Repairing Broken Bones (activity)

Subject Areas	biology, life sciences, science & technology
Associated Unit	Biomedical Engineering and the Human Body
Associated Lesson	Bone Fractures and Engineering
Activity Title	Repairing Broken Bones
Header	Insert image 1 here, right justified so text wraps around it

Image 1

ADA Description: Cutaway medical illustration shows repaired fibula and tibia with plate and screws, and intramedullary rod and screws.

Caption: Devices such as plates, screws and rods are designed by engineers for doctors to surgically implant to help mend severely fractured bones.

Image file name: cub_biomed_lesson10_activity1_image1web.jpg

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Grade Level	10 (9-12)
Activity Dependency	None
Time Required	300 minutes
Time Required Note	Students' in-depth engineering design and build projects require multiple 60-minute periods to complete; suggest 60 minutes on five different days
Group Size	3
Expendable Cost per Group	US$5

Summary
Students learn about how biomedical engineers aid doctors in repairing severely broken bones. They learn about using pins, plates, rods and screws to repair fractures. They do this by designing, creating and testing their own prototype devices to repair broken turkey bones.

Engineering Connection
Biomedical and materials engineers create devices that doctors use to repair severe bone fractures. Materials engineers develop biocompatible materials that integrated into the body easily. Biomedical engineers use these materials to design pins, plates, rods and screws that can be used to help support and repair broken bones.

Educational Category = #2

1. relates science and/or math concept(s) to engineering
2. provides engineering analysis or partial design
3. provides complete engineering design process

Keywords

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

Educational Standards

Colorado Science [2009]: none

Colorado: Math [2009]: **2.6.a**

Standard: 2. Patterns, Functions, and Algebraic Structures *(Grades PreK - 12)*

6. Quantitative relationships in the real world can be modeled and solved using functions *(Grades 9 - 12)*

a. Represent, solve, and interpret problems in various contexts using linear, quadratic, and exponential functions *(Grades 9 - 12)*

ITEA educational standard(s) [2000]: **Abilities for a Technical World 11.O**

International Technology Education Association-ITEA STL Standards Technology (Grades 9 - 12)

Abilities for a Technological World *(Grades K - 12)*

Standard 11. Students will develop abilities to apply the design process. *(Grades K - 12)*

As part of learning how to apply design processes, students should learn that: *(Grades K - 12)*

O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. *(Grades 9 - 12)*

ITEA educational standard(s) [2000]: **The Designed World 14.K**

International Technology Education Association-ITEA STL Standards Technology (Grades 9 - 12)

The Designed World *(Grades K - 12)*

Standard 14. Students will develop an understanding of and be able to select and use medical technologies. *(Grades K - 12)*

In order to select, use, and understand medical technologies, students should learn that: *(Grades K - 12)*

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.*(Grades 9 - 12)*

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 activity, students should be able to:

- Describe how engineers aid doctors in repairing severe bone fractures.
- Create prototype devices to aid in the healing of bone fractures and test them for strength.
- Evaluate the strengths and weaknesses of a prototype medical device based on model testing.

Materials List

For the teacher's introductory presentation:

- Bone Repair Challenge (ppt)
- computer and LCD projector to show a PowerPoint presentation (or make overhead transparencies of the PPT file and use an overhead projector)

Each group needs:

- 1 turkey femur (drumstick)
- safety glasses or goggles, one per student
- other supplies, depending on group design (see below)

- Repairing Broken Bones Design Worksheet, one per person

For the entire class to share:
[Note: These supplies depend on student designs, so you could wait to purchase them after designs are finalized.]

- ~1 yard (~1 m), half-inch diameter steel or aluminum rod
- ~20 metal screws (suggestion: 10 half-inch long plus 10 one-inch long)
- epoxy
- metal strip (sold in coils at hardware stores, usually with plumbing supplies; already has screw holes in it)
- 1-2 extra turkey bones
- other materials or supplies that students include in their designs

Suggested tools:
[Use any of these items that are accessible; a machine shop may have some items]

- drill (a drill press is preferred, but a hand drill is okay)
- hack saw
- screw driver
- (optional) tile drill bit (makes drilling into bone easier and less likely to crack)

Introduction / Motivation

(Have ready to show to the class the attached Bone Repair Challenge PowerPoint presentation.)

Who has ever broken a bone? How did you repair it? When a bone breaks, it immediately begins healing itself. Usually, a doctor can assist a minor bone fracture by "immobilizing" the broken region with a cast or a sling to minimize its movement while healing. However, when severe fractures occur, sometimes more intense measures must be taken. For severe fractures, doctors must consider the risk of infection, the length of time needed to heal the break, and how to best heal the bone correctly to restore function and mobility.

For severe fractures, biomedical and materials engineers assist doctors by developing various devices used to help heal bones. Two categories of bone repair are internal and external fixation. Internal fixation is a temporary or permanent fixture that directly attaches to the bone under the skin for alignment and support. These include pins, rods, plates, screws, wires and bone grafting. External fixation is a temporary repair support outside of the skin that stabilizes and aligns the bone while the body heals. These devices include screws, metal braces and casts. External fixation devices can be adjusted outside of the bone. In some cases, internal fixation methods are chosen because they can provide increased patient mobility and quicker healing time.

Biomedical and materials engineers must consider the strength and biocompatibility of the device as well as ease of implantation and minimal invasiveness for the patient. Over the next few class periods, we will break turkey femurs and then work in groups to engineer ways to repair the bones. Let's see if you can make the bone stronger than before it was broken!

