ACTIVITY OUTLINE

Part 1: The Model Leg

1. Review Rope Jumping.
2. Discuss Moving Bones.
3. Explain the Role of Muscles.
4. Introduce the Muscle Transparency.
5. Introduce the Tendon.
6. Show Muscle and Bones Together.
7. Find Working Muscles.
8. Introduce the Model Leg.
9. Assemble Legs.
10. Check the "Bones."
11. Muscle-up the Knee Joint.
12. Distribute Muscle and Tendon Materials.
13. Muscle-up the Foot.
14. Compare Model Legs to Real Legs.
15. Go beyond Model Legs.
16. Learn Muscle Names.

Part 2: The Model Thumb

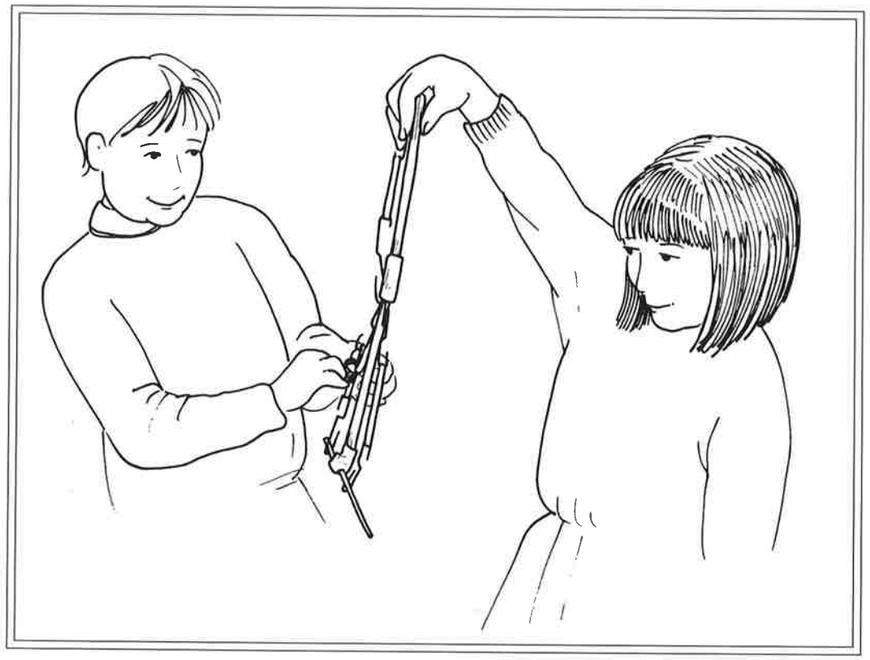
17. Review the Model Leg.
18. Look at the Hand.
19. Use the Poster and Transparency.
20. Describe the Model Thumb Challenge.
21. Introduce the "Tendon."
22. Introduce Ligaments.
23. Clean Up.

Britannica
ENCYCLOPAEDIA BRITANNICA EDUCATIONAL CORPORATION
310 South Michigan Avenue Chicago, IL 60604
1-800-554-9862 extension 6554

This material was prepared with the support of National Science Foundation Grant No. MDR-8751727. However, any opinions, findings, conclusions, statements, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of NSF.

Full Option Science System
Lawrence Hall of Science
University of California
Berkeley, CA 94720
1-510-642-8941
FOSS

MUSCLES



STRAND

Life Science

SCIENCE CONCEPTS

Contraction
Muscle function
Muscle structure
Skeletal movement

SCIENCE THINKING PROCESSES

Observing
Communicating
Comparing
Organizing

INTERDISCIPLINARY ACTIVITIES

Language
Physical education

PURPOSE

In *Muscles* the students will

- Learn that muscles contract when they work.
- Build an operating model to demonstrate how muscles move legs and feet.
- Build an operating model to demonstrate how muscles move thumbs.
- Learn concepts that will contribute to understanding of the following themes: **Pattern**, **Structure**, **Interaction**, and **System**.

