Chapter 12
Bones and joints

Unit
1B

Unit content

Body systems
Organs within systems are organised for efficient functioning and interaction.

Systems:
- principal organs within the main body systems
- structural layout of at least two systems related to efficient functioning
- interaction between systems
- efficient functioning related to different structures in systems *e.g. types of bones and joints in the skeletal system*.

Figure 12.1 X-rays of a knee joint

The 206 bones of the adult skeleton form a framework on which the other organs of the body are arranged. However, the bones do much more than provide support. They are living organs that are used for protection of vital body parts, storage of materials and manufacture of blood cells (see Chapter 11).

In this chapter we look in more detail at the types of bones, how they are connected to each other and the role of the bones and muscles in movement.

Types of bones

Bones can be classified by their size and shape.

Long bones

Long bones are found in the arms, legs, hands and feet. They are the typical bones that we see drawn in comics and cartoons. Each has a shaft and two ends that are wider than the shaft (see Fig. 12.2). The shaft is hollow and, in a living bone, is filled with yellow bone marrow. **Yellow marrow** is rich in fat and is an important store of

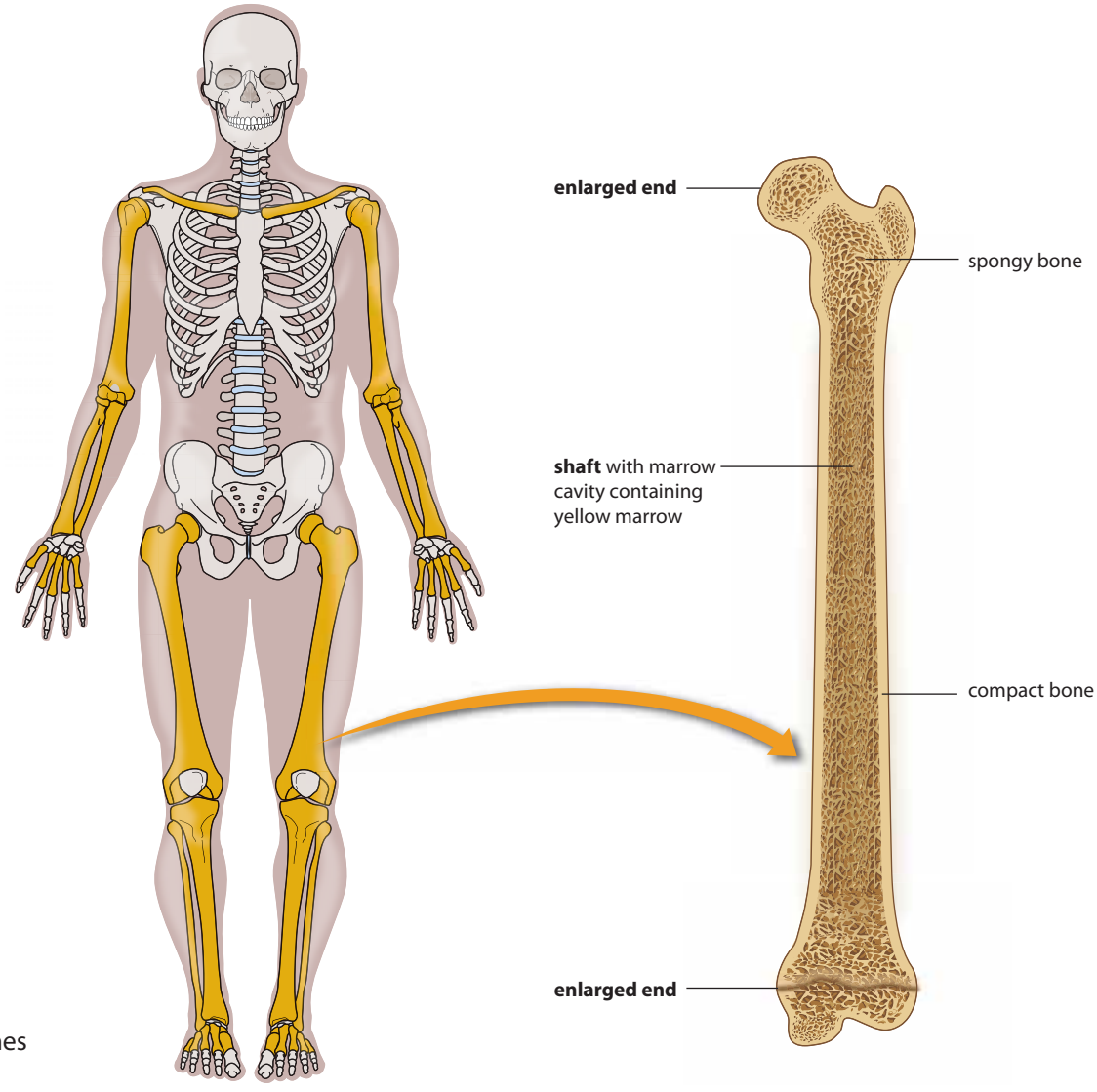


Figure 12.2 Long bones and their location

energy. The enlarged ends of long bones provide space for the attachment of muscles. Inside the ends is spongy bone that has spaces filled with red marrow.

Examples of long bones are the collar bone, the bones of the arms and legs and the bones in the palm of the hand and the sole of the foot.

Short bones

Short bones are shaped roughly like a cube. They give strength and compactness but only limited movement. The bones of the wrist and ankle are short bones (see Fig. 12.3). Some people also classify the knee cap as a short bone. Although movement between the wrist and ankle bones is limited, there are so many short bones that the wrist and ankle are quite flexible.

Find out more about bones and their scientific names at http://www.innerbody.com/image/skelfov.html

Flat bones

Flat bones are in the form of broad, flat plates. Their shape provides either protection or a large surface for attachment of muscles (see Fig. 12.4). The flat bones of the skull provide protection for the brain, while the ribs and breastbone protect the heart and lungs. The shoulder blade and pelvis (also flat bones) have a large surface for attachment of muscles.

