 2000 g (2.5 lb) Pull-type spring scale (available from educational supply companies)

Materials of the Entire Class to Share:

- Zippered plastic bags
- Sand or aquarium rocks

Safety Precautions: Remind students, as appropriate, of basic rules for the use of tools and the conducting of inquiry.

Procedure:

Engagement:

If you have not already shown the video, you may wish to do so at this time. Have students brainstorm definitions of the term bioengineering.

Exploration:

Have students do the activity **"How Slip Resistant are Your Shoes?"** Have students place a weighted bag of sand or gravel in each shoe so that the total weight is between 1 and 2 pounds (500-1000g).

Explanation and Extension:

Have students read and discuss the handout and timeline and evaluate the design of the school's computer workstations.

Evaluation:

Have students examine the definitions they created at the beginning of the lesson and modify them based on what they have learned.

Ideas for Further Exploration:

- Have students continue their use of Pull Meters to explore the effectiveness of shoe treads and tire treads in increasing traction.
- Have students use the Pull Meters to explore the effectiveness of lubricants and special materials in reducing friction.
- Have students research the issue of whether student backpacks are ergonomically suitable for use as book bags.

References:

- **12 Tips for an Ergonomic Computer Workstation**, available online at: http://ergo.human.cornell.edu/dea651/dea6512k/ergo12tips.html

ACHIEVEMENT #9:

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Student Handout

How Slip-Resistant are Your Shoes?

Slips and falls are a common cause of injury, accounting for about 20% of injuries. To reduce the chances of slips, building planners may incorporate special slip-resistant surfaces in hallways and on walkways. In some workplaces where slippery surfaces cannot always be avoided, workers may be encouraged to wear slip-resistant shoes. I 1953, the Department of Commerce proposed the a surface can be called "slip resistant" if it takes at least a force of 0.5 pounds to begin to drag a 1-pound weight across the surface. The US Patent Office has issued over 50 patents for slip-resistance testing devices since 1985. One of the simplest testing devices is called a Horizontal Pull-Meter and consists of a 50-pound block attached to a scale that can read forces up to 80 pounds.

The design of shoe soles considers the amount of traction the wearer is likely to need under typical wear conditions. Let's use a simple version of the Pull-Meter to compare how different shoes perform on different surfaces. Since we will be using shoes instead of a 50-pound block, we will use a smaller scale and record our measurements in ounces or grams, instead of in pounds.

Materials for Each Inquiry Team:

- Shoes with different types of soles
- 2000 g (2.5 lb) Pull-type spring scale
- Variety of test surfaces

Materials of the Entire Class to Share:

- Zippered plastic bags
- Sand or aquarium rocks

Procedure:

1. Use the plastic bags and sand to add weight to each shoe until all the shoes you are testing weigh the same amount using the large spring scale. Record that weight in ounces or in grams.
2. To test a shoe, place it on a surface, attach the scale and gently begin to pull parallel to the surface.
3. Record the force required to just begin to move the shoe across the surface, using the same unit used for weighing the shoe.
4. As time allows, explore different surfaces.

What is Bioengineering and what does it have to do with slip resistance?

Since “bio” refers to “life”, **bioengineering** can be broadly defined as the application of engineering to the solution of problems in biology and medicine. What kinds of products are the result of bioengineering?

The video and the timeline on the next page emphasize that part of bioengineering that is concerned with developing medical testing equipment or artificial organs and joints, and cell and tissue engineering. This is sometimes called **biomedical engineering**.

The broad field of bioengineering also includes **genetic engineering** (also called biotechnology). Genetic engineering has led to the transfer of genes between species, creating plants and animals with new characteristics and allowing the mass production of useful proteins.

Finally, bioengineering can be defined to include **ergonomic** engineering, which is “the application of knowledge about human abilities, human limitations, and human characteristics to the design of products, tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.” So, using the broadest definition, someone trying to develop slip-resistant shoes or slip-resistant floor surfaces would be a **bioengineer**, along with people who develop artificial limbs, medical equipment, and much more.

Many of the achievements in bioengineering are the consequence of creative people being able to think of new ways to apply technology originally developed for another application.

An Ergonomic Analysis of Computer Workstations

The principles of ergonomics are being applied to the design of safe work environments.
In factories, machinery is being redesigned to increase worker safety and productivity.

In many businesses today, workers primarily work at a computer, often for long periods of time. Some of these workers develop back strain, eyestrain, and sometimes even more serious problems such as carpel tunnel syndrome, a condition that may require surgery. To reduce the frequency of these health problems, design engineers are designing computer monitors, workstations, and desk chairs based on knowledge of how the human body works.

