



Name _____

Bones as Levers

You may not think of your limbs as being machines, but they are. The action of a muscle pulling on a bone often works like a type of simple machine called a **lever**.

Most of the bones of the **limbs** (arms & legs) act as **levers**. These levers are powered by muscles.

A lever is a rigid rod able to rotate about a fixed point known as a fulcrum, formed by the **joint**. Any **force** applied to the lever is called the **effort**.

A force that resists the motion of the lever, such as the downward force exerted by a weight on the bar, is called the **load** or the **resistance**.

The contraction of the muscles is the **effort** and the part of the body concerned is known as the **resistance** or **load**.

Bones of the body act as levers (a mechanical device) which create a mechanical advantage of **strength** or **speed**.

Types of Levers in the Body

Levers are classified according to the positions of the fulcrum, effort and load or resistance. (See chapter 5 in your textbook to review this information)

There are three classes of levers, identified as **first**, **second**, and **third class** levers. We can tell the classes of levers apart by:

1. The **force** you apply (or the effort you make).
2. An **opposing force** such as a weight, which is usually called the load.
3. The pivot point, or **fulcrum** of the action.

Each of the three types of levers can be found in the human body.

In each type of lever, notice where the fulcrum is located compared to the effort and the load. In your body, the **effort is the force that your muscles apply** to the lever. The **load is the weight that resists the pull of your muscles**.

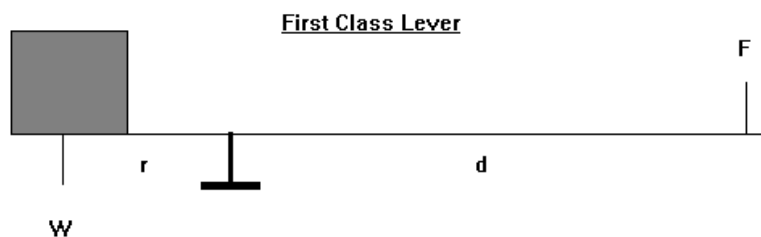
The benefits gained by using a machine is measured by a ratio called mechanical advantage.

Mechanical advantage is a measure of how many times a simple machine multiplies an effort applied to a load. First-class and second-class levers can have a significant mechanical advantage. **Third-class levers** increase distance and speed, but they **cannot increase force**.

Connections between joints, called "synovial joints," are **fulcrums**, the bones they connect are levers, and the muscles attached to them apply force (or resistance).

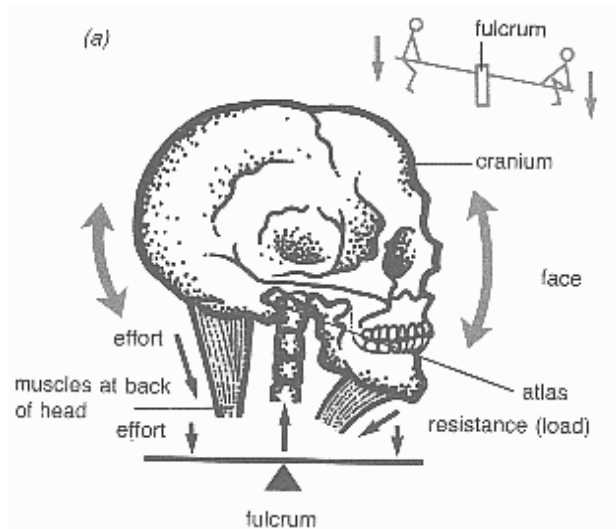
First Class Lever

In a first class lever, the weight and force are *on opposite sides* of the fulcrum:



A small force can be used to **advantage** over a heavy weight if a long force arm or lever arm can be used. Examples of this lever include scissors, crowbars, and teeter-totters.

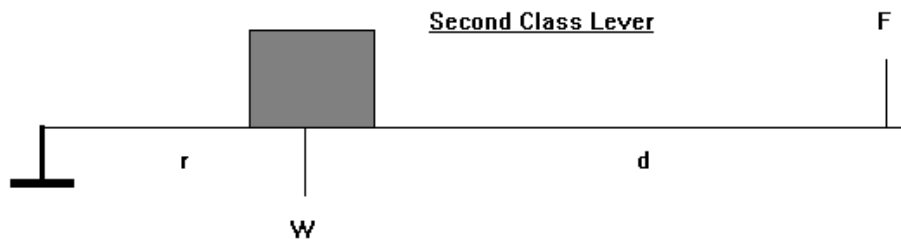
An example of a **first-class lever** is the joint between the **skull and the atlas vertebrae** of the spine: the spine is the fulcrum across which muscles lift the head.



