Break a Leg!

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Fields of Interest: Biology, Physiology, Medicine

Brief Overview: Mentees will be learning some basic information about the structure and function of bones, how they heal when broken, and how they work to produce movement.

Agenda:

- Introduction (5 min)
- Module 1: Build-a-Bone Workshop (15 min)
- Module 2: Messy Break~~up~~ (5-10 min)
- Module 3: The Bee's Knees (20-25 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- ➔ Bone
- ➔ Bone Marrow
- ➔ Hematoma
- ➔ Muscle
- ➔ Tendon
- ➔ Ligament

Background for Mentors

Module 1

- Bone
- Blood Vessels
- Bone Marrow
- Compact Bone
- Spongy Bone

Bone is a rigid part of the body that protects vital organs, produces important components of blood, and allows us to move. Bones also store minerals and provide structure to the body. They come in many different shapes and are mostly all connected together to form the skeleton.

Contrary to what people might believe, bones are not non-living or just made up of minerals, but contain a dense network of **blood vessels** and nerves. They can get hurt, heal, and grow just like any other part of the human body.

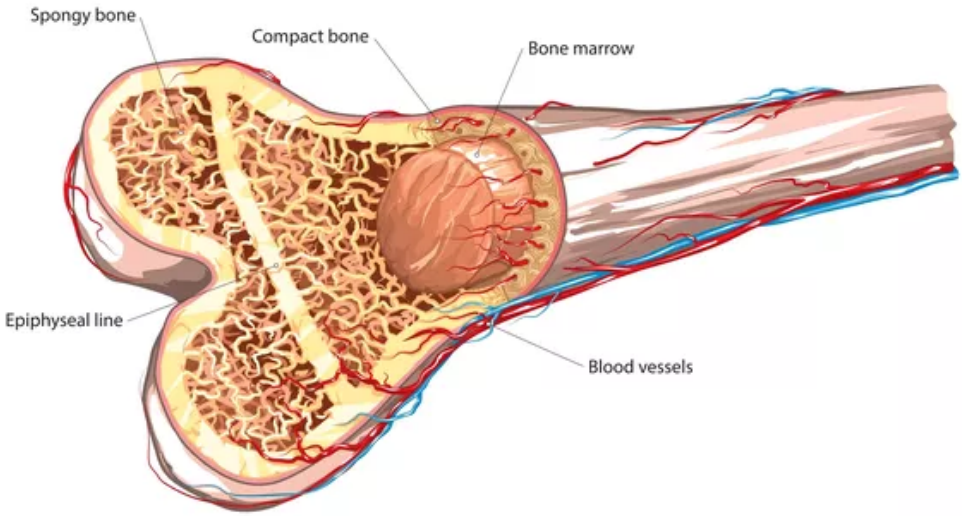


Figure 1: Diagram of bone

Large bones, like those found in the legs, hips, and ribs, contain **bone marrow**, a spongy, fatty tissue that produces red and white blood cells. Bone marrow produces about 500 billion blood cells per day to keep up with their high turnover rate.

Compact bone is the strong, dense bone that forms the outer layer of most bones. **Spongy bone** is porous bone that forms the interior and ends of bones. Both are required, as a skeleton made up of entirely compact bone would be too heavy, while one made up of entirely spongy bone would be too fragile.

Module 2

- Hematoma
- Osteoblast
- Cast/Splint
- Soft/Hard Callus
- Remodeling

When bones break, an intricate process begins to repair and restore them to their original structure. Because of the large quantity of blood vessels in bone, breaking the bone leads to a significant amount of bleeding. A **hematoma** is the large blood clot that forms around a fracture. The blood carries with it cells and other substances that start to heal the bone (platelets, stem cells, growth factors).

Osteoblasts are cells that produce bone matrix, made up of collagen and hydroxyapatite, to heal a fracture. During the healing process, osteoblasts form a **soft** and then **hard callus** of bone material around the site of the break. After the bone has been mostly healed(usually within a few months), it begins the process of **remodeling**, where osteoblasts work together with osteoclasts, which remove bone matrix, to slowly bring the bone back to its original shape. This remodeling process is also what allows bones to grow as we age and adapt to the increased stresses placed on them by exercise.