THEMES

Pattern
Structure
Interaction
System

OVERVIEW

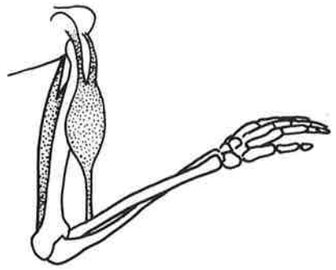
In *Muscles* the students start by looking and feeling for their muscles when the muscles are working, particularly the ones used during rope jumping. They are given three pieces of information: muscles contract when they work, muscles attach to bones with tissues called tendons, and muscles attach across joints to move bones.

In Part 1 the students work in pairs to build a model leg and foot with simulated muscles and tendons that emulate the actions of a leg and foot during jumping. In Part 2 the students build model thumbs with tendons and ligaments that make the thumbs operate properly.

BACKGROUND FOR THE TEACHER

Muscles power the movement of the human body. They do it by performing one simple action: they **contract**, or shorten, when they receive a signal from the central nervous system to do so. When the thousands of long fibers in a muscle all shorten in concert, the result is a powerful pull bringing the two ends of the muscle toward each other. If the two ends of a muscle are attached to the bones on opposite sides of a joint, the bones move.

The elbow joint is a good example of this action. A powerful muscle, the **biceps**, is located on top of the humerus (upper arm bone). The biceps, like all other muscles, has strong ropelike tissues called **tendons** at each end. Tendons attach muscles to bones. One end of the biceps is attached to the humerus near the shoulder, and the other end is attached to the lower arm bones just below the elbow joint. When the signal goes out to the biceps to contract, the muscle shortens, causing the arm to **flex**, or bend, at the elbow.



A second muscle, the **triceps**, located under the humerus, acts in opposition to the biceps. When the triceps contracts it **extends** the arm at the elbow. Muscles are arranged in opposition throughout the body as **flexors** and **extensors**, making it possible to do such things as straighten up after bending over to pick up a pencil from the floor, or close your mouth after yawning.

Frequently the two bones forming a joint are connected directly to each other with another kind of tissue called **ligament**. Ligaments always attach from bone to bone, whereas tendons always attach muscle to bone. Ligaments add strength to active joints like knees and elbows as well as forming tubes or bridges through which tendons run. This kind of guiding ligament is found in the wrist, arm, and fingers. The long tendons that flex the fingers run through ligament arches, rather like fishing line running through the guides on a fishing rod.

Over 650 separate skeletal muscles pull the bones in our skeletons this way and that. Muscle pull allows us to nod, reach, run, clap, smile, blink, bite into an apple, lift a bowling ball, twirl a hula hoop, and flip a Frisbee. And we can perform these movements over and over again. Muscles are amazingly durable. If a muscle is overtaxed, however, it can tire to the point that it can no longer contract until it has had time to rest. Also, when a muscle is fatigued and called upon to do some work, it will sometimes contract and stay contracted. This condition is a **cramp**.

Muscles that are used excessively, stretched too far, or torn can become inflamed, swollen, and painful. This **strained** muscle will heal fairly quickly, as there is usually relatively little physical damage to the muscle fibers.

Sometimes ligaments are injured, particularly in athletic competition or falls. If a ligament is stretched beyond its limit, or torn, it can become seriously inflamed, grossly swollen, and extremely painful. This is a condition called a **sprain**. Sprain injuries happen most often to ankles, but knees, elbows, and wrists can be sprained as well. Sprains require a relatively long healing period before the muscles in the area can again be used with all their power.

EXTENSIONS AND APPLICATIONS

NOTE: After the activity, cook up the wings and remove the meat to feed to a pet.

1. **Dissect a Chicken Wing.** Chicken wings have nicely developed muscle groups that move the several bones in the wing during flight. By carefully cutting off the skin, the students can find muscle groups and determine the bones to which they connect. They can also see the white tendons at the ends of the muscles that connect muscle to bone.

2. **Add Extensors.** Every flexor muscle that bends the skeleton at a joint is opposed by a muscle called an extensor that straightens the joint. Have the students reassemble their leg models and thumb models with the addition of extensor muscles.