http://www.botany.uwc.ac.za/Sci_Ed/grade10/manphys/skel_mus.htm

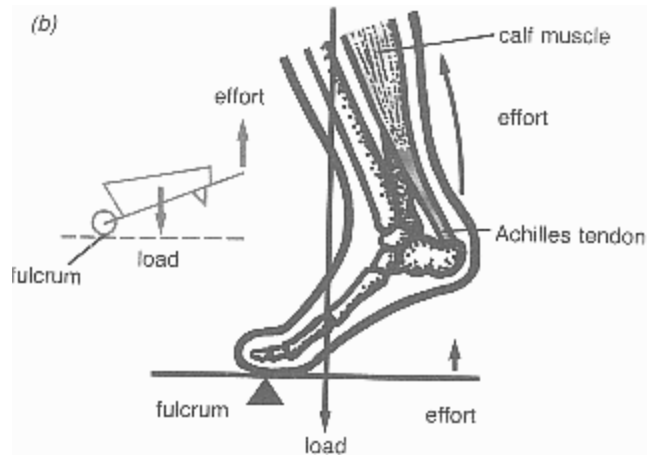
Second Class Lever

In the second class lever, the load is between the fulcrum and the force:



A smaller effort can be used to advantage over a larger weight. An example of this lever is a wheelbarrow.

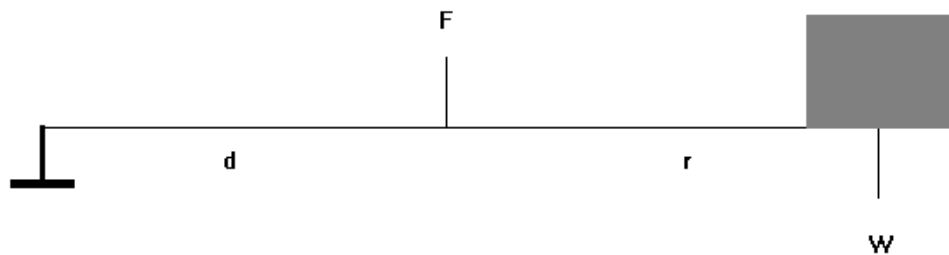
An example in the human body of a **second-class lever** is the **Achilles tendon**, pushing or pulling across the heel of the foot.



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Third Class Lever

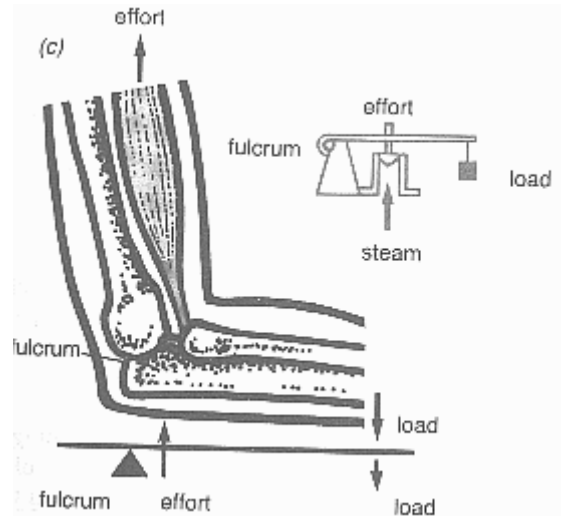
In the third class lever, the force is between the fulcrum and the load:



In this case, there is no force advantage – force is NOT increased. In fact, a larger force is actually needed to move a smaller weight, so there is a force **dis**advantage. The use of this lever is in the *gain in **speed** of movement of the weight.*

Examples of this lever class include: The inside door handle of a car, the coiled spring pulling on a screen door, a pair of finger-nail clippers, and tweezers.

An example of a **third-class** lever in the human body is the **elbow joint**: when lifting a book, the elbow joint is the fulcrum across which the biceps muscle performs the work.



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More Information About Levers & A Brief Review

- ☞ A lever is characterized by a fulcrum, a force arm and a weight arm.
- ☞ The **force arm** is the distance from the fulcrum to the point where force is applied.
- ☞ The **weight arm** is the distance from the fulcrum to the center of gravity of the weight.
 - **First Class Lever:** The fulcrum is between the force and the weight.
 - **Second Class Lever:** The weight is between the fulcrum and the force.
 - **Third Class Lever:** The force is located between the fulcrum and the weight.
- ☞ Most of the movements of the body are produced by third class levers.
- ☞ Third class levers give the advantage of speed of movement rather than strength.
- ☞ Second class levers give the advantage of strength.
- ☞ First Class levers can give the advantage of strength or speed depending on where the fulcrum is located.
- ☞ Since the human body is made up mostly of third-class levers, its movements are adapted more to speed than to strength. (Short force arm/long weight arm)

Forces in the Body

Athletes display some of the wonderful shows of **force** that the human body is capable of performing.

Such force is only possible through the arrangement of the *muscles*, *bones* and *joints* that make up the body's lever systems.

Bones act as the **levers**, while joints perform as living **fulcrums**.




Skeletal muscles create motion by *pulling* on tough cords of connective tissue called **tendons**. These tendons in turn pull on the bone which creates motion.

Muscles move bones through **mechanical leverage**. As a muscle contracts, it causes the bone to act like a lever with the joint serving as a fulcrum

Muscle exerts **force** by converting chemical energy (created during **respiration**) into tension and contraction. When a muscle contracts, it shortens, pulling a bone like a lever across its hinge.

