Chapter 17

Support and Movement

Why are skeletons often used to scare people on Halloween? Many people associate a skeleton with a dead person, but your skeletal system is quite alive and it is an extremely important body system. Why is your skeleton so important? You probably know that your bones provide support and structure for your body. Did you also know that your bones and muscles protect your vital organs, and allow you to move? Did you know that bones produce blood cells and store important minerals that your body needs? Your jaw, neck, arms, feet, and other skeletal/muscle partners work like simple machines to accomplish daily tasks. After reading this chapter, you will see that the human systems of support and movement can do more than scare people on Halloween!

Key Questions

1. ***Why are bones so important to the human body, and how many are there?***
2. ***How do muscles move bones?***
3. ***Why is the human body like a machine?***

17.1 Bones and Muscles

Like a machine, your body consists of many parts that move. Those parts are your bones and muscles. Muscles are attached to bones by tendons. Muscles and bones work in coordination with your nervous system to move your body on demand. In this section you will learn about the structure and function of bones and muscles and how they work together.

The skeletal system

Growth of the skeletal system

The *skeletal system* is the name given to the collection of bones in your body. A baby's body has about 300 bones at birth. These eventually fuse (grow together) to form the 206 bones in an adult. Much of a baby's skeleton is made of cartilage. As you grow, most of the cartilage grows and is slowly replaced by bone with help from calcium. By the time you are 25, growth is complete. Then, your bones will have reached their final size.

Functions of the skeletal system

The skeletal system serves many important functions including:

- It protects the vital organs such as the brain, heart, and lungs.
- It gives your body shape and form.
- It allows for movement.
- It produces blood cells and stores minerals.

How the skeleton is divided

The human skeleton is divided into two parts. The **axial skeleton** consists of bones that form the *axis* of the body. It supports and protects many organs and includes the skull, vertebral column, ribs, and sternum. The **appendicular skeleton** includes the bones of the limbs and the *girdles*. The *pectoral girdle* forms your shoulders and anchors your arms. The *pelvic girdle* forms your hips and anchors your legs. The diagram on the next page shows the major bones of your body.

VOCABULARY

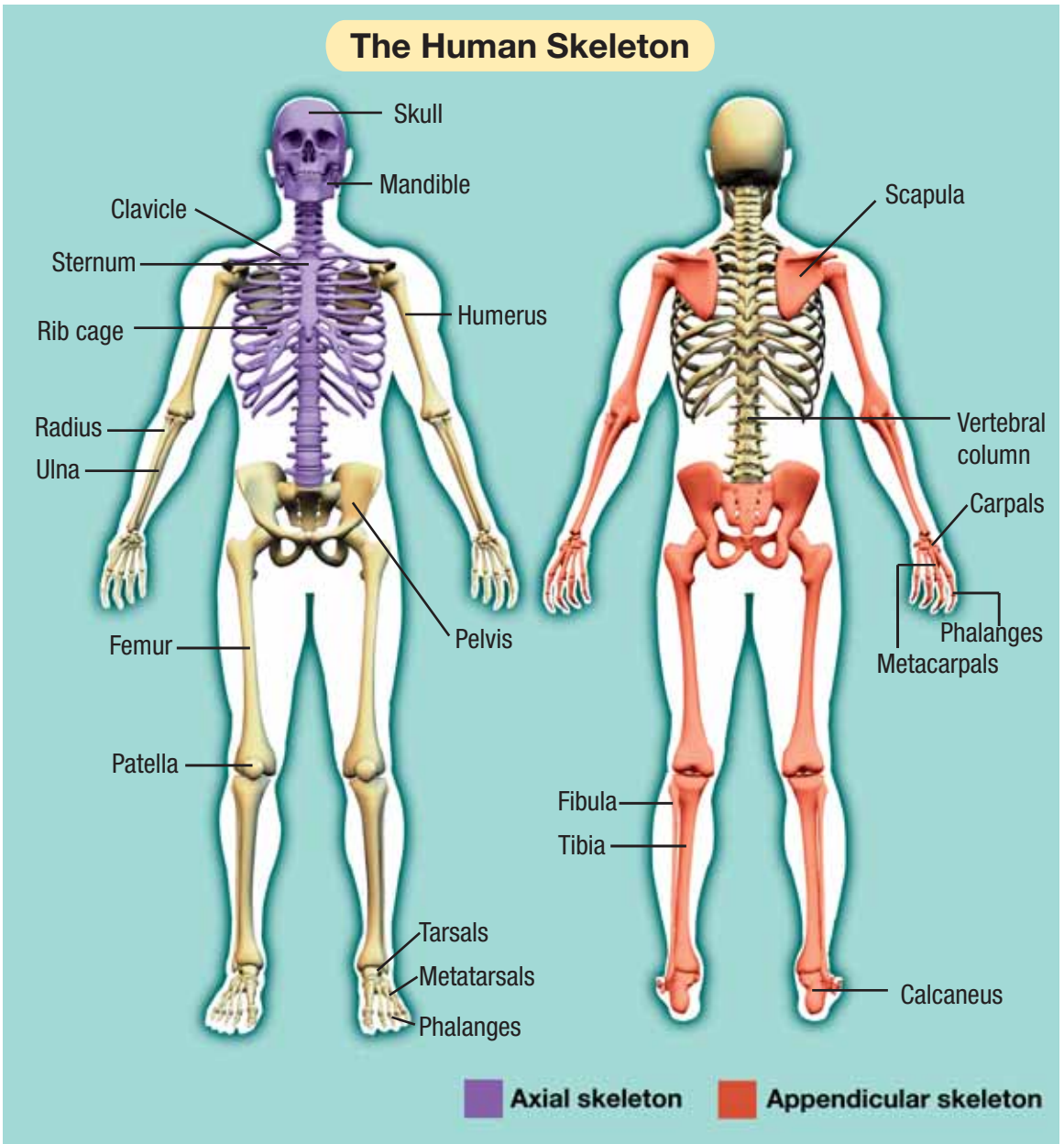
axial skeleton - forms the axis of the body and includes the skull, vertebral column, ribs, and sternum.

appendicular skeleton - the bones of the limbs, including the bones of the pectoral and pelvic girdles.

STUDY SKILLS

Learning your bones

The human skeleton is shown on the next page. Study the diagram and find the location of the bones of your own body. Learn the names of the major bones on the diagram. Then, try to identify the bones on a model skeleton without looking at the names on the diagram.



Your bones

Here are the common names for some of your bones

Mandible - jaw bone

Sternum - breast bone

Scapula - shoulder blade

Humerus - upper arm

Radius/ulna - forearm

Femur - thigh

Tibia - shin bone

Phalanges - fingers and toes

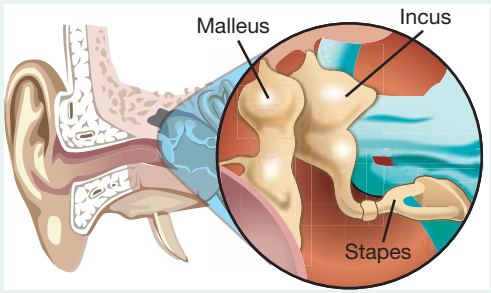
Pelvis - hip

Patella - knee cap

Calcaneus - heel

What are the smallest bones in your body?