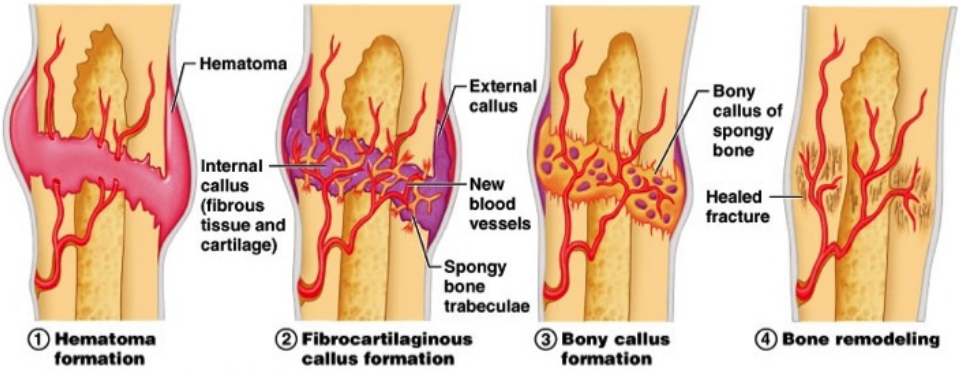


Figure 3: The steps of bone healing

Casts and **splints** are used to stabilize a fractured bone while it heals. Without something to stabilize it, the bone may heal slowly or unevenly while also causing pain and damage to the surrounding area.

Module 3

- Muscle
- Ligament
- Tendon
- Joint
- Torque

Muscle is tissue that contracts to produce force and movement. Bones provide a strong structure for muscles to connect to. **Ligaments** are tissue that connects bone to bone, while **tendons** connect muscle to bone. All of these tissues are located at a **joint**, which is the location where two bones meet. Not all joints are involved in movement, but many, such as the knee, elbow, and shoulder, are. All of these tissues exist in many shapes and sizes to produce an incredible complexity of movement for the human body.

Torque is the rotational force applied to a joint to produce movement. When muscles contract, they produce torque on the joint, which causes the joint to flex or extend. Muscles cannot produce force by lengthening. Ex: You don't kick your leg by relaxing your hamstrings, but by contracting your quadriceps.

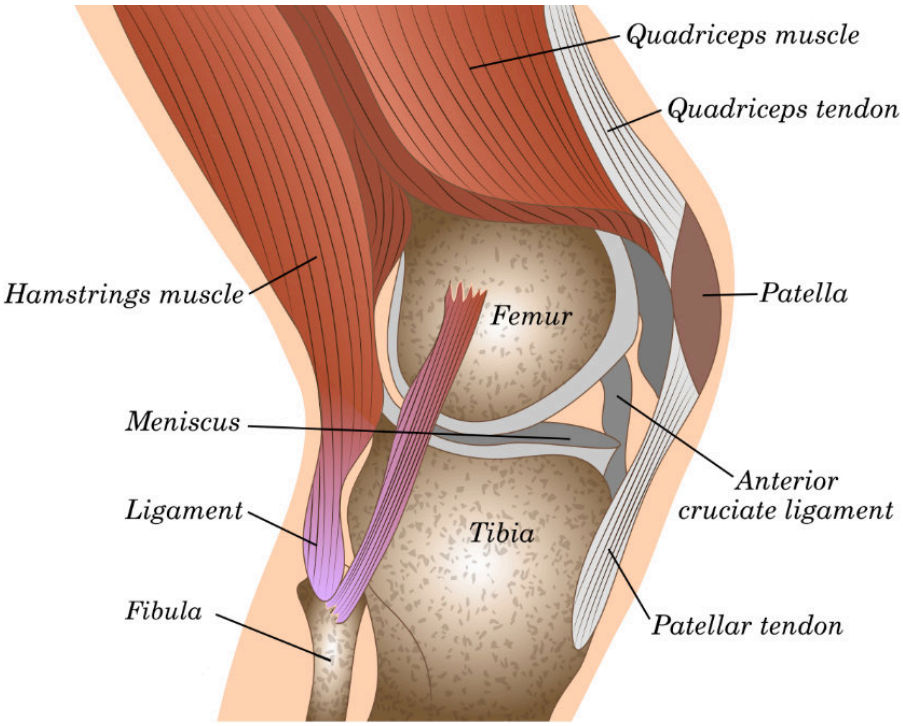


Figure 2: Diagram of the knee joint

Introduction

Concepts to Introduce ● Introduce mentees to the idea that the skeletons they see during Halloween are larger versions of their own skeletons. ● Try to get mentees to think about bones as living things that have a variety of functions.	**Questions to Pique Interest** ● Have you ever broken a bone? ● What do you think is inside your bones? ● What are some things your bones are important for? ● How do you think your knee works?
Scientists, Current and Past Events ● Bone marrow is a key player in many cancers and cancer treatment. ● Recent research has focused on how to accelerate bone regeneration to recover from injuries. ● Prof Tony Keaveny ○ Bone Biomechanics ● Prof Sabrina C. Agarwal ○ Skeletal Biology	**Careers and Applications** ● Orthopedic surgeon ● Forensics ● Paleontology ● Osteologist

Module 1: Build-a-Bone Workshop

In this module, the mentees will be learning about the structure of a bone. The activity involves each mentee making their own model of a bone!