FOSS FOR ALL STUDENTS

Hands-on science provides opportunities for students to learn from each other. The experience will be enriched for students with disabilities and students from culturally and linguistically diverse populations by using specialized tools and procedures where appropriate.

Visually Impaired. Students with visual impairments will be able to participate fully in the assembly and operation of the articulated leg and thumb models.

Physically Disabled. Students with physical disabilities will need some assistance with the fine motor actions needed to assemble the model leg and thumb. They can indicate where muscles and tendons should be attached and observe the results as partners construct models by following their instructions.

Culturally Diverse. For students learning English, pay particular attention to the vocabulary development and use the posters and transparencies to reinforce their understanding of the relationship between bones and muscles.

NOTE: This icon alerts you to suggestions for working with diverse populations (see FOSS for All Students in the module *Overview*).

VOCABULARY DEVELOPMENT

contract: to become smaller in size.
joint: the place where two bones meet and move.
ligament: the tissue that connects bone to bone. Ligaments often guide the placement of tendons.
muscle: tissue that can contract, resulting in movement of bones.
tendon: the ropelike tissue that connects muscle to bone.
tissue: any of a number of different kinds of body-building materials, such as muscle, tendon, ligament, bone, and fat.

NOTE: Be sure all students understand and can use these words:
- extend
- flex
- similar
- simulate

LANGUAGE DEVELOPMENT

1. **Discuss Jumping Muscles.** Recall the rope jumping. Ask the students to think about the joints that bend and the muscles that move the bones when they jump. Let the students get up and do a little jumping to review. Bring out the *Bone Names* and *Muscle Names* sheets for reference. Ask the students to work in groups to discuss where muscles might attach to bones to move the shoulder, elbow, neck, and hips.

2. **Identify Muscle Bridges.** Use the *Muscle Names* student sheet to call the name of a muscle. Let a student identify the two bones that the muscle moves. Call on another student to demonstrate the movement.

3. **Describe Aches and Pains.** Have the students write a letter to a friend, describing some muscle aches and pains as a result of a hard day of sports, bicycling, or other activity. Ask them to use scientific names for the muscles. Share the letters between students and have them figure out what ailments the other student suffered.

4. **Research Muscles in Space.** Astronauts experience muscle and bone atrophy while in space. Encourage students to read about the experiences of American and Soviet space travelers and the measures taken to prevent the loss of bone and muscle tissue.

NOTE: The students will probably have to use the *Muscle Names* and *Bone Names* sheets to help with this activity.

PHYSICAL EDUCATION

1. **Research Injuries.** Muscles can be injured in the body where they can't be seen, e.g. strains and sprains. Have students find out

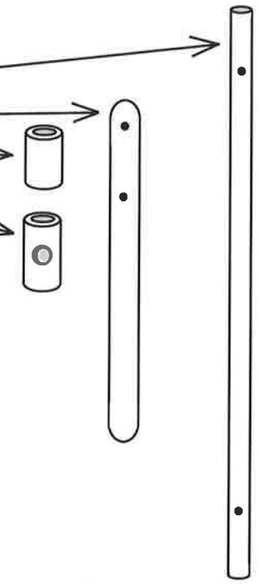
- What is damaged in each kind of injury?
- What is the best immediate treatment for each injury?
- What is the best long-term treatment for recovery?
- What can be done to prevent these injuries?

2. **Research Cramps.** A cramp is a painful condition caused by a muscle that contracts and does not relax. Cramps can occur during strenuous activity or a considerable time afterward. Have the students find out what happens during a cramp, what causes cramps, how to alleviate the pain, and how to prevent their occurrence.