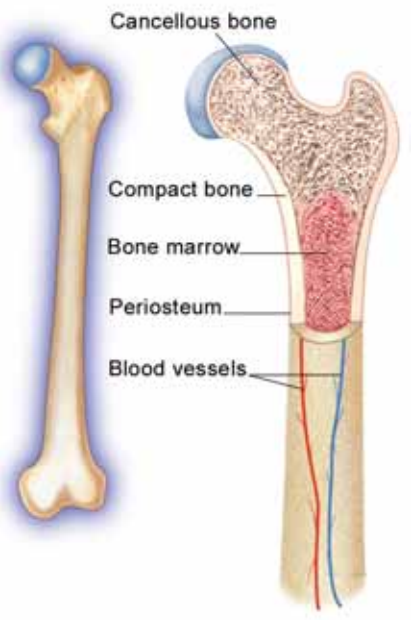
The bones of your inner ear!



What is bone?

The structure of bone

If you've ever seen a real skeleton in a museum, you might think that all bones are dead. But the bones that make up your skeleton are living organs. Bones are made of many layers of connective tissue and minerals produced by living cells. Almost every bone in your body has a similar structure:



- The outer surface of bone is called the periosteum. The **periosteum** is a thin membrane that contains blood vessels to nourish the bone and nerves.
- The next layer is called compact bone. **Compact bone** provides most of the strength and support. It is the smooth, hard part you see when you look at a skeleton. Tiny canals within compact bone contain blood vessels (Figure 17.1).
- Within the compact bone are many layers of cancellous bone. **Cancellous bone** has many open spaces like a sponge. Cancellous bone is not quite as hard as compact bone, but it is still very strong.
- In many bones (like the femur), the cancellous bone protects the innermost part of the bone called bone marrow. **Bone marrow** is a thick, jelly-like layer that makes blood cells or stores fat. *Red bone marrow* produces red blood cells. *Yellow bone marrow* stores fat.

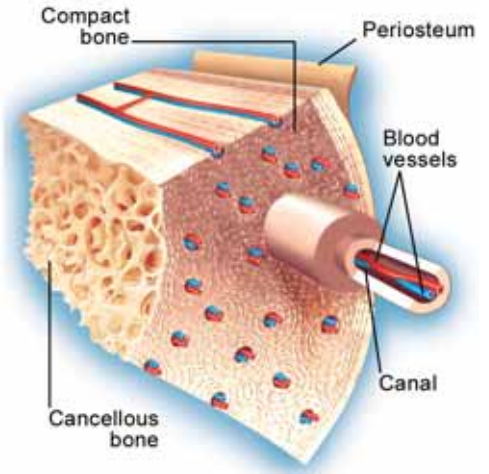


Figure 17.1: *A cross section of the femur—longest bone in your body.*

VOCABULARY

periosteum - the outer surface of a bone that contains blood vessels and nerves.

compact bone - the layer of bone that provides most of its strength.

cancellous bone - the layers of bone that have many open spaces like a sponge.

bone marrow - a thick, jelly-like layer of bone that makes blood cells or stores fat.

Joints

Fixed and moving joints

The place where two bones meet is called a **joint**. Some joints are fixed while others move. Your skull has some fixed joints called sutures. *Sutures* close up the bones of the skull. Moving joints are the ones that let you twist, bend, and move different parts of your body. Figure 17.2 shows the types of moving joints.

Hinge joints

One type of moving joint is called a **hinge joint**. Your elbows and knees each have hinge joints. They allow you to bend and then straighten your arms and legs. These joints are like the hinges on a door. Just as most doors can only open one way, you can only bend your arms and legs in one direction. You also have many smaller hinge joints in your fingers and toes.

Ball and socket and sliding joints

Another important type of moving joint is the **ball and socket joint**. You can find these joints at your shoulders and hips. They are made up of the round end of one bone fitting into a small cup-like area of another bone. Ball and socket joints allow movement in every direction. *Sliding joints* allow bones in your hand to glide over one another and provide flexibility.

Where bones meet

Bones are held together at the joints by ligaments. **Ligaments** are strong elastic bands of connective tissue. When bones move, there is friction. Cartilage helps cushion the areas where bones meet. Have you ever seen someone lubricate a door hinge to stop it from squeaking? Your joints have their own lubricating fluid called *synovial fluid*. This fluid helps them move freely.

VOCABULARY

joint - the place where two bones meet.

hinge joint - joints that allow one-way movement.

ball and socket joint - joints that allow movement in all directions.

ligament - a strong elastic band of connective tissue.

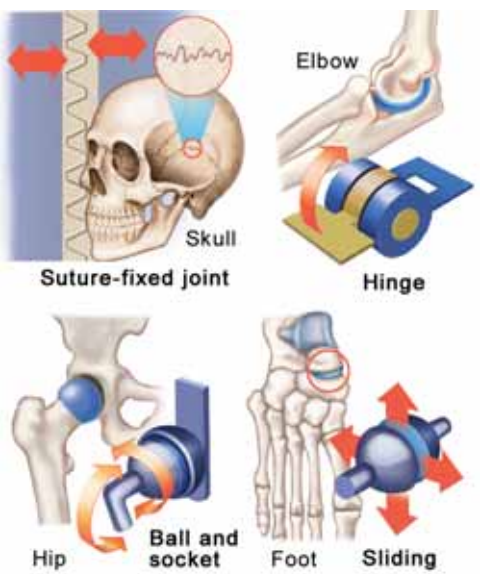


Figure 17.2: *Three types of moving joints.*

The muscular system

What is the muscular system?

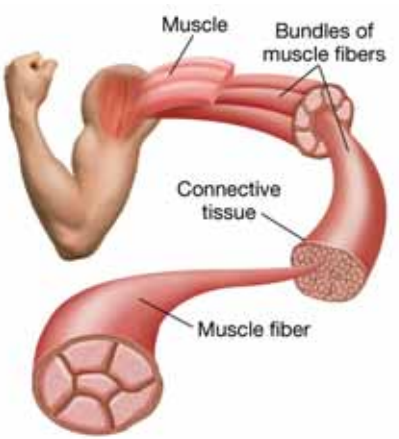
The **muscular system** consists of skeletal muscles and tendons. *Skeletal muscles* are made of skeletal muscle tissue. Recall that the other two types of muscle tissue are cardiac muscle and smooth muscle. A **tendon** is a strand of tough connective tissue that attaches a skeletal muscle to a bone. The major function of the muscular system is to move bones. It also provides support and protection for your organs. Figure 17.3 shows some human body muscles.

Muscle action

The beating of your heart and movement of your digestive tract are both examples of involuntary muscle action. *Involuntary* means you do not control the movement. Most of the time, skeletal muscles are involved in voluntary muscle movement. *Voluntary* means that you can control it. When you lift an object, it is voluntary. You can voluntarily blink your eyes. However, sometimes blinking your eyes is involuntary.

