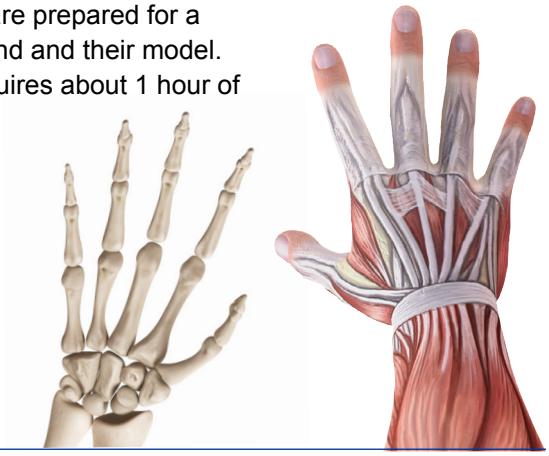
Flex and Extend: Modeling a Human Hand

Lead students in an engaging and creative project where they build a model that demonstrates the flexing action of the human hand. Students use craft materials and follow the procedure below to assemble a model of the hand. As students learn about the tendons and muscles of their own hands, they are prepared for a discussion about the similarities and differences between a biological hand and their model. Students can conduct this activity individually or in pairs. The activity requires about 1 hour of class time to complete.



Correlation to Next Generation Science Standards

- Science and Engineering Practices
  - Developing and using models
  - Constructing explanations and designing solutions
- Crosscutting Concepts
  - Cause and effect
  - Structure and function
  - Systems and system models

Background

Musculoskeletal movement

Humans are large and complex organisms that require muscular and skeletal systems for support and locomotion. A specialized type of tissue, **skeletal muscle**, is attached to the bones of the skeleton, and contraction of this muscle tissue enables the movement of bones. Skeletal muscle is under voluntary control by the somatic nervous system, meaning that there is conscious control over muscle contraction and relaxation.

The junction of 2 bones is called a **joint**. Bones are connected at joints by tissue called **ligaments**. Another type of connective tissue, **tendons**, serves to link skeletal muscles to bones across a joint. Muscles are necessary to move the bones. The attachment point of a muscle medially (near the midline of the body) is called the **origin**. The attachment point of a muscle distally (further from the midline of the body), generally on the more mobile bone, is called the **insertion**.

When skeletal muscles contract, the insertion point is pulled toward the stationary origin, causing bones to move at a joint. It is important to remember that muscles act by exerting a pulling force, never a pushing force. Contracted muscles are shorter and thicker than when they are relaxed. Muscles work as antagonistic pairs; when 1 muscle contracts, the other relaxes.

Bones of the hand and wrist

The human hand is composed of a wrist, palm, and 5 fingers. The wrist is made up of 8 tightly packed bones called the carpals. Medially, the carpals connect to the bones of the forearm, the radius and ulna. Distally, the carpals are connected to the metacarpals and muscles of the hand. Five metacarpal bones make up the bones of the palm, and each one is in line with 1 finger. The metacarpal that connects to the thumb has the widest range of motion, allowing it to oppose the other fingers. The phalanges are the bones that make up the fingers. There are 3 in each finger and 2 in the thumb. The junction of each bone in the finger is visible as the knuckle.

Muscles of the hand and wrist

There are many muscles responsible for the movement of the wrist, hand, and fingers. They originate from the humerus, radius, and ulna. The muscles can be divided into 2 groups: the flexors and extensors. The flexors of the hand and wrist are on the anterior side of the forearm; the extensors are on the posterior side. The flexor muscles

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shorten (flex), causing the fingers to close, or draw the palm of the hand toward the wrist. The extensors shorten (flex), causing the fingers to open, or draw the palm of the hand away from the wrist.

Materials

Cardboard, cardstock, or foam board, 8½ × 5½"

5 straws or tubing

Marker

String, 5'

5 beads

Pair of scissors

Craft knife

Roll of tape (clear or electrical)

Metric ruler

Preparation

1. Gather all materials.
2. Discuss any relevant safety issues with the class. Review safe handling methods for craft knives and scissors.
3. Review the provided background information and share pertinent information with your class.

Procedure

1. Trace your hand and wrist on cardboard, cardstock, or foam board to create the hand template.
2. Mark the joints of your hand and wrist on the template. Make lines representing knuckle joints and the crease at the thumb pad that is created when you touch your thumb and pinkie finger (see Figure 1).