Muscles move and this causes us to move. We are capable of performing a wide variety of movements, but, ***muscle itself moves only by becoming shorter***. They shorten and then they rest - a ***muscle can pull but it cannot push***.

There are almost 700 skeletal muscles of the human body, controlled by a few basic principles involving muscle movements or muscular activity.

-  Skeletal muscles produce movements by pulling on bones or tendons. The tendon gives a very firm anchorage. The point where a muscle is connected to a bone is called the point of **insertion**.
-  The bones serve as **levers** and joints act as **fulcrums** for the levers. Muscles can only contract a short distance, but since they are attached near a joint, the movement at the opposite end of a limb is greatly increased. The biceps muscle of the arm may contract only 89 to 90 *mm*, but the hand will move about 60 *cm*.
-  The **skeletal** or **voluntary muscles act in pairs** rather than singly. One of the muscles produces **contraction** while the other allows **relaxation**. **Flexion** (bending) occurs when contraction causes two bones to bend toward one another, while **extension** (straightening out) occurs from contraction of muscles, resulting in an increase in angle between two bones. Such pairs of muscles are

called **antagonistic**. Often antagonistic muscles are in groups, for example, both the *brachialis* and the *biceps* muscles flex the arm at the elbow and antagonize the triceps, but only when the palm is facing upwards. In pairs or groups of antagonistic muscle, one is usually much stronger than the other. The biceps, which flex the arm are larger and more powerful than the triceps which extends it.

☠ When the body is at **rest**, the some of the antagonistic skeletal muscles remain in a state of contraction, called **muscle tone**, which holds the body in rigid position. If the person becomes **unconscious**, or is asleep, muscle tone is lost as the muscles relax completely.

Questions:

1. A first class lever has the _____ in the middle.
2. Give an example of a first class lever: _____
3. Draw a diagram of a first class lever:

4. A second class lever has the _____ in the middle.
5. Give an example of a second class lever: _____
6. Draw a diagram of a second class lever:




- 7. A third class lever has the _____ in the middle.
- 8. Give an example of a third class lever: _____
- 9. Draw a diagram of a third class lever:

- 10. For **EACH** of the three classes of levers, explain the advantage gained by using this type of lever.

- 11. What type of lever do we find most often in the human body?

- 12. Explain how a muscle exerts force:

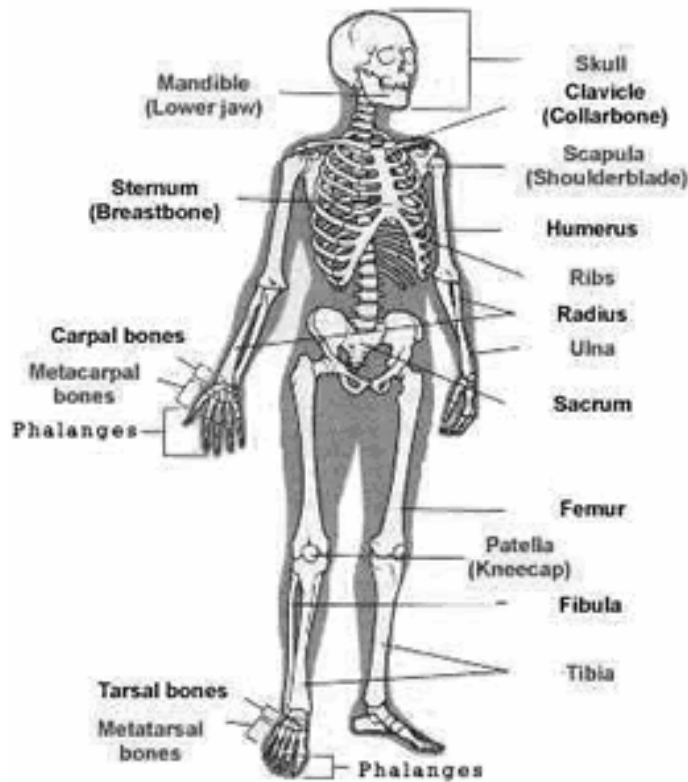
13. Examine the following diagrams, write down next to each picture which class of lever the picture represents and explain why:

Lever in the body:	Type of lever and why:
 <p>Calf muscle</p> <p>Stand on tiptoe</p>	
 <p>Look upwards</p>	
 <p>When the muscle contracts, it flexes the limb at the joint</p> <p>Lift an object</p>	

14. Describe each of the following:
- a. Advantage (mechanical advantage)
 - b. Antagonistic
 - c. Effort
 - d. Extension
 - e. Flexion
 - f. Force
 - g. Force arm
 - h. Fulcrum
 - i. Insertion
 - j. Joint
 - k. Levers
 - l. Limbs
 - m. Load
 - n. Muscle tone

- o. Resistance
- p. Tendon
- q. Weight arm

15.



Circle and label each one example of each class of lever on the skeleton.

Label the fulcrum, effort and load for each class of lever.