See how this **example filled-in lesson template** looks on the TeachEngineering website:
http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_biomed/cub_biomed_lesson10.xml

Bone Fractures and Engineering (lesson)

Subject Areas biology, life science, science & technology

Associated Unit Biomedical Engineering and the Human Body

Lesson Title Bone Fractures and Engineering

Header Insert Image 1 here

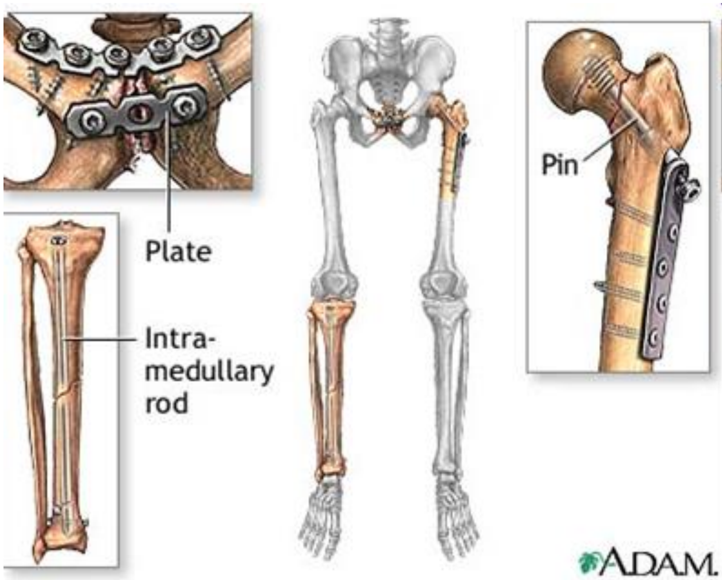


Image 1

Image file: cub_biomed_lesson10_image1web.jpg

ADA Description: Drawing shows a human skeleton of pelvis, legs and feet with three locations containing bone repair using a pin, plate and intramedullary rod.

Source/Rights: Medline Plus Medical Encyclopedia, US National Library of Medicine, National Institutes of Health http://www.nlm.nih.gov/medlineplus/ency/presentations/100077_3.htm

Caption: Engineers design the pins, plates, rods and screws used to repair bone fractures.

Grade Level 10 (9-12)

Lesson # 10 of 10

Lesson Dependency None

Time Required 20 minutes

Summary

Students learn about the role engineers and engineering play in repairing severe bone fractures. They acquire knowledge about the design and development of implant rods, pins, plates, screws and bone grafts. They learn about materials science, biocompatibility and minimally-invasive surgery.

Engineering Connection

Biomedical engineers and material science engineers create devices that doctors use to repair severe bone fractures. Biomedical engineers design devices that work well with the body, and can be implemented with relatively little pain for the patient and with relative ease by a doctor or surgeon. Materials science engineers create and design materials that are accepted by the body and have properties similar to bone and other human tissues.

Engineering Category = #1: Relating science and/or math concept(s) to engineering

Keywords

bio, biocompatible, biocompatibility, biomedical engineer, bone, break, broken bone, cast, design, doctor, fracture, materials science, medical, repair

Educational Standards

Next Generation Science Standards: Science [2013] = S2454606

Engineering Design… (Grades 9 - 12); Students who demonstrate understanding can: (Grades 9 - 12)
Current Standard: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (Grades 9 - 12)

Next Generation Science Standards: Science [2013] = S2454608

Engineering Design… (Grades 9 - 12); Students who demonstrate understanding can: (Grades 9 - 12)
Current Standard: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (Grades 9 - 12)

ITEEA 2000, grades 9-12, 19.M: = S114179E

Standard 19. Students will develop an understanding of and be able to select and use medical technologies. In order to select, use, and understand medical technologies, students should learn that:
M. Materials have different qualities and may be classified as natural, synthetic, or mixed.

ITEEA 2000, grades 9-12, 14.K: = S11417FC

Standard 14. Students will develop an understanding of and be able to select and use medical technologies. In order to select, use, and understand medical technologies, students should learn that:
K. Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.

Colorado science 2009, grades 9-12: 2.6.a: = S1142520

Standard: 2. Life Science
6. Cells, tissues, organs, and organ systems maintain relatively stable internal environments, even in the face of changing external environments
a. Discuss how two or more body systems interact to promote health for the whole organism

Pre-Requisite Knowledge

A basic understanding of bones, how they work and what they are made of. See the Our Amazing Skeleton lesson.

Learning Objectives

After this lesson, students should be able to:

- Describe how engineers aid doctors in repairing severe bone fractures.
- Describe two factors that engineers must consider when designing devices to help heal fractured bones.

Introduction / Motivation

(Have ready to show to the class the attached Bone Repair and Biomedical Engineering PowerPoint presentation, which contains information, explanations, drawings, photographs and examples of the subject matter covered in the Lesson Background & Concepts for Teachers section. Follow-up with a quiz, as described in the Assessment section.)