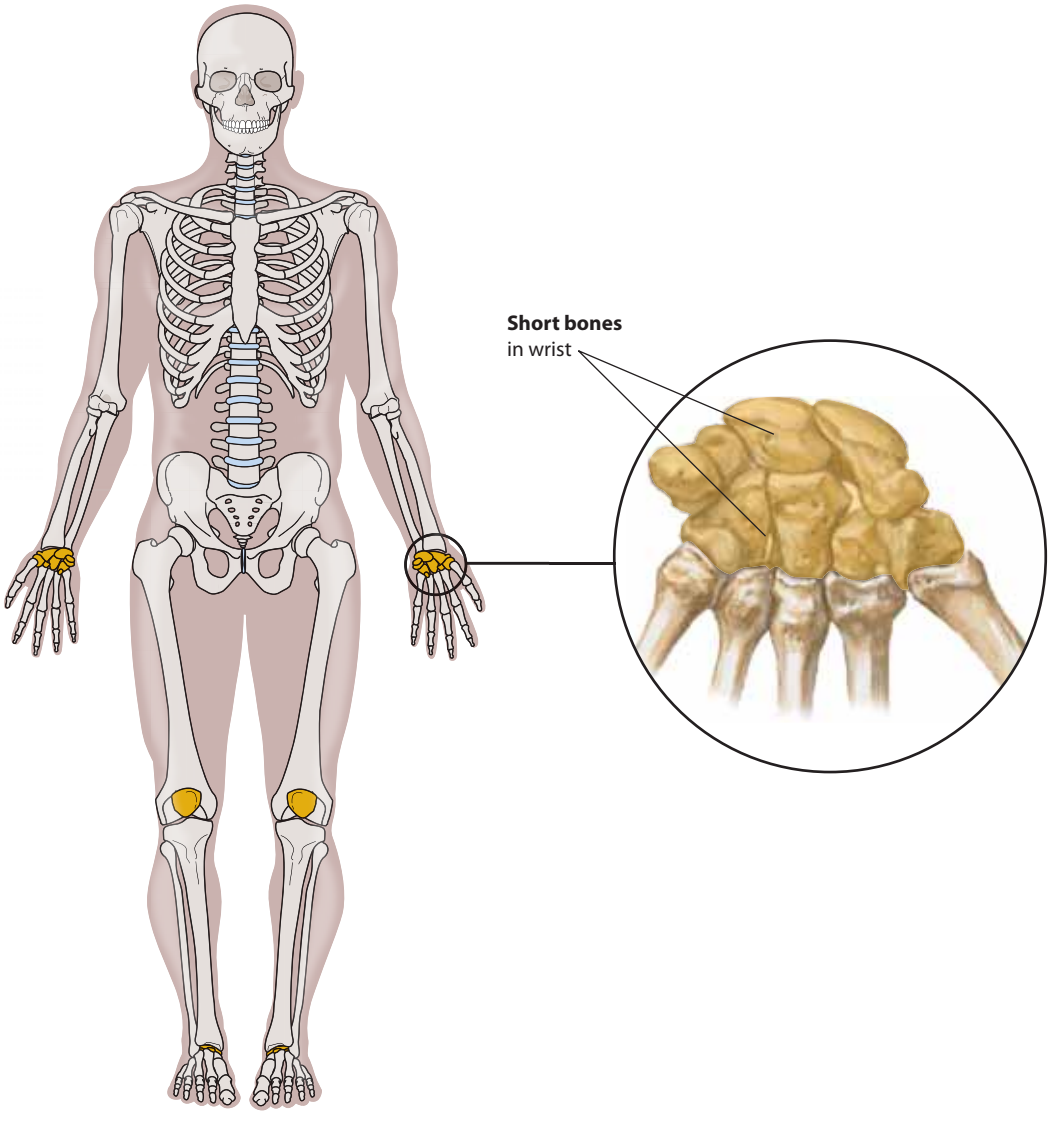


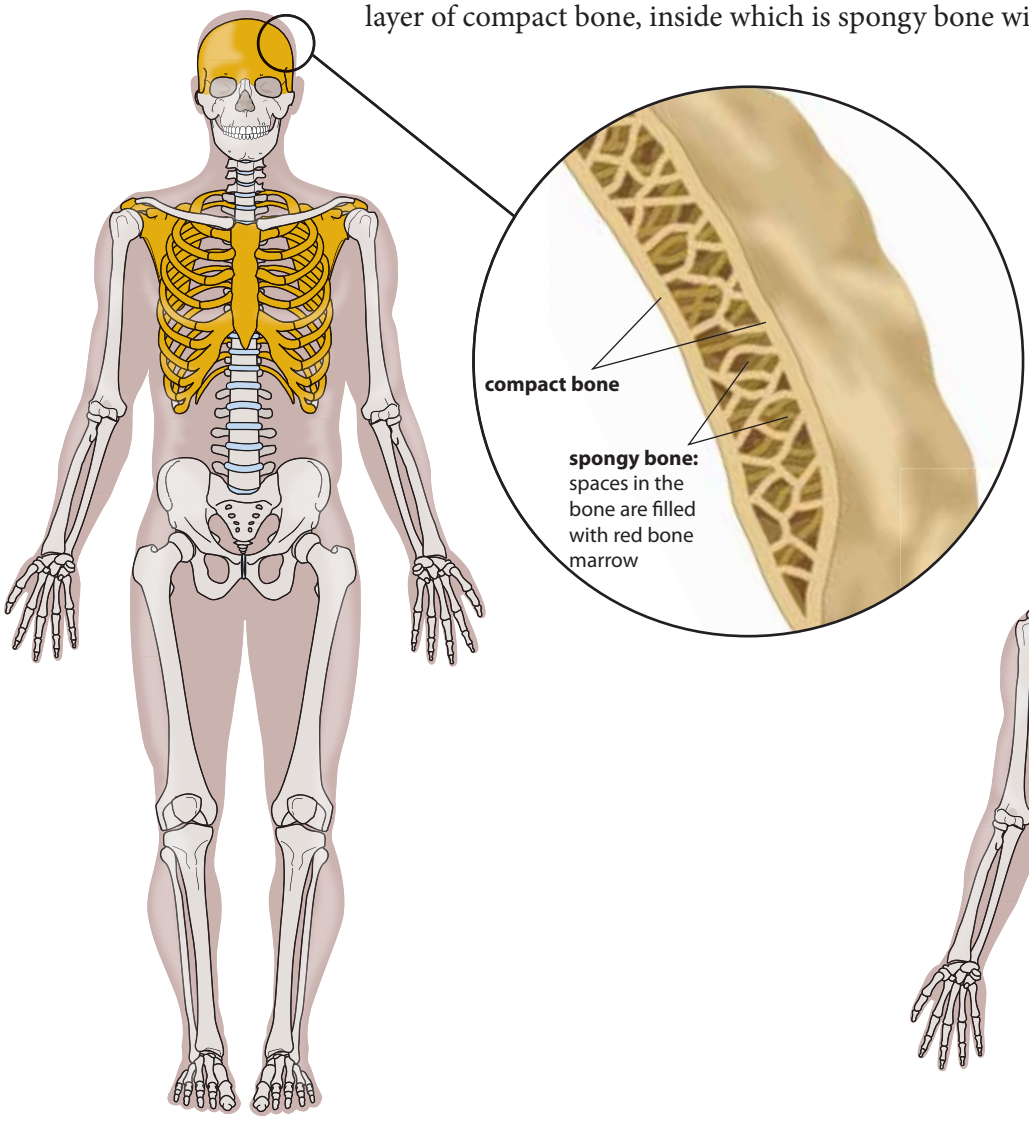
Figure 12.3 Short bones and their location