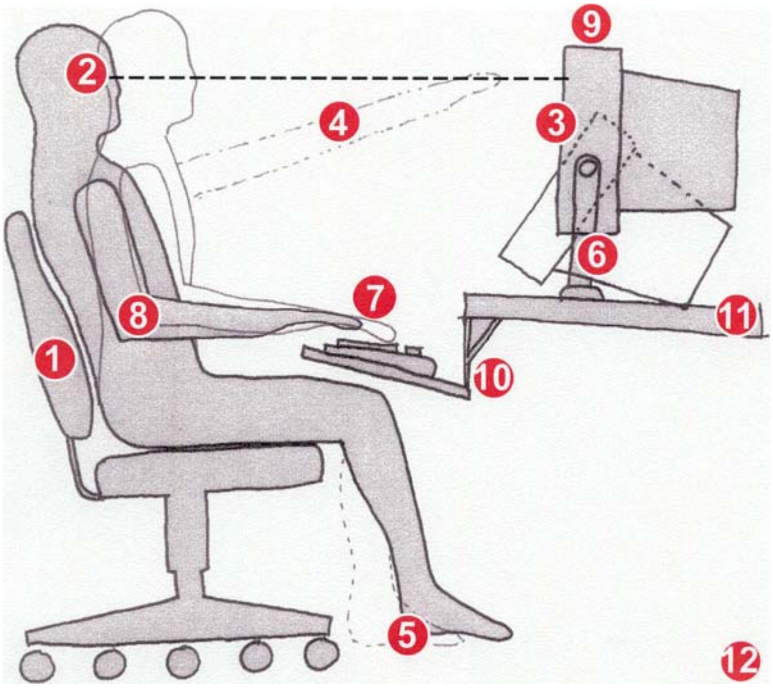
The handout **10 Tips for an Ergonomic Computer Workstation** is based on ergonomics research and can be used to either set up or evaluate computer workstations. Use it to evaluate the workstations in your school and to make recommendations for improvement.

Student Handout (continued)

Timeline of Important Events Related to Achievement #9:

1895	Roentgen takes an X-ray of his wife's hand.
1903	Dutch physiologist develops the electrocardiograph.
1932	Heart defibrillator developed.
1942	First metallic hip replacement.
1945	Artificial kidney machine developed.
1950s	Development of artificial heart valves.
1950s	Industrial ergonomics, design of industrial machinery to consider human efficiency, health, and safety, emerges as a field of study.
1953	First successful application of a heart-lung machine.
1954	First human kidney transplant.
1956	Plastic contact lenses developed.
1957	First externally worn, battery-powered pacemaker developed.
1960	First totally implanted pacemaker.
1973	CAT scan developed, based on technology developed to computer-enhance pictures of the moon for the Apollo program.
1974	Paper on "Traction in Football Shoes Under Dynamic Loading" presented at the 27th Annual Conference of Engineering in Medicine and Biology.
1982	First permanent artificial heart, designed by Robert Jarvik, implanted.
1985	Soft bifocal contact lenses developed.
1985	Development of implantable ventricular defibrillator.
1998	First human use of a Ventricular Assist Device, based on NASA aerospace engine pump design.
1999	Artificial hand that enables the user to have finger control developed.

10 Tips for an Ergonomic Computer Workstation:



1. Use a good adjustable chair and sit back.

Your upper and lower back should be well supported by the chair.

2. Have the top of monitor 2-3" above your eyes.

Your eyes should be in line with a point on the screen that is 2 to 3 inches below the top of the monitor. If the monitor is above or below this height, your neck will be raised or lowered and the result may be neck pain.

3. There should be no glare on the screen.

4. Sit at arm's length.

The monitor should be at a comfortable distance for viewing, which is usually around arm's length (sit back, raise your arm, and your fingers should touch the screen).

5. Keep your feet on the floor or on a footrest.

Chair height should be set so that the chair seat does not compress the back of the knees.

6. Use a document holder.

7. Keep wrists flat and straight (level with forearms). (See also number 10)

8. Keep arms and elbows close to body.

9. Center the monitor and keyboard in front of you.

10. Use a "negative tilt" downward sloping keyboard tray.

Desktop keyboards and those placed on conventional keyboard trays (those that slope up) do not fully allow the elbows and wrists to remain in a neutral posture (elbows close to the body and wrists level with the forearms).