Skeletal muscle tissue

Skeletal muscle tissue is made up of thousands of cylindrical muscle fibers often running the entire length of the muscle. Bundles of fibers are bound together by connective tissue. Blood vessels and nerves run through the connective tissue. Muscle fibers contain long muscle cells each with thousands of mitochondria for energy. During a muscle contraction, a complex reaction causes muscle fibers to shorten. When the muscle relaxes, muscle fibers return to their original position.



VOCABULARY

muscular system - a body system that consists of skeletal muscles and tendons.

tendon - a strand of tough connective tissue that attaches a skeletal muscle to a bone.

Figure 17.3: *Some human muscles.*

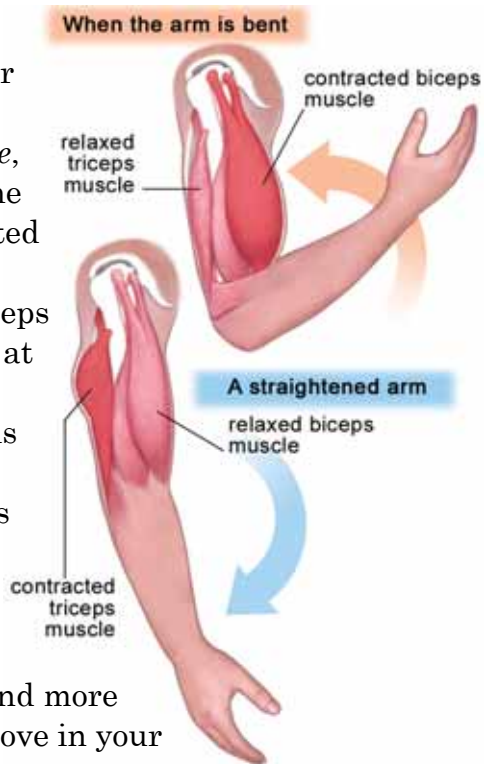
Movement

Muscles work in pairs

Muscles usually work in pairs called flexors and extensors. If a muscle bends part of your body, it is called a **flexor**. If a muscle straightens part of your body, it is called an **extensor**. Flexor and extensor pairs are found across many of your joints. These pairs provide almost all the movement of your skeleton.

An example of muscle movement

An example of a flexor and extensor working together is found in your arm. The flexor is the *biceps muscle*, located at the front of your arm. The extensor is the *triceps muscle*, located at the back of your arm. When the biceps muscle is contracted, the triceps muscle is relaxed. Your arm bends at the elbow joint and raises your forearm. When the triceps muscle is contracted the biceps muscle is relaxed. Now, your arm straightens out.



Exercise

Muscles require movement and exercise to remain strong. Muscles actually become stronger, larger, and more efficient with more exercise. You move in your every day activities. This is sufficient to maintain your muscle strength. *Resistance exercise* requires muscles to overcome resistance (weight). This increases muscle size and strength. *Aerobic exercise* like running, swimming laps, and cycling strengthens the heart and increases the endurance of skeletal muscle.

VOCABULARY

flexor - a muscle that bends part of your body.

extensor - a muscle that straightens part of your body.

Figure 17.4: *Resistance and aerobic exercises.*

17.1 Section Review

1. Match the names of the bones below to letters in the diagram (Figure 17.5).
   - humerus
   - femur
   - pelvic bone
   - vertebral column
   - sternum
   - ulna
2. Tell whether each bone in question 1 is part of the appendicular skeleton or axial skeleton.
3. Match each layer of bone to its function.

Organ system	Function
1. red marrow	a. provides most of the strength and support
2. periosteum	b. produces red blood cells
3. cancellous bone	c. stores fat
4. yellow marrow	d. contains blood vessels and nerves
5. compact bone	e. contains many open spaces like a sponge

4. Name a place on your body that has each type of joint:
   a. hinge joint
   b. ball and socket joint
   c. sliding joint
5. In the pair of muscles below, which is the extensor? Which is the flexor?
   a. triceps
   b. biceps

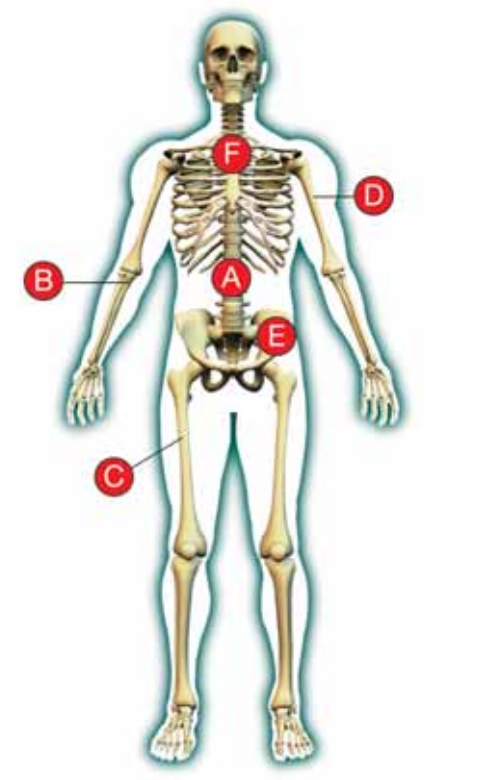


Figure 17.5: *Use this diagram to answer question 1.*

17.2 The Human Body as a Machine

You may have heard the human body described as a machine. In fact, it is. Your bones and muscles work as *levers* to perform everything from chewing to throwing a ball. The lever is an example of a *simple machine*. In this section, you will learn how simple machines work. You will also learn how certain parts of the human body work as levers. First, you need to know a little about the concept of *force*.

Forces

What is a force? A **force** is a push or pull, or any action that has the ability to change motion. Forces are created in many different ways. For example, your biceps muscle creates a force when you raise your arm. Earth's gravity creates forces that pull on everything around you. On a windy day, the movement of air creates forces.

Measuring force Weight is a measure of the force exerted by gravity. Weight is therefore a measure of force. The *pound* is the English unit of force. The *newton* (N) is the SI unit of force. A force of one newton is the exact amount of force needed to cause a mass of one kilogram to increase in speed (accelerate) by one meter per second each second (Figure 17.6). The newton is a smaller unit of force than the pound. One pound of force equals 4.448 newtons. How much would a 100-pound person weigh in newtons? Remember that 1 pound = 4.448 newtons. Therefore, a 100-pound person weighs 444.8 newtons.

VOCABULARY

force - a push or a pull, or any action that has the ability to change motion.