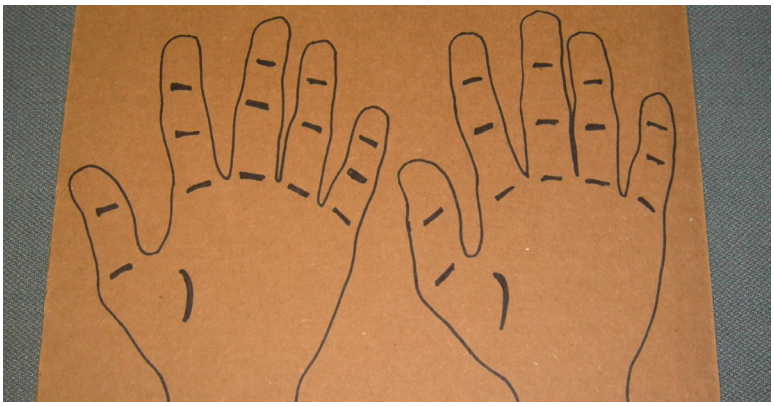

Figure 1. Traced hands with joints marked.

3. Use a craft knife to score the thumb crease. This will allow the thumb to be slightly opposable.
4. For each finger and thumb, measure and cut straws or tubing that extend from the tip of the finger to the wrist (see Figure 2).

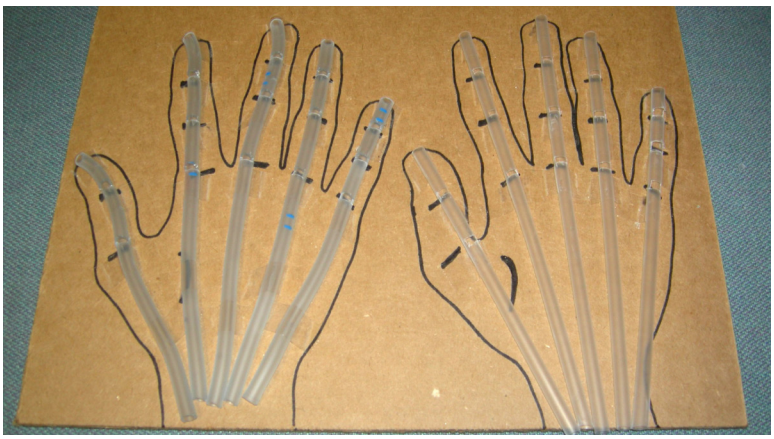

Figure 2. Straws extend from the tip of the thumb and each finger to the wrist.

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5. Tape the straws down to the hand template along each finger and down the thumb to the wrist; the straw should be centered in the finger. Avoid taping where the joint lines are marked. The ends of the straws should meet at the wrist.
6. Trim uneven ends of the straws from the fingers so that they line up at the wrist. The straw for the thumb may sit overtop of the others at an angle.
7. At each marked joint line, cut a small notch in the straw with a craft knife and remove a piece of the straw (see Figure 3). Be careful not to cut all the way through the straw.

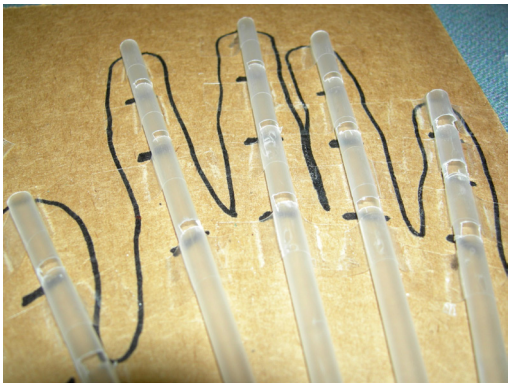

Figure 3. Small notch cut in the straw at each marked joint line.

8. Cut five 30-cm pieces of string.
9. Tie 1 piece of string in a loop that threads through the tip of the finger and the second knuckle.
10. Thread the remaining length of string through the straw so that the excess string is free at the wrist (see Figure 4).
11. Repeat steps 9 and 10 for each finger and thumb.

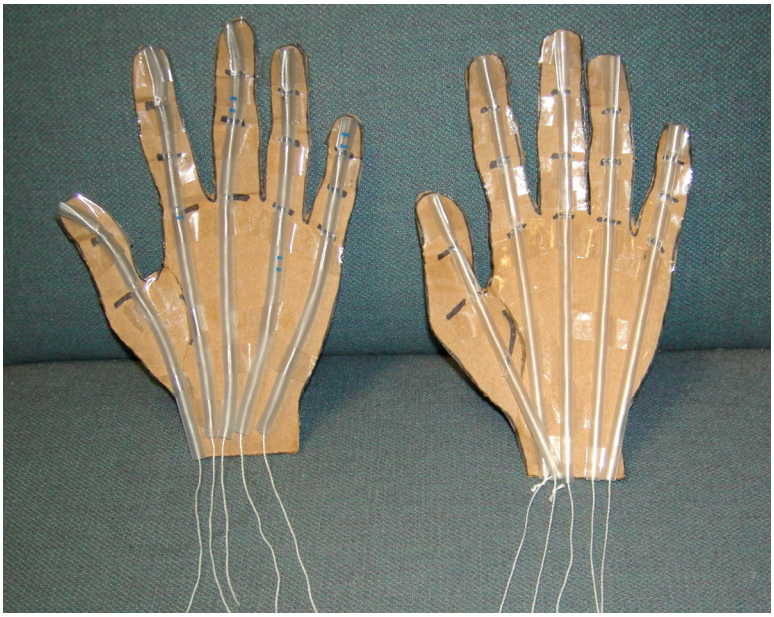

Figure 4. String threaded through the tip of the thumb and each finger and the second knuckle. Remaining length of string threaded through the straw so that excess is free at the wrist.