Teaching Goals

1. **Bone:** Rigid tissue that provides support and protection to the body
2. **Blood Vessels:** Tubes that carry blood around the body
3. **Bone Marrow:** Soft tissue in the middle of some bones that produces blood cells and platelets
4. **Compact Bone:** Strong, dense bone that forms the outer layer of bones
5. **Spongy Bone:** Porous bone that forms the interior and ends of bones

Materials (per mentee)

- Sponge
- Yellow, red, and blue pipe cleaners (⅓ each)
- White PlayDoh (about .5 oz)

Different Methods for Teaching

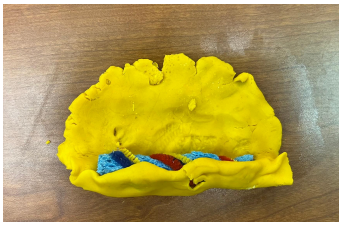
1. Draw a diagram! Helps to visualize the different layers involved in bone structure.
2. Compare bone structure to a frozen ice cream bar or other food with a hard exterior and soft interior.
3. Compact and spongy bone teaching goals can be combined if needed.
4. To explain the concept of blood vessels, have mentees observe visible blood vessels through their own skin.

Procedure

1. Twist together yellow, red, and blue pipe cleaners around a thin piece of sponge to form blood vessels, nerves, and bone marrow.
2. Form white playdough around the core to form a bone. This might work best if you flatten out the playdough and roll it around the sponge and pipe cleaners.
3. Mentees can name their bone and decorate it if they would like.

Figure 1: *Pipe cleaners and sponge*

Figure 2: *In playdough.*

	 **Figure 3:** Starting to roll  **Figure 4:** *Sentience (probably has a soul)*

Classroom Notes

The main goal here is for mentees to understand that bones are alive, grow, and change.

Module 2: Messy Breakup

In this module, mentees will learn about how bones heal when they break. The activity involves the whole classroom where mentors and mentees will act out the healing process.

Teaching Goals	**Materials**
1. **Hematoma:** A large blood clot that forms around a fracture 2. **Osteoblast:** A cell that produces bone to heal a fracture 3. **Cast/Splint:** Materials used to stabilize a fracture while it heals 4. **Soft/Hard Callus:** An intermediate between hematoma and healed bone 5. **Remodeling:** Long-term healing and hardening of broken bone	• None!

Different Methods for Teaching

1. Take things very slowly! At every step, ensure the mentees are following your teaching goals and can apply them to the activity.
    a. Activity is very flexible, adjust teaching style as needed for your site.
        i. I.e. one round without explaining, next round explain little-by-little what is happening.
2. Ask mentees if they have ever broken a bone. Did they use a stabilizing cast/splint?
3. Compare hematomas to bruises.
    a. Could also compare breaking a bone to something like cutting your skin.
4. If explaining the Soft/Hard Callus teaching goal, ask mentees if they have ever had a skin callus (hard, raised bump on skin due to pinching/rubbing).

Procedure

1. Mentors will stand in a line to represent the osteoblasts while mentees surround them to represent bone.
2. A mentor will break the line, showing a fracture.
3. Mentors and mentees will represent the different steps of bone healing by
    a. Forming a ‘hematoma’
    b. Linking hands across the gap
    c. Returning to their original conformation
4. See diagram at right. Red squares are mentors and blue circles are mentees.

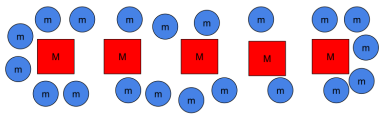


Figure 1: Unbroken bone

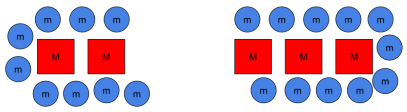


Figure 2: Fractured bone

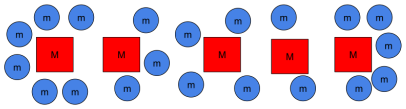


Figure 3: Healing bone

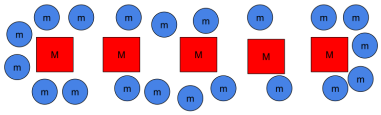


Figure 4: *Completely healed bone*

Classroom Notes

If the activity isn't hitting for your mentees or if they're really tired and don't feel like moving around, you can move on.