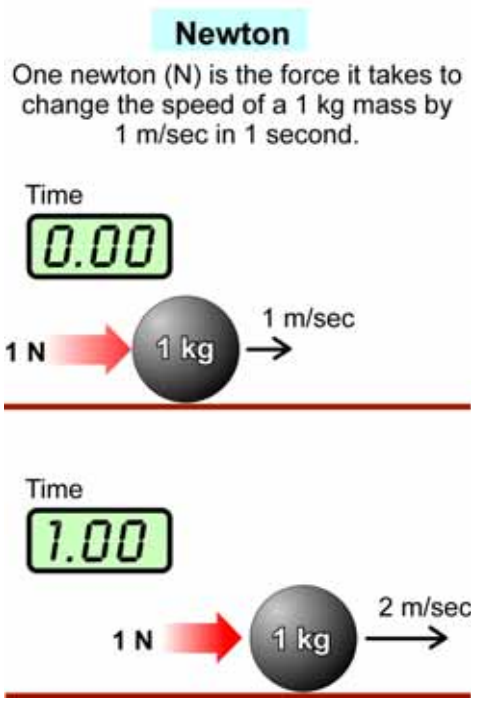
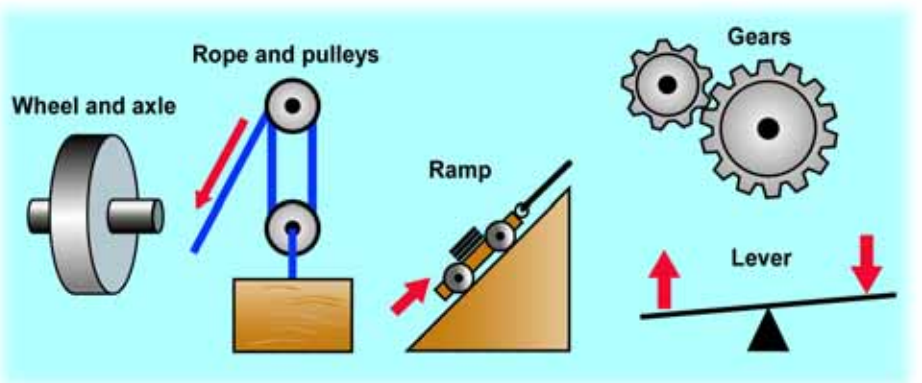


Figure 17.6: *The definition of a newton.*

Simple machines

The beginning of technology

A *simple machine* is an unpowered mechanical device, such as a lever. Some other simple machines are a wheel and axle, ropes and pulleys, gears, and a ramp.



Input force and output force

Simple machines are often used to lift heavy loads. A lever allows you to move a rock that weighs 10 times as much as you do (or more). You can think of simple machines in terms of an *input force* and an *output force*. With a lever, the **input force** (also called the *effort*) is the force you apply. The **output force** is the force exerted on the *load* you are lifting (Figure 17.7).

ropes and pulleys

A simple machine can create an output force large enough to lift a heavy load with a smaller input force. In ropes and pulleys, the input force is what you apply to the rope. The output force is what gets applied to the load you are trying to lift. One person could lift an elephant with a properly designed set of ropes and pulleys (Figure 17.8)!

VOCABULARY

input force - the force applied by a lever (also called the effort).

output force - the force exerted on the load.

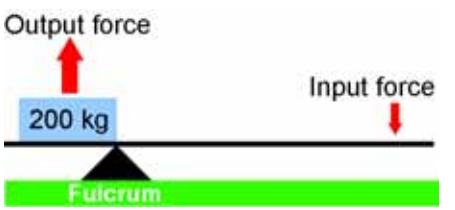


Figure 17.7: *Forces in a lever.*

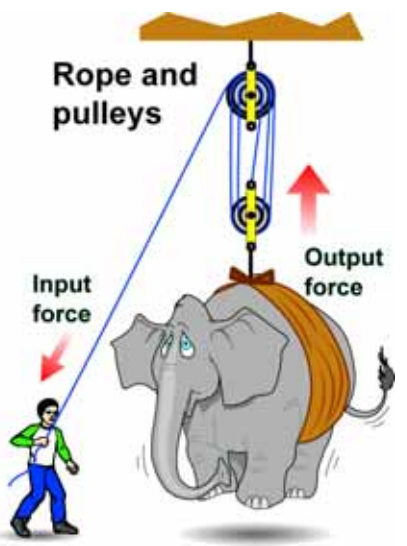


Figure 17.8: *Forces in a set of ropes and pulleys.*

Levers and mechanical advantage

Examples of levers

A lever can be made by balancing a board on a log (Figure 4.7). Pushing down on one end of the board lifts a load on the other end of the board. The downward force you apply is the input force. The upward force the board exerts on the load is the output force. Other examples of levers include: pliers, a wheelbarrow, and the human biceps and forearm.

Parts of the lever

All levers include a stiff structure (the lever) that rotates around a fixed point called the **fulcrum**. The side of the lever where the input force is applied is called the input arm. The output arm is the end of the lever that moves the rock or lifts the heavy weight. Levers are useful because you can arrange the fulcrum and the input and output arms to adapt to the task you need to perform.

The ability of a lever to perform a task depends on its mechanical advantage. **Mechanical advantage** is the ratio of output force produced by a simple machine to the applied input force. The higher the output force in relation to the input force, the greater the mechanical advantage. You can calculate mechanical advantage by dividing the output force, in newtons, by the input force, in newtons as shown in the formula below:

MECHANICAL ADVANTAGE

$$\text{Mechanical advantage} \rightarrow MA = \frac{F_o}{F_i}$$

F_o ← Output force (N)

F_i ← Input force (N)

VOCABULARY

fulcrum - the fixed point where a lever rotates.

mechanical advantage - the ratio of output force produced by a simple machine to the applied input force.

SOLVE IT!

Suppose the output force of a machine is 10N and the input force is 5N. What is the mechanical advantage of the lever? Using the formula, you get:

$$MA = \frac{\text{output force (N)}}{\text{input force (N)}} = \frac{10\,\text{N}}{5\,\text{N}} = 2$$

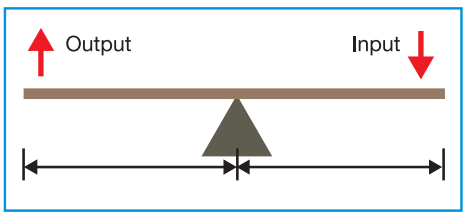
Calculate the mechanical advantage for each lever:

1. Output force = 25N
   Input force = 5N
2. Output force = 10N
   Input force = 2N
3. Output force = 5N
   Input force = 10N

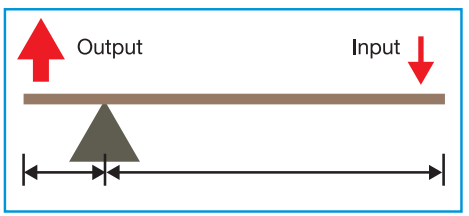
Mechanical advantage and length of input and output arms

Lever arm length and mechanical advantage

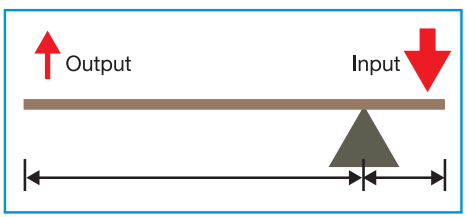
The input force that is applied to a lever and the output force are related to the lengths of the input and output arms. When the input and output arms are the same length (because the fulcrum is in the middle of the lever), the input and output forces are the same. The input and output forces are different if the fulcrum is not in the center of the lever. The side of the lever with the longer arm has the smaller force.