MATERIALS

Part 1: Model Legs

For each pair of students
- 2 Dowels with holes, 18-cm
- 1 Popsicle stick with holes, 11-cm
- 1 Rubber tube, no hole
- 1 Rubber tube, with hole
- 3 Rubber bands, large (#62)
- 6 Paper clips, regular
- 1 Student sheet called *Muscle Names**



For the class
- 1 *Leg and Foot* poster
- 1 *Leg Muscle* transparency
- • Extra rubber tubes
- • Extra paper clips, regular
- Δ • Containers, 1/2-liter
- Δ 8 Basins
- 1 Duplication master for *Muscle Names*

Part 2: Model Thumbs

For each pair of students
- 1 Popsicle stick, no holes
- 2 Popsicle-stick pieces, 4-cm, with hole
- 2 Rubber tubes, no hole
- 1 Piece of string, 30-cm
- 2 Twist ties

For the class
- 1 *Arm and Hand* poster
- 1 *Arm Muscle* transparency
- 1 Scissors*
- • Extra rubber tubes
- • Extra twist ties
- Δ • Containers, 1/2-liter
- Δ 8 Basins

* Supplied by the teacher
Δ FOSS **Measurement** kit item

GETTING READY

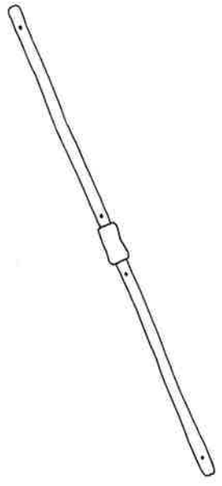
1. **Schedule the Activity.** This activity has two parts. Each part will take up to 1 hour.

2. **Distribute Materials.** This activity has lots of little parts to keep track of during the materials distribution and collection. To aid distribution, place the small items in 1/2-liter containers: rubber tubes in one, paper clips in another, Popsicle sticks in a third, etc. At the end of the activity the process can be reversed.

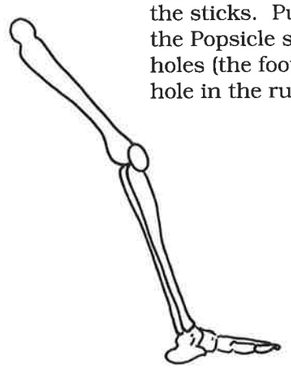
Basins can be used by the GETTERs to bring all of the small items to their collaborative groups.

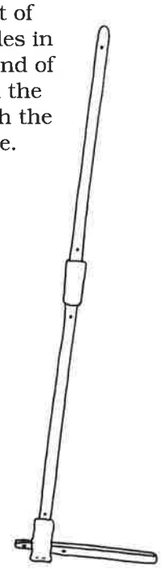
3. **Practice Making a Model Leg.** In Part 1 each pair of students constructs a model leg and foot. Practice making one, attaching the simulated tendons (paper clips) and muscles (rubber bands).

a. Connect two dowels (upper and lower leg bones) with a rubber tube (no hole). The sticks should be pushed into the rubber tube (knee) until they touch. The holes in the dowels should be aligned directly over one another.



b. Slip a rubber tube (with a hole) over the end of one dowel. The hole through the tube should be 90° out of alignment with the holes in the sticks. Push the end of the Popsicle stick with the holes (the foot) through the hole in the rubber tube.

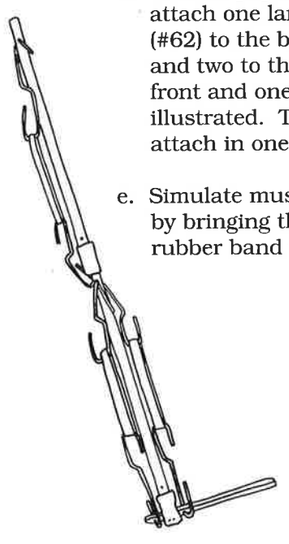




c. Open up six regular paper clips to make S hooks. These simulate tendons. The smaller hook of the S attaches to the rubber band (muscle); the larger hook attaches through a hole in a dowel or a stick.

d. Use the paper-clip hooks to attach one large rubber band (#62) to the back of the knee and two to the foot—one in front and one in back—as illustrated. Three hooks will attach in one hole at the knee.

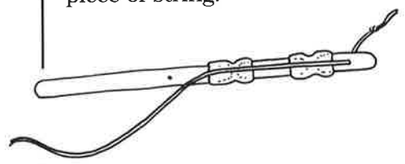
e. Simulate muscle contraction by bringing the two ends of a rubber band together.