How many of you have had a broken bone? Or, know someone who has? What did the doctor do to fix it? (Expect "Put a cast on it" to be a common answer.) Do any of you know of other steps doctors take to fix more serious breaks? (Take suggestions from students.) That's correct, doctors use rods, pins, plates and screws to help repair broken bones. Do you think doctors design, create and use pins, plates and rods by themselves? Biomechanical engineers and materials science engineers help doctors develop and design bone-fixing devices. These engineers play important roles in making sure the materials will be accepted by the body and not lead to other complications. They design special surgical stainless steel, titanium alloys and polymers especially for medical implants. They also make sure that the devices can be inserted in a way that supports the body in repairing the bone, and not weaken it.

Engineers must consider many things when designing devices to repair broken bones. Some important things to consider are:

- Is it strong?
- Is it minimally invasive?
- Is it biocompatible?
- Is it inexpensive?
- Is it easy to implement?

Engineers want devices to be strong enough to support the body, match the properties of bone well, and not be rejected by the body. Doctors desire devices that are easy to implant, inexpensive, and minimally invasive for the patient. All of these factors have been considered and have influenced current bone repair devices and techniques. Next, let's learn more about how engineers aid doctors in repairing serious bone fractures.

(Show the class the attached Bone Repair and Biomedical Engineering PowerPoint presentation, and follow-up with a quiz as described in the Assessment section. Then conduct the associated activity)

Lesson Background & Concepts for Teachers

Typical Breaks

When a bone breaks it immediately begins to heal itself. When minor fractures occur, doctors cast the broken region so it will not move while healing. Figure 1 illustrates the steps of this healing process. Problems occur, however, when bones are not able to heal correctly on their own. In these cases, doctors and engineers are needed.

IMAGE Insert Figure 1 here

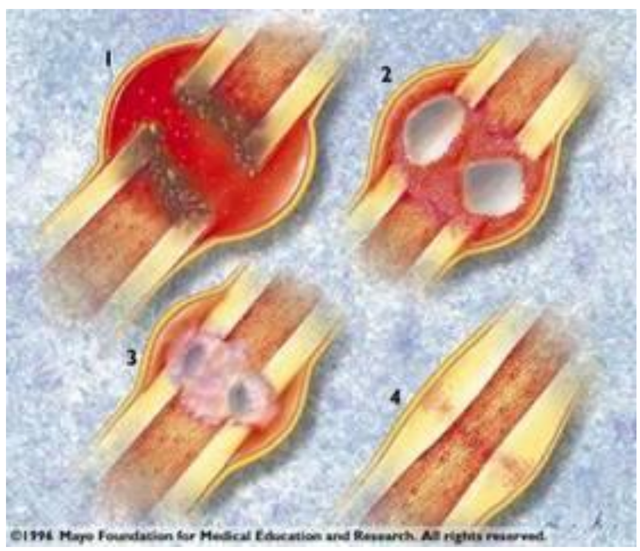
Figure 1

Image file: cub_biomed_lesson10_figure1web.jpg

ADA Description: Four cut-away drawings show a broken bone that morphs into a bridged and then fully-healed bone.

Source/Rights: My Health http://www.myhealth.gov.my/myhealth/eng/dewasa_content.jsp?lang=dewasa&sub=0&bhs=eng&storyid=1144234963517

Caption: Figure 1. After a bone fracture, 1) within minutes, blood clots form and inflammation occurs, 2) within two days to two weeks, soft bridging bone forms, 3) within two to six weeks, hard bridging bone forms, 4) and full union takes place within three to six months.



Bone Repair

(See the attached Bone Repair and Biomedical Engineering PowerPoint presentation.) When severe fractures occur, doctors and engineers help the body repair broken bones for certain reasons:

- To restore function and position
- Likely not to heal correctly
- A high risk of infection
- A very long healing time

The two categories of bone repair are internal and external fixation. Internal fixation is temporary or permanent fixtures directly attached to the bone under the skin, for alignment and support. Internal fixation includes pins, rods, plates, screws, wires and bone grafting.

External fixation is temporary repair supports outside of the skin that stabilizes and aligns bone while the body heals. External fixation includes screws in the bone to hold it in place, and metal braces or casts; these can be externally adjusted.

Internal fixation is recognized for providing increased patient mobility and quicker healing time.

Materials Engineering

Materials science engineers play important roles in designing devices and technologies to help heal fractured bones; they continually seek and concoct materials that closely match bone properties and are biocompatible. This is challenging! Bone is incredibly strong while also being fairly flexible, while most strong materials are brittle and unable to flex like bone.