Module 3: The Bee's Knees

In this module, mentees will learn how bones work with muscles to help us move. The activity involves mentees making their own model of a knee and using it to kick a cotton ball.

Teaching Goals	**Materials (per mentee)**
1. **Muscle:** Tissue that contracts to produce force and movement 2. **Ligament:** Tissue that connects bone to bone 3. **Tendon:** Tissue that connects muscle to bone 4. **Joint:** The place where two bones connect 5. **Torque:** The rotational force applied to a joint to produce movement	• 2 popsicle sticks • 1 popsicle stick half • 1 rubber band • Tape • 1 cotton ball

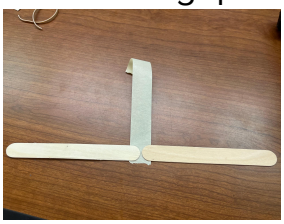
Different Methods for Teaching

1. Use the mentees' models to point out how ligaments and tendons hold a joint together.
    a. For more advanced sites, perhaps abstain from telling them which part of the model is what. Instead, have them try to identify the individual parts from the teaching goals listed.
2. **L**igaments **L**ink! **T**endons **T**ug!
    a. Ligaments *link* two bones together. Tendons aid with the *tugging* of muscle attached to bone.
3. For sites that did Jared's plane lesson, connecting the muscles teaching goal to what mentees have already learned about force would be great!
4. Muscles move by contracting. This means that they get shorter to produce force, just like the rubber bands on their builds! Demonstrate this by having mentees lift something up from waist level (essentially do a bicep curl). The bicep head should shorten!

Procedure	**See Instructions on Next Page**
1. Pass out the materials to your mentees and guide them through the build. 2. When they have finished building, let them decorate their knees and compete to kick their cotton ball across a table or the floor. 3. To use the knee, hold one end, pull the other end down/back, and release. 4. If the mentees are able to split their attention, explain how each part of their build represents a part of an actual joint.	

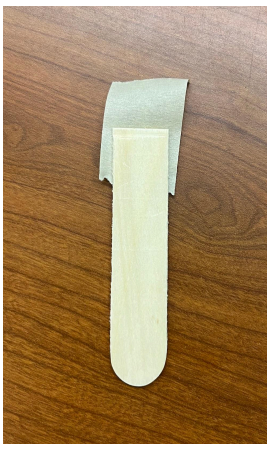
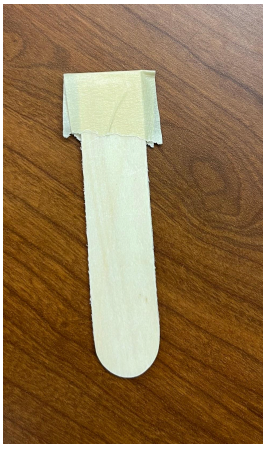
Artificial Knee Instructions

1. Tape two popsicle sticks together end to end with a small gap between them.



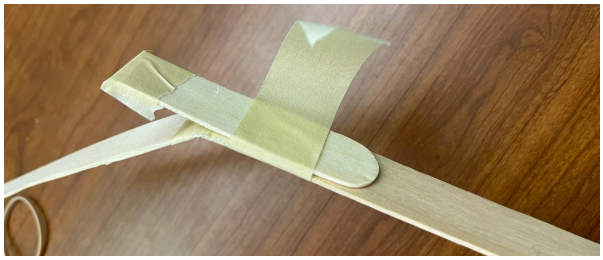

2. Bend the sticks back and forth at the joint to make sure it can move.

3. Tape the end of the halved popsicle stick.

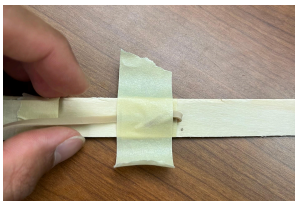
4. Tape the halved popsicle stick to **<u>one</u>** of the full popsicle sticks, leaving about ⅓ of it extending past the joint.

IMPORTANT: Knee will not kick if this is not done properly.



5. Cut rubber band and tape one end to one popsicle stick, leaving a little sticking out at the end.

6. Fold the little excess the other way (towards the joint) and tape it down. Repeat **5-6** on the other end.



Classroom Notes

Make sure mentees are not hitting each other with their knees. They can't hurt each other that badly, but they might still get angry at each other. Also, mentees may be very eager to decorate as soon as possible, but encourage them to complete the build first, since it could be very time-consuming.

Conclusion

Let mentees continue to play with their knees. As long as they're engaged, you've done your job!