Output arm = Input arm
Output force = Input force
Mechanical advantage = 1



Output arm < Input arm
Output force > Input force
Mechanical advantage > 1



Output arm > Input arm
Output force < Input force
Mechanical advantage < 1

< Means less than > Means greater than

Varying the length of the arms

For some levers, the output arm is longer than the input arm and the output force is less than the required input force. Levers designed this way achieve a wide range of motion on the output side. For example, a broom is a lever used to sweep floors (Figure 17.9).

SOLVE IT!

The mechanical advantage of a lever can be calculated if you know the lengths of the input and output arms using this formula:

$$MA = \frac{\text{length of input arm}}{\text{length of output arm}}$$

Use the formula above to calculate the mechanical advantage of a lever with an input arm that is 40 cm long and an output arm that is 60 cm long.

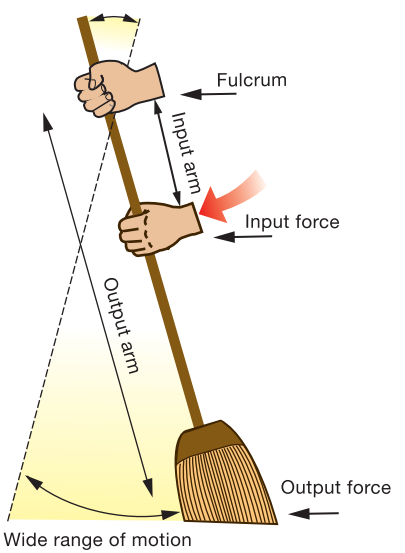


Figure 17.9: *A broom has a mechanical advantage of less than 1.*

The three classes of levers

The three types of levers

There are three types of levers, as shown in Figure 17.10. They are classified by the locations of the input and output forces relative to the fulcrum.

First-class levers

First-class levers always have the fulcrum between the input force and the output force. If the input arm of a first-class lever is larger than the output arm, you can produce a large output force relative to the input force. Sometimes the input arm of a first-class lever is shorter than the output arm. In this case, the output force is less than the input force. The advantage of a lever designed this way is that work done by the lever can be done faster—a small amount of motion of the input arm translates into a huge motion made by the output arm. The mechanical advantage of a first-class lever can be greater than one or less than one. Examples of first-class levers include pliers and see-saws.

Second-class levers

Second-class levers always have the output force between the fulcrum and the input force. Therefore, the input arm will always be longer than the output arm in second-class levers. What does this mean in terms of mechanical advantage? It means that mechanical advantage will always be greater than one. Second-class levers always multiply force. Wheelbarrows are second-class levers.

Third-class levers

Third-class levers always have the input force between the fulcrum and the output force. This means that the output arm is always longer than the input arm and mechanical advantage is less than one. If mechanical advantage is less than one, then you can never multiply force by using a third-class lever. Third-class levers do result in a wide range of motion that is important in moving your arms or sweeping large areas when you use a broom.

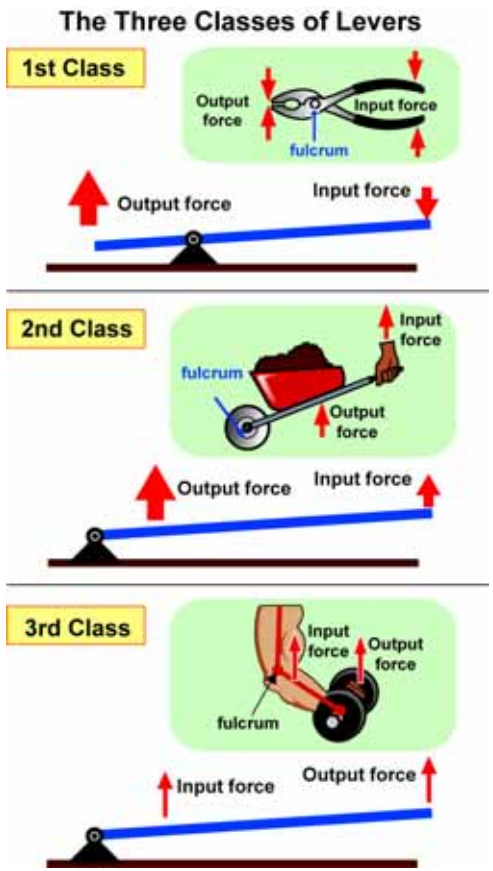


Figure 17.10: *Examples of three kinds of levers.*

Levers in the human body

In the human body, all bones act as levers and each joint can serve as a fulcrum.

The neck Stop reading for a moment. Relax your neck so that your head drops slowly forward. The head is a heavy object—about 4.5 kilograms. Your head drops forward when you relax your neck because your head and neck work like a first-class lever (Figure 17.11). The fulcrum is at the top of the neck. The muscles in the neck provide an input force that allows you to raise your head. When you relax these muscles, gravity causes your head to fall forward.

The jaw Think about how your jaw works when you bite into an apple. When biting, your jaw works as a third-class lever. The input force (applied by your jaw muscles) occurs between the fulcrum (the joint where your jaw bone connects to your skull) and the output force which is applied to the apple.

The arms Your forearms work as third-class levers (see Figure 17.10 on the previous page). As you have learned, third-class levers require more input force than output force. However, the gain in third-class levers is range of motion. The range of motion of your arms is very important in that it makes it possible to reach, pick up objects, and lift them. Often, we are doing tasks that don't require a lot of output force. For example, when you turn a page of this book, you need range of motion to move the page, but you don't need a lot of force!

Feet When you stand on your toes, the feet act as second-class levers (Figure 17.12). Your toes are the fulcrum. The input force is provided by your calf muscles. The output force is the weight of your foot being lifted.