(Show the class the attached Bone Repair Challenge PowerPoint presentation to introduce or review the kinds of broken bones and the current medical internal fixation approaches to repair them [pins, rods, plates, screws, etc.]. The presentation includes medical illustration and x-ray examples, and concludes with the activity design challenge on one slide.)

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.
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.
prototype	An original, full-scale, and usually working model of a new product, or new version of an existing product.

Procedure

Background

These are suggested procedures, which you may need to alter, depending on the availability of equipment and tools.

Before the Activity

- Purchase enough turkey drumsticks to equal to the number of groups plus one or two extras, the bigger the bones the better. Ask if a butcher or meat plant might donate them. Eat the turkey or remove the meat from the bones.
- To make the turkey femurs as clean as possible, boil them and remove any remaining meat and other tissue. If necessary, soak the bones in a solution of 90% warm water and 10% bleach or ammonia to make cleaning them easier.
- Let the bones dry for ~24 hrs.
- Gather materials and make copies of the Repairing Broken Bones Design Worksheet, one per person.

Day 1: Bone Breaking

1. Divide the class into groups of three students each.
2. Break the turkey femurs, keeping track of the maximum weight each bone could bear before breaking. Two suggested methods:
    - Use a stress tester, such as an Instron universal testing machine, to break bone from the side and/or from compression. Universities often have stress testing equipment.
    - Bridge a bone across two desk edges and hang enough weight from the center of the bone until it breaks. Expect a turkey femur to bear up to 200 lbs (91 kg), depending on its size. (This approach is described in more detail as part of the Sticks and Stones Will Break That Bone! activity.)

Days 2-4: Bone Repair

1. Challenge teams to design and build repairs for their fractured bones. Encourage them to try to make the bone even stronger than before. Have students follow along with the design worksheet during this process.
2. Have students carefully examine the extent and nature of the bone fracture(s), and brainstorm possible ways to repair their broken turkey bones.

3. Have students draw two or three engineering designs (sketches) to repair bone. Make sure they label the parts and materials that they intend to use in each prototype design.
4. Have students choose their best design and present it to the class. Require presentations to include reasons for their design choices, and engineering advantages and disadvantages (and other factors, as described in the Assessment section). Encourage the rest of the students to provide constructive feedback and suggestions.

Image Insert Image 2 here, right justified so text wraps around it

Image 2

ADA Description: Photo shows two students holding and taping a six-inch bone.

Caption: Students work together to repair a broken turkey bone.

Image file name: cub_biomed_lesson10_activity1_image2web.jpg

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5. Direct students to begin fixing their bone, as designed. Encourage careful work, bones can be brittle and are not replaceable.
6. Have students present their final prototype "products" to the class again. In these presentations, have them explain what steps they took as well as what they would improve upon.

Image Insert Image 3 here, left justified so text wraps around it

Image 3

ADA Description: Photo shows a long bone clamped into a metal base with an overhead device pushing down on it. The bone has a metal strip and screws attached lengthwise to and along the bone.

Caption: Using an Instron universal testing machine to test the strength of a repaired turkey bone.

Image file name: cub_biomed_lesson10_activity1_image3web.jpg

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Day 5: Bone Testing

1. Have each group predict the performance of their repaired bone.
2. Break each reinforced bone using the same method used before.
3. Have students record how well their bone resisted the weight compared to its unbroken state. Record how much weight the reinforced bone withstood, and any other observations during the test. Have students complete their worksheets while others complete the stress testing.
4. When testing is complete, discuss and compare all results as a class.
5. Have students give final presentations, answering questions as described in the Assessment section.

Attachments

Bone Repair Challenge (ppt)
Bone Repair Challenge (pdf)
Repairing Broken Bones Design Worksheet (doc)
Repairing Broken Bones Design Worksheet (pdf)

Safety Issues

- Have students wear eye protection throughout the activity as bone fragments may splinter and fly.
- Provide proper training and safety measures when using any power tools.

Troubleshooting Tips

Experiment with bone breaking in advance of the activity to make sure your method works well.

Have on hand one or two extra bones in case students have problem when fixing their original bone or with which students can practice drilling.

Investigating Questions

None

Assessment

Pre-Activity Assessment

Brainstorming: In small groups, have students engage in open discussion. Remind them that no idea or suggestion is "silly." Respectfully listen to all ideas. Ask the students:

- What are different ways to reinforce a broken bone?

Activity Embedded Assessment

Design Presentations: After creating two or three design solutions for fixing the broken bone, have each group present their best design and answer the following questions:

1. How does the design support the weight and movement of the patient?
2. Is it minimally invasive (easy for a doctor to implant)? Why or why not?

3. Are the materials biocompatible?
4. Is it realistic?
5. What are the design strong points and weaknesses?
6. Which design did you choose? Why?

Post-Activity Assessment

Final Presentations and Project Reflection: After testing their devices, have students consider again the questions from the activity-embedded assessment, as well as the following:

7. How did your repair handle the load during testing?
8. Where on the bone did the repair fail? Why do you think it failed there?
9. How could you have improved your device?

Activity Extensions

Have students, individually or in groups, draw final designs based on what they learned from the testing and presentations.

Activity Scaling

- For lower grades, have students work on smaller bones, such as chicken wings. Or conduct the fourth-grade Sticks and Stones Will Break That Bone! activity, which includes a class demonstration to break a chicken bone by applying a load until it fails (fractures), followed by student teams acting as biomedical engineers, designing (on paper) their own splints or casts to help mend fractured bones.
- For lower grades, have students repair their bones solely with external fixation, such as bracing, casts or splints.

Additional Multimedia Support

None

References

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Other

None

Redirect URL

None

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Supporting Program