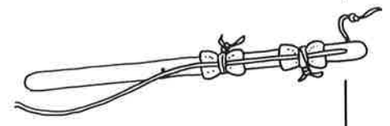
DOING THE ACTIVITY

MATERIALS:
1 String, 30-cm

21. **Introduce the "Tendon."** Challenge the students to use a piece of string as a tendon to make the thumb flex. Tell them they can run the string through the hole in the end bone and tie a knot. Let the GETTERs get a piece of string.



22. **Introduce Ligaments.** Tell the students that there are many places in the body where bones are connected with **ligaments**. Sometimes tendons run through special guides made of ligaments. Ligaments in the fingers and thumb are like the guides on a fishing rod through which the line runs. For proper thumb action the students will have to add ligaments made from the twist ties. Show them how to wrap the twist tie loosely around the joints to guide the tendon.



Let the GETTERs get two twist ties for each thumb.

MATERIALS:
2 Twist ties

23. **Clean Up.** After the students have completed and demonstrated their thumbs, ask them to disassemble the models and return the pieces to their proper containers. Have a few students inventory and repackage the pieces for storage.

REFLECTING ON THE ACTIVITY

Good questions can motivate students to think about new ideas, and can help them realize connections to other areas of study. **Recall questions** get them to remember information, **integrating questions** get them to process information, **open-ended questions** get them to infer, create, and solve problems, and **thematic questions** help them realize connections among scientific ideas and processes. Below are examples of these types of questions.

1. What kind of tissue moves the bones? [Muscle] What kind of tissue connects the muscle to the bone? [Tendon] What tissue connects bone to bone and forms guides for tendons? [Ligament] (recall)

2. How do muscles change when they work? [Get shorter and tighter; contract] (recall)

3. What muscles in the arm are similar to the muscles you put on the model leg? [Muscles that flex the arm and move the hand up and down] What muscles and tendons in the foot are similar to the muscles and tendons on the model thumb? [Muscles and tendons that flex the big toe] (integrating)

4. Which of your muscles do you use the most? (open-ended)

5. What would life be like without muscles? (open-ended)

6. When you feel your muscles and tendons through your skin, how does it make you feel? (feeling)

7. Explain how the skeletal and muscular systems work together at the elbow joint to effect movement. (thematic: Interaction)

DOING THE ACTIVITY

14. **Compare Model Legs to Real Legs.** Call on a few teams to demonstrate the three functions their legs can perform: toe up, toe down, knee bend. Have the students demonstrate that their own legs can perform the same functions. Ask the students to locate their own muscles that contract when they perform these actions, and to feel how they change.

15. **Go beyond Model Legs.** Have the students move their real foot and leg in ways that their model leg can't. Have the students attempt to locate the muscles that allow them to perform these movements.

MATERIALS:
2 *Muscle Names* sheets

16. **Learn Muscle Names.** Distribute the *Muscle Names* student sheets. Ask the students to identify by name some of the muscles that come into play when they perform various movements of their legs.

Part 2: The Model Thumb

17. **Review the Model Leg.** Discuss the model leg and the actions it performed. Have the students explain how it worked, using the terminology of *muscle* and *tendon*. Review muscle contraction as the means by which muscles do their work.

18. **Look at the Hand.** Direct the students to look at their hands and to flex their fingers into a claw several times. Ask them to find the muscles that operate their fingers. Confirm that these muscles are in the lower arm and that long tendons attach them to the fingers to move them.

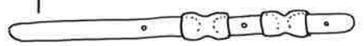
19. **Use the Poster and Transparency.** Bring out the *Arm and Hand* poster. Place the *Arm Muscle* transparency over the poster to show how one end of the muscle group attaches to the arm bones and the other end attaches to the fingers by long tendons. When the muscles contract, the fingers curl to grip objects. Have the students feel for the tendons on the inside of their wrists.

20. **Describe the Model Thumb Challenge.** Bring out the short sticks (phalanges), long sticks (metacarpals), and rubber tubes with no holes (joints). Challenge the students to assemble the parts into an articulated model of the thumb. Let the GETTERs get the materials and let pairs of students assemble a thumb.