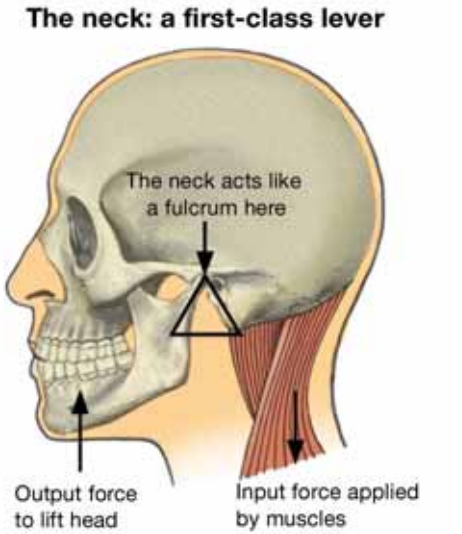


Figure 17.11: *The neck is an example of a first-class lever.*

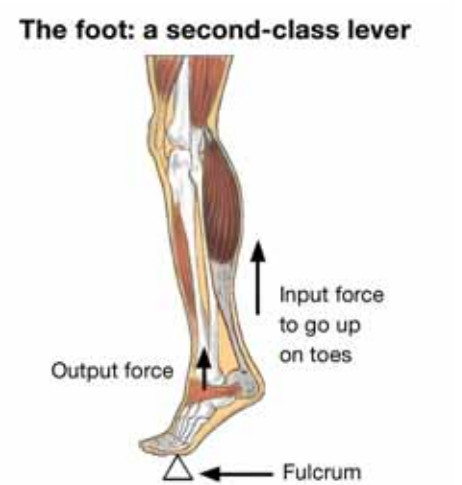
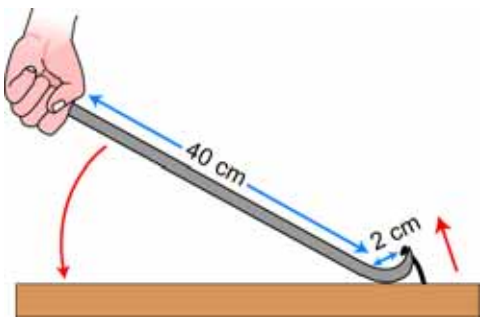


Figure 17.12: *The foot is an example of a second-class lever.*

17.2 Section Review

1. What is a force? Name two units used to measure forces.
2. How much does a 5 pound bag of flour weigh in newtons?
3. What is a simple machine? List three examples.
4. For the simple machine below: (a) Which is the output force? (b) Which is the input force? (c) Calculate the mechanical advantage.



5. Calculate the mechanical advantage for each lever:
   a. A lever has an input force of 15 N and an output force of 60 N.
   b. A lever has an input arm that is 35 cm and an output arm that is 7 cm.
   c. A lever has an output force of 5 N and an input force of 50 N.
6. The picture in Figure 17.13 shows the location of levers in the human body. For each lever in the diagram:
   a. Tell whether it is a first-class, second-class, or third-class lever.
   b. Tell whether the mechanical advantage is greater than, less than, or equal to 1.

CHALLENGE

Solve each challenging problem below.

1. A lever has a mechanical advantage of 2. Its output force is 100N. What is the input force of the lever?
2. A lever has an input arm that is 25 cm long. If it has a mechanical advantage of 5, what is the length of its output arm?
3. The total length of a lever is 100 cm. If the fulcrum is placed 75 cm from the edge of the output arm, what is its mechanical advantage?

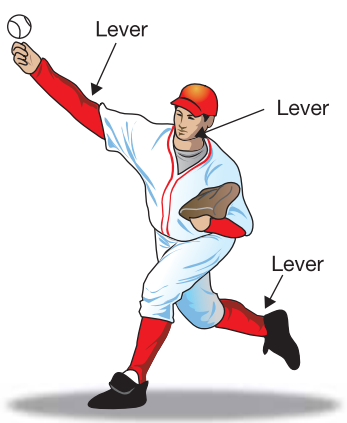
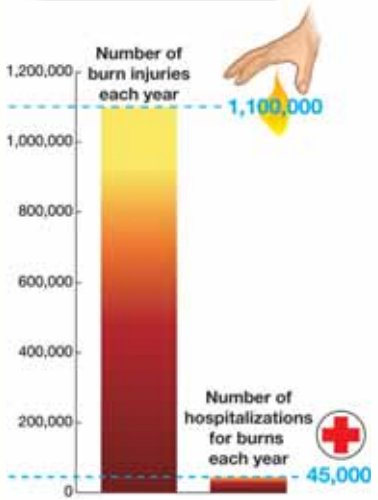


Figure 17.13: *Use the diagram to answer question 6.*

HEALTH CONNECTION

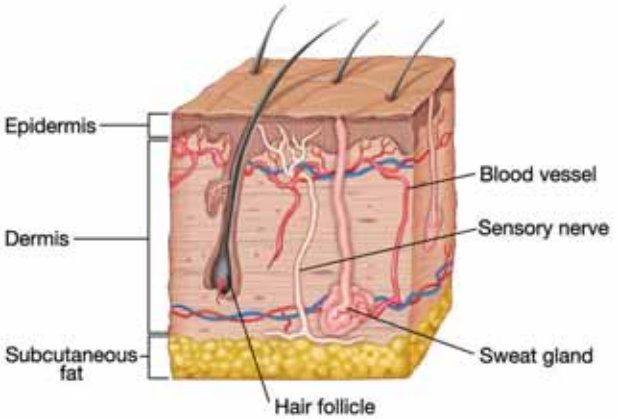
Skin Grafts for Burn Victims



According to the American Burn Association, there are 1.1 million burn injuries in the United States each year. About 45,000 Americans need to be hospitalized because of serious burns. Some 50 years ago, there were fewer than 10 hospitals in the country that specialized in treating burns. Today, there are +about 200 special burn care centers. There are many types of burns, including those caused by fire, heat, chemicals, electricity, sunlight, and nuclear radiation.

Layers of the skin

The skin is the largest organ of the human body. It has several functions: to serve as a protective barrier against infection, to help keep our bodies at the correct temperature, and to provide us our sense of touch.



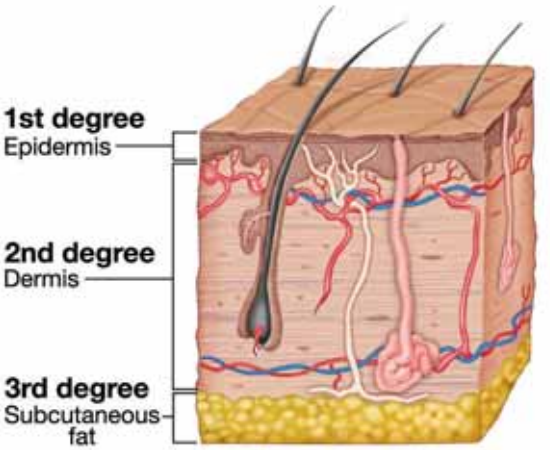
There are three main layers of the skin: epidermis, dermis, and subcutaneous fat. The epidermis is the outer layer of skin that you see. The body constantly adds new cells to this layer because 30,000-40,000 dead cells flake off the surface of your skin every minute. The epidermis also contains a substance called melanin, which gives skin its color.

The dermis is the tough and stretchy layer of skin that lies below the epidermis. The dermis contains nerve endings, blood vessels, oil glands, and sweat glands.

The bottom layer of skin is called the subcutaneous layer. It mostly contains fat to help your body stay warm. The subcutaneous layer also provides a cushion to protect your body from injury.

Degrees of burns

The degree of a burn is determined by how deeply it penetrates the skin. Burn wounds are classified into three depths. A first-degree burn is a minor burn that affects only the epidermis - a sunburn, for instance. Symptoms include redness, swelling, pain, and peeling skin. A second-degree burn is deeper and causes more damage to the skin. Blisters occur with second-degree burns and there is damage to the dermis. A third-degree burn is the most severe type of burn. It damages all the layers of skin and can sometimes expose muscle or bone. Healing from third-degree burns is slow and may result in much scarring.