Commonly used implant material for orthopedic devices include surgical stainless steel, titanium alloys and polymers. Stainless steels are made from nickel, chrome and molybdenum, combined into endless combinations for characteristics that are desired for different applications (strength, flexibility, biocompatibility, etc.). While the “surgical” versions are designed to be easy to sterilize, strong, and corrosion-resistant, sometimes the human immune system reacts to the nickel component. Titanium is a reactive metal and its surface quickly oxidizes upon exposure to air, which provides an excellent surface on which bone grows and strongly adheres. Advances are being made in the uses of polymers that are designed to degrade in the body. Sometimes a fractured bone that is supported by a steel plate can be re-fractured, damaged, or opened to risk of infection upon removal of the device. But, the same device made of a polymer can be engineered to degrade at a rate that slowly transfers load to the healing bone and does not require another surgical procedure to remove.

Vocabulary / Definitions

Word	Definition
biocompatibility	A characteristic of some materials that when they are inserted into the body do not produce a significant rejection or immune response.
biomedical engineer	A person who blends traditional engineering techniques with the biological sciences and medicine to improve the quality of human health and life. Biomedical engineers design medical devices and implants, artificial body parts, surgical and diagnostic tools, and medical treatment methods.
bone graft	Bone taken from a patient during surgery or a bone substitute that is used to take the place of removed bone or to fill a bony defect.
external fixation	The process of installing temporary repair supports outside of the skin to stabilize and align bone while the body heals. Examples: screws in bone, metal braces, casts, slings.
fracture	An injury to a bone in which the tissue of the bone is broken.

internal fixation	The process of fastening together pieces of bone in a fixed position for alignment and support, using pins, rods, plates, screws, wires, grafting, and other devices, all under the skin. Can be temporary or permanent fixtures.
intramedullary rod	A medical device inserted into the bone marrow canal in the center of the long bones, such as femur or tibia.
materials science engineer	A person who studies the characteristics (composition, structure, behavior) and processing of materials for purposes of their use in science, engineering and technology. This includes the study and design of metallic, ceramic, polymeric and composite materials. Also called materials engineer.
orthopedist	A bone doctor.

Associated Activities

Repairing Broken Bones — Students investigate the processes that biomedical engineers use to aid doctors in repairing severely broken bones by designing, creating and testing their own prototype devices to repair broken turkey bones.

Lesson Closure

What are some of the current devices and techniques designed by engineers to help doctors repair severely broken bones? (Answer: Pins, rods, plates, screws, wires, bone grafting, metal braces, casts, slings.) Which of these are used temporarily? Which might be used permanently? What's a difference between internal and external fixation? (Answer: Repair work that is attached directly to the bone [under the skin] is internal fixation; repair supports outside of the skin are external fixation.)

While the current technology for bone repair has greatly increased the number of bones that are successfully healed each year, much improvement can still be made. Young engineers (like you!) still have work to do. As you saw in the presentation, some surgeries are intense and invasive, and can result in patients being in hospital for long periods of time.

What things might engineers take into consideration when designing devices to help heal fractured bones? (Answer: Strength, minimally invasive, biocompatibility, expense, ease of implementation.) Engineers play important roles in making sure the materials are accepted by the body, and that the devices can be inserted safely into the body. A commonly-used material, titanium alloy, is as strong but not as flexible as bone. Do you think engineers can still improve the implementation and materials used in bone repair?

Assessment

Pre-Lesson Assessment

Discussion Questions: Solicit, integrate and summarize student responses. Have students discuss the following questions together in small groups.

- Do you know anyone who has a rod, pin or plate in their body?
- Why do you think people need to have these devices put into their body?
- How do these things help people?
- What types of things do you think are considered in the making of rods, pins, plates and screws that are inserted into the body?
- Who do you think designs these types of devices?

Post-Introduction Assessment

Quiz: After completion of the Bone Repair and Biomedical Engineering PowerPoint presentation in the Introduction/Motivation portion of the lesson, have students complete the attached Bones Quiz.

Lesson Summary Assessment

Device Design & Presentation: Have students imagine they are biomedical and materials science engineers. Challenge groups of 3-4 students to design on paper their own devices to repair fractured tibiae (shinbones). Then have the teams present their designs to the class. Ask the groups to consider the following in their design:

- From what material is your device made?
- How does it support the body?
- Is it easily implanted?
- Would it be inexpensive?
- Do you think the body would accept it? (Is it biocompatible?)

Lesson Extension Activities

None

Additional Multimedia Support

Refer to an excellent four-part bone fracture repair series that includes drawings and summary explanation of the devices and surgical procedures involved in fracture repair. See the MedlinePlus Medical Encyclopedia website at http://www.nlm.nih.gov/medlineplus/ency/presentations/100077_4.htm.

References

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Attachments

Bone Repair and Biomedical Engineering (ppt)
Bone Repair and Biomedical Engineering (pdf)
Bones Quiz (doc)
Bones Quiz (pdf)
Bones Quiz Answers (doc)
Bones Quiz Answers (pdf)

Other

None

Redirect URL

None

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Key: Yellow highlight = required component