Flat bones consist of two plates of compact bone between which is a layer of spongy bone (see Fig. 12.4). The spaces in the spongy bone are filled with **red marrow**, which is where blood cells are produced.

Irregular bones

Irregular bones have complex shapes that cannot be described as long, short or flat. They include the vertebrae, which make up the backbone, some of the skull bones and the upper and lower jaw bones (see Fig. 12.5). Irregular bones have a thin outside layer of compact bone, inside which is spongy bone with red marrow.

Figure 12.4 Flat bones and their location



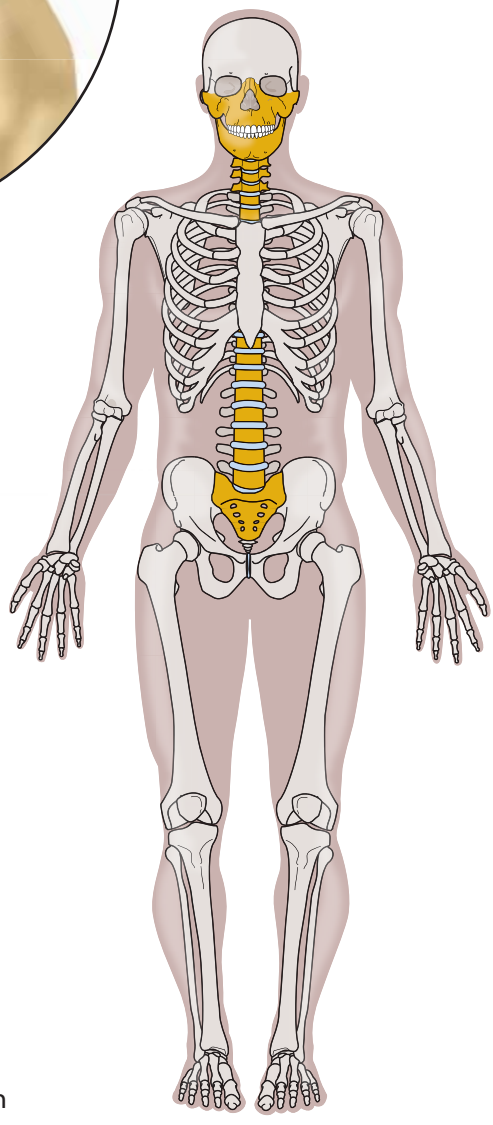


Figure 12.5 Irregular bones and their location

Cartilage

Bone and cartilage are connective tissues (see Chapter 4). In connective tissues the cells are usually separate from one another. The spaces between the cells are filled with non-cellular matrix. In bone the matrix is hard and solid, but in cartilage it is flexible (see Fig. 12.6).

Cartilage occurs in parts of the adult skeletal system where flexibility is required. Most bones also start off as cartilage. During foetal development and during childhood the cartilage changes into bone.

Cartilage forms the external ear and the tip of the nose. Feel an ear and the tip of your nose. They are flexible but firm enough to be held in shape. Cartilage also forms the larynx (voice box or Adam's apple) and the rings that hold the windpipe open and covers the surfaces of bones where they join each other.

Figure 12.6 Cartilage as seen under a microscope

Joints

A **joint** is where two or more bones come together. The hyoid bone, a small bone in the neck, is the only bone that does not have a joint with any other bone.

When we talk about joints, we are