Sources of skin grafts

Patients with severe burns are often treated with skin grafts. Surgeons who are specially trained in treating burn victims perform these procedures.

Skin grafts may involve taking healthy skin from an unburned part of the patient's body and placing it on the damaged area. This procedure is also called autografting, "auto-" referring to the graft being from the same individual.

Sometimes patients with large burns do not have enough undamaged skin for autografting, so skin is taken from a human donor. This is called an allograft, "allo-" referring to the donor being of the same species but different genetically.

However, skin from human donors is not always available, either. Sometimes skin from an animal donor (such as a pig) is used. This is called a xenograft, "xeno-" referring to the donor being of another species. The problem with donated skin is the risk of infection; the body's immune system often rejects the donated skin.

A system that helps burn victims to heal is the Integraâ Dermal Regeneration Template. This is not a replacement for skin, because it is not made from living cells. It provides a protective covering so that a patient's own cells can grow. These cells arrange themselves into a layer similar to a normal, healthy dermis.

Scientists are trying to develop a true artificial skin. It would work like normal skin and could be used to treat large burn areas. Scientists hope to create cells that will grow hair follicles and sweat glands, and so look and feel more like normal skin. Much research is still to be done but scientists hope artificial skin will become available in the near future.

New procedures for skin replacement

In 1987, a procedure for permanent skin replacement was developed involving creating large amounts of skin in the laboratory using skin cells from the burn victim. The body is less likely to reject this skin because it is made from the patient's own cells. This laboratory-created skin does not look or function like normal skin. Its color may be different from the patient's, and it does not contain hair follicles or pores for sweating.

Questions:

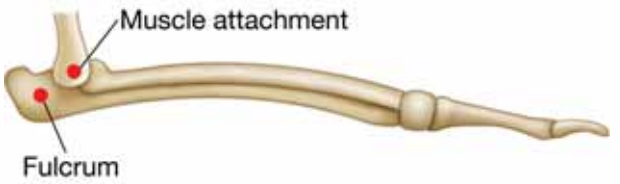
1. What are the different causes of burns?
2. What are the three layers of the skin and what do they contain?
3. What are the different degrees of burns and which layers of the skin do they affect?
4. What types of skin grafts are available to burn patients?

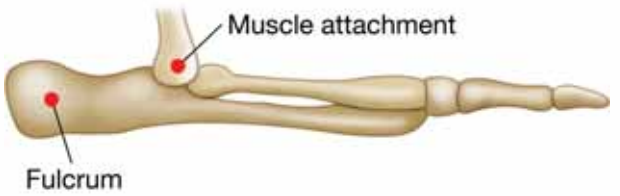
CHAPTER ACTIVITY Leg levers - Digger or Runner?

Some animals do a lot of running, while others spend a lot of their time digging. The way the leg lever is put together for each of these animals is different. In this activity you will find the mechanical advantage of two leg bones and decide which one is from a digger and which is from a runner. For this activity, you will need graph paper with 0.5 cm boxes, a pencil, and a calculator.

What you will do

1. Place a piece of graph paper over the leg bone sketches shown to the right. Trace both leg bones without moving or lifting the paper until all the tracing is done. Begin with the left side of each bone so it starts on one of the graph box lines. This will make it easier to count boxes in the next steps.
2. There are two important measurements to make when comparing the leg levers. One measurement is the distance from the fulcrum to the point of muscle attachment, and the other is from the fulcrum to the opposite end of the bone. Count how many boxes there are from the fulcrum to the muscle attachment point and label this on each sketch. This is the *input distance*.
3. Count how many boxes there are from the fulcrum to the right side of the lever and label this on each sketch. This is the *output distance*.
4. To find the mechanical advantage of each leg bone, divide the *input distance* by the *output distance*. Your number will be less than one.
5. Record the mechanical advantage for each leg bone beside the sketch. There is no unit label for mechanical advantage, because it is a ratio or comparison of measurements.





Applying your knowledge

The leg bone with the higher mechanical advantage can generate more force. The leg bone with the lower mechanical advantage can move quickly.

a. Now that you know the mechanical advantage of each leg bone, which leg bone belongs to the digger? Explain your answer.
b. Which leg bone belongs to the runner? Explain your answer.
c. Levers can be set up in three different ways, depending on where the fulcrum is in comparison to the input and output sides of the lever. Use your textbook to review the three types of levers. What class of lever is represented by the digger and runner leg bones? Explain your answer.
d. Use everyday items like popsicle sticks, fasteners, and rubber bands to model a runner leg lever and a digger leg lever. You may use any materials you wish, but the goal is to make a model that you can use to demonstrate the difference in how the two leg bones generate force and speed.

Chapter 17 Assessment

Vocabulary

Select the correct term to complete the sentences.

appendicular skeleton	bone marrow	extensor
axial skeleton	cancellous bone	flexor
ball and socket joint	compact bone	force
input force	hinge joint	fulcrum
ligament	muscular system	joint
mechanical advantage	tendon	periosteum
output force		

Section 17.1

1. Two muscles usually work together: the _____, which bends the body part, and the _____, which straightens the body part out.
2. Inside the layers of bone, _____ makes blood cells or stores fat.
3. Skull, vertebral column, ribs and sternum make up the _____, while the bones of limbs and girdles make up the _____.
4. The primary function of the _____ is movement.
5. _____ more spongy and not quite as strong as _____.
6. The two types of _____s are fixed and moving.
7. The _____ is a thin membrane that has blood vessels to nourish the bone and nerves.
8. The knee is an example of a _____, whereas the shoulder is an example of a _____.
9. The strand of tough connective tissues that attaches a skeletal muscle to a bone is called a _____.
10. _____ hold bones together at joints.

Section 17.2

11. The fixed point where a lever rotates in called the _____.
12. The _____ is calculated by dividing the output force by the input force.
13. Scientists use the Newton to express _____.
14. A simple machine can be used to create a large _____ with a small _____.

Concepts

Section 17.1

1. Explain why a human has more bones as a baby than as an adult.
2. What are the four major functions of the skeletal system?
3. Name and describe the two parts of the skeletal system.
4. Circle the correct answers to complete the following statement.
   The (pectoral, pelvic) girdle forms the shoulders, while the (pectoral, pelvic) girdle forms the hips.
5. Draw and label a cross section of bone.
6. Predict what might happen to a person that has a disease of the periosteum.
7. Your skull is made up of 22 bones. All but one of the joints is fixed. What is the one movable joint of the skull?
8. Describe the three types of moving joints.
9. Compare and contrast ligaments and tendons.
10. When a person suffers from arthritis, their cartilage is damaged. Why does this make movement painful?

11. Label these muscle movements are voluntary or involuntary: movement of the digestive tract, blinking of the eye, beating of the heart, raising the forearm.
12. Muscle fibers contain thousands of _____ for energy.
    a. endoplasmic reticulum
    b. lysosomes
    c. ribosomes
    d. mitochondria
13. The quadriceps muscle is on the front of the thigh. The hamstring muscle is on the back of the thigh. Explain what happens to the leg when each of these muscles contracts and relaxes.
14. Describe the two types of exercise. Give an example of each.