12. Tie a bead onto the end of each string about 5 cm from the wrist. Each bead serves as a handle for flexing a finger (see Figure 5).

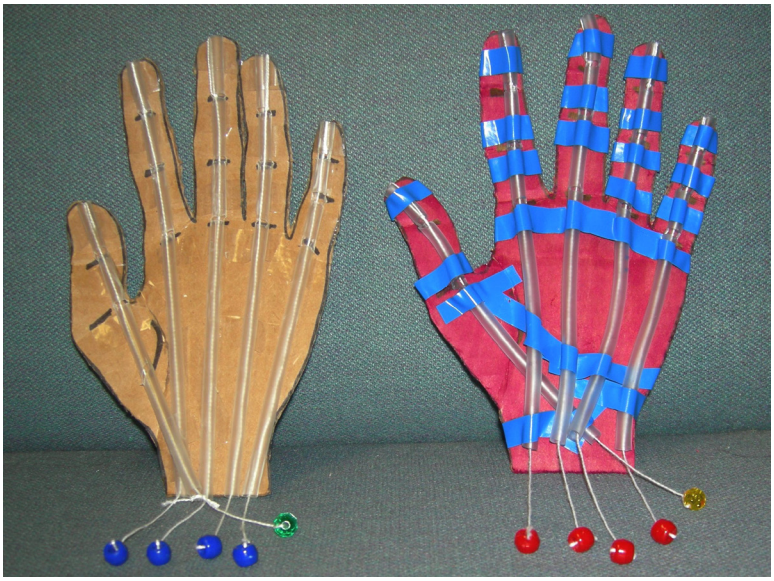

Figure 5. Bead tied onto the end of each string about 5 cm from the wrist.

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13. Score the knuckles on the backside of the hand (see Figure 6).
14. Bend the joints of each finger and thumb to create bends in the cardboard.
15. Pull beads to flex and extend the fingers and thumb.
16. Clean up workspace and make sure sharp objects are put in a secure location.

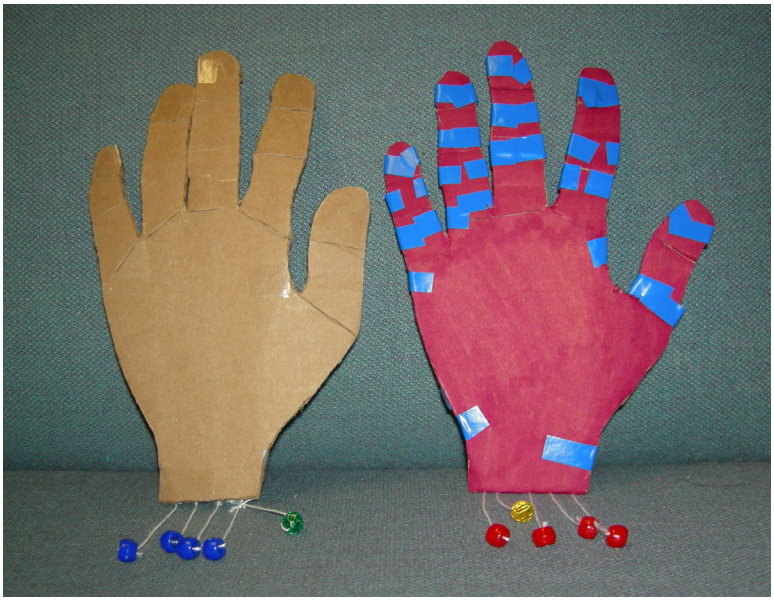

Figure 6. Knuckles scored on the backside of the hand.

Discussion

Engage students in a conversation about muscles and tendons. How does this model resemble a human hand and what are its limitations as a model? Students should recognize that the cardboard represents the bones of the hand and wrist. The strings are like tendons connecting the bones to muscles. The flexion of the muscles is represented by pulling the strings. There are no extensor muscles or extensor tendons demonstrated in the model. The fingers return to position when the flexor muscles are relaxed (strings released), but in the human hand, the antagonistic muscle would bring the fingers back to neutral position. You may have students discuss or extend the activity to craft extensor tendons and muscles to add to their model.