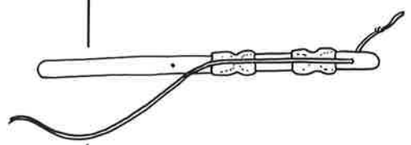
MATERIALS:
2 Popsicle-stick pieces
1 Popsicle stick
2 Rubber tubes, no hole

4. **Practice Making a Model Thumb.** In Part 2 the students use Popsicle-stick pieces and string to make a model articulated thumb. Practice making one by attaching the simulated tendon (string) and ligaments (twist ties) to the model.

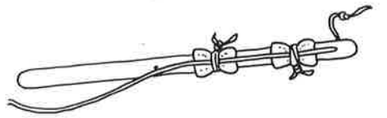
a. Use two rubber tubes (no hole) to connect two short Popsicle-stick pieces and a whole Popsicle stick (no holes).



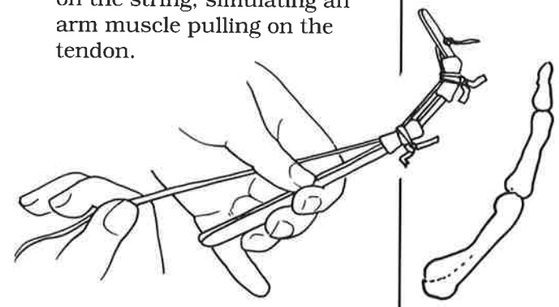
b. Run the end of a 30-cm string (tendon) through the hole in the last segment of the thumb. Tie a knot so it will not pull through.



c. Use twist ties to form guides (ligaments) for the tendon at the two joints. Make sure the twist ties are not too tight on the string.

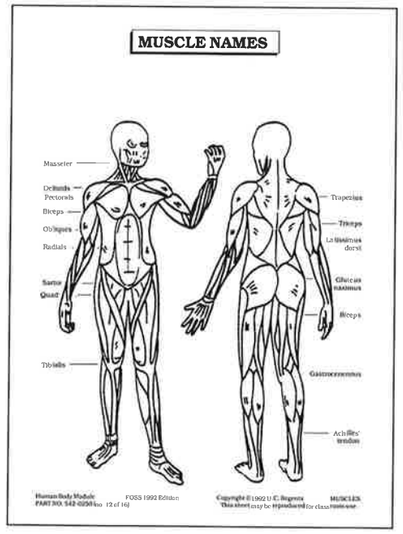


d. Operate the thumb by pulling on the string, simulating an arm muscle pulling on the tendon.



5. **Copy Student Sheets.** Use the duplication master to make a copy of the *Muscle Names* sheet for each student.

STUDENT SHEET



NOTE: Sidebars listing materials are for pairs of students.

Part 1: The Model Leg

1. **Review Rope Jumping.** Remind the students of the rope jumping they did and ask them to recall the body movements they observed. Review the bones that played important roles in the jumping. Encourage the students to use the scientific names for the bones.

2. **Discuss Moving Bones.** After reviewing what the students remember about bones, move toward the purpose of this activity by asking,

We know bones don't move by themselves, so how do you suppose bones move? What do we have in our bodies that provides the power to move our bones?

When the students mention muscles, ask them where they have muscles in their bodies. Ask them to feel for muscles in places like the upper arm, lower arm, upper leg, calf, and jaw.

3. **Explain the Role of Muscles.** Tell the students,

***Muscles** are responsible for all movements of the body. Nothing moves if no muscle is working.*

*When muscles work, they **contract**. That means that when they work, muscles actually become shorter. Contracted muscles feel tight and hard. If a muscle is attached to two bones, they will be pulled toward each other when the muscle contracts.*

*Muscle is an example of one of the body's **tissues**. Tissues are the different kinds of body-building materials, such as muscle, tendon, ligament, bone, and fat.*

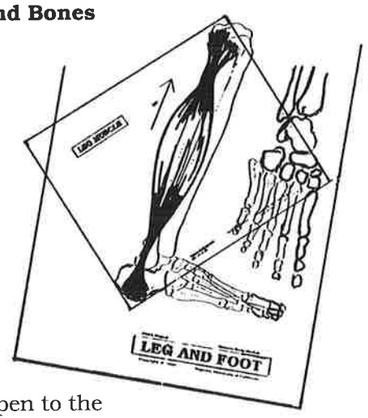
4. **Introduce the Muscle Transparency.** Bring out the *Leg Muscle* transparency. Hold it against a white background. Identify it as a drawing of a typical large muscle in the human body.