Section 17.2

15. Give three examples of different forces.
16. Look around your house and school for everyday examples of simple machines. List at least five that you find.
17. What is the difference between input force and output force?
18. Draw and label a lever with these terms: fulcrum, input force, output force.
19. Which of these is not a lever?
    a. pliers
    b. wheelbarrow
    c. ramp
    d. human biceps and forearm
20. Circle the correct answers to complete the statement. The side of the lever that is (longer, shorter) has the (smaller, greater) force.
21. What is the advantage of having a longer output arm than input arm?
22. How are levers classified?
23. Name and describe the three types of levers.
24. Identify each of the following levers as first, second, or third class:
    a. seesaw
    b. wheelbarrow
    c. tweezers
25. Match these descriptions to the correct type of lever:

a. 1st class	1. load - effort - fulcrum
b. 2nd class	2. load - fulcrum - effort
c. 3rd class	3. fulcrum - load - effort

26. Circle the correct answers to complete the statement. In the human body, (bones, joints) act as levers and (bones, joints) can serve as fulcrums.
27. Pick a lever in the human body to describe. Name the class of the lever and identify the fulcrum.

Math and Writing Skills

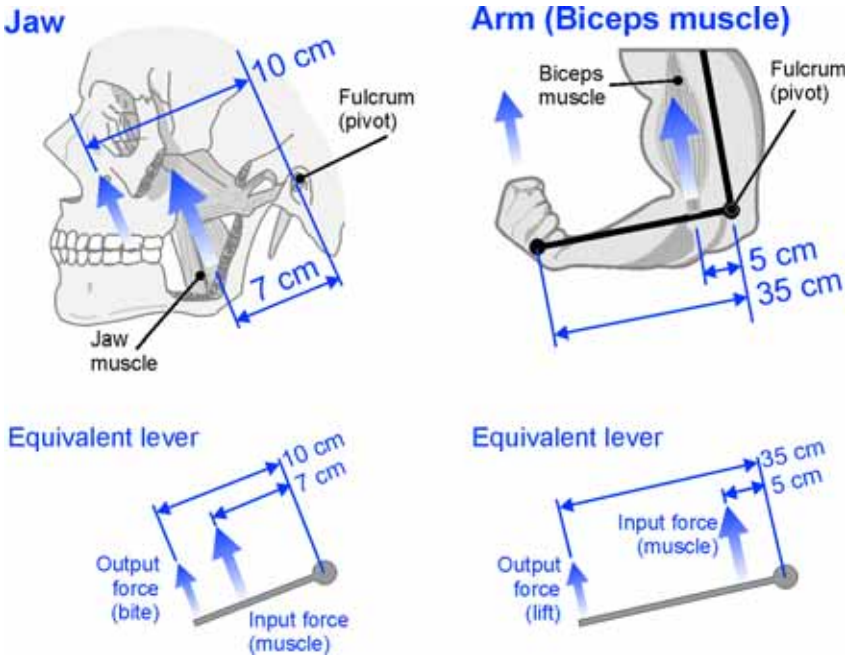
Section 17.1

1. Your friend tells you that bones are non-living things. Is your friend correct? Explain.
2. Write a persuasive paragraph about the importance of calcium to bone development.
3. Since cancellous bone is spongy, it weighs less than compact bone. Predict how an organism's overall body weight would be affected if all bones were made up of only compact bone. How might this be a challenge?

4. Bones are comprised of: 30% living tissue, cells, and blood vessels; 45% mineral deposits; and 25% water. Create a pie graph to show the make up of bones.
5. A male adult's height is 3.84 times the length of his thigh bone. If a male's thigh bone is 18.2 inches long, how is his overall height?
6. Design a robot that will fold the laundry. Make a sketch of your idea and label the types of joints necessary to perform this task.
7. How would your life be different if your involuntary muscles were voluntary? Write about a typical day at school if all your muscles were voluntary.
8. Muscles only pull - they can never push. Explain how it is possible for the human body to push something if this statement is true.
9. Make a poster to show how exercise is important for muscles.
10. your brother is crazy about lifting weights! Try and convince him to include aerobic exercise in his workout routine.
11. While you were training for track season, you reduced your resting heart rate from 82 to 67 beats per minute through daily exercise. How many contractions have you saved your heart each day?

Section 17.2

12. Tim weighs 800.64 newtons. How many pounds does he weigh?
13. Write a short story with as many examples of simple machines as you can. Create a separate answer key so that you can have a classmate try to find the examples.
14. Explain how rowing a boat is an example of a lever. Be sure to identify the location of the input force, output force, and fulcrum.
15. Your jaw works as a lever when you bite an apple. Your arm also works as a lever, as do many of the bones in your body. Using the diagrams below, answer the following questions by analyzing the changes in force and distance.



a. Using the distances shown, calculate and compare the mechanical advantage of the jaw and arm. Which is larger?
b. Suppose the jaw and biceps muscles produce equal input forces of 800N. Calculate and compare the output forces in biting (jaw) and lifting (arm). Which is larger?
c. Suppose you need an output force of 500N. Calculate and compare the input forces of the jaw and biceps muscles required to produce 500 N of output force. Explain how your calculation relates to the relative size of the two muscles.

16. A car gets stuck in the mud. The driver is using a lever to try to get out. If the driver applies an input force of 500 N and the mechanical advantage is 5, what is the output force?
17. Fill in these comparison statements with <, >, or =.
    a. If the mechanical advantage equals 1, the output force _____ the input force.
    b. If the output arm is less than the input force, the mechanical advantage _____ 1.
    c. If the mechanical advantage is less than 1, the output force is _____ the input force.
18. If the mechanical advantage of a lever is 12 N and the length of the input arm is 48 cm, what is the length of the output arm?
19. You just got a job at your local home improvement store! Your first assignment is to give a presentation on the three types of levers. Write an informative description of the types of levers and how they can be used to help with home improvement projects.
20. Write an article for the sports section of a newspaper about a recent sporting event of your choice. Include at least five examples of joints as levers in your article.

Chapter Project

Human Body Presentation

The human body's skeletal and muscular systems are complex and interesting, and for this project, you will choose a topic from the list below to learn more about these systems. Choose a topic, research it, and decide on a way to present your findings. You may decide to write a report, create a poster, build a model, write a poem or song, or put together a short book about what you have learned.

Choose a topic:

- Where did the funny bone get its name, and why does it hurt so much when you hit it?
- What actually makes that sound when you crack your knuckles?
- What does it mean to "pull a muscle", and what should you do to care for this type of injury?
- What is a major disease that can harm that skeletal or muscular system?
- How do X-rays work?
- How do doctors categorize different types of bone fractures?

1. Research your topic and take notes on what you learn. You must use four different sources of information, with no more than two of them being websites. Be sure to list your sources!
2. Create a product, such as a report, mini-storybook, model, poster, or something else of your choice to share what you've learned with your classmates.