Tell the students that there are over 650 muscles that play a part in moving the body. These are known as **skeletal muscles**.

5. **Introduce the Tendon.** Point to the stringy areas at each end of the *Leg Muscle* transparency. Tell the students that muscles attach to bones with these strong ropelike tissues called **tendons**. Every skeletal muscle attaches to two different bones with tendons.

NOTE: Some skeletal muscles connect between bone and skin, allowing such actions as smiling and frowning.

6. **Show Muscle and Bones Together.** Display the *Leg and Foot* poster. Lay the *Leg Muscle* transparency over the bones and align them carefully. Show how the tendons of the muscle attach to the heel bone and to the back of the tibia. Ask the students what they think will happen to the bones when the muscle contracts. [The toe will point.]



7. **Find Working Muscles.** Ask the students to find their muscle that corresponds to the one illustrated on the transparency. Show them how to feel their calf as they go up on their toes and as they squat. They should feel the muscle become harder and fatter. They should also feel the Achilles' tendon at the back of their ankles.

NOTE: Be sure to encourage students to get up and feel their muscles.

Encourage them to find other muscles working when they move other parts of their bodies.

- Flex the arm at the elbow.
- Open and close the hand.
- Work the jaw as if chewing.
- Shrug the shoulders.
- Do deep knee bends.

8. **Introduce the Model Leg.** Tell the students that they will work in pairs to build a model of a leg that shows how muscles move bones.

Identify the parts they will use to make their legs.

- *Two dowels (18-cm) are used for leg bones.*
- *One rubber tube (no hole) is used for the knee joint.*
- *One rubber tube (with hole) is used for the ankle.*
- *One Popsicle stick with holes is used for the foot.*

MATERIALS:
2 Dowels
1 Rubber tube, no hole
1 Rubber tube with hole
1 Popsicle stick

Challenge the students to assemble the five pieces to create a model of a jointed leg and foot.

9. **Assemble Legs.** Ask the GETTERs to get the materials needed for two model legs. Let the teams tackle the problem. Allow about 5 minutes.

NOTE: It is tempting for the students to "kick" their neighbor with the model leg. Admonish the students to resist this temptation.

10. **Check the "Bones."** When most of the legs are assembled, call for attention. Ask the teams to check their model legs, making sure that the holes in the dowels are oriented the same way, and that the dowels are pushed far into the rubber tube "knee" until they touch. Allow a minute for everyone to complete this phase of construction.

11. **Muscle-up the Knee Joint.** Challenge the students to add one muscle to the model leg that will bend the knee. Tell them,

- *One rubber band will be used for a muscle.*
- *Paper clips will be used for tendons. Open paper clips to make an S hook.*
- *Muscle contraction is simulated by bringing the two ends of the rubber band together.*

12. **Distribute Muscle and Tendon Materials.** Ask the GETTERs to get one rubber band and two paper clips for each team in their group. Let the teams attach the muscle to the knee only at this time. Plan 5 to 8 minutes for this part.

13. **Muscle-up the Foot.** When the knees are working, call for attention and challenge the students to attach two more muscles to their model legs, one that makes the toe point down and one that lifts the toe up.

Have the GETTERs get two more rubber bands and four more paper clips for each leg. Allow 15 to 20 minutes for the job to be completed.

NOTE: Only the knee joint muscle is put on at this time.

MATERIALS:
1 Rubber band
2 Paper clips

MATERIALS:
2 Rubber bands
4 Paper clips

REMINDER: Remind the students to simulate muscle contraction by bringing the two ends of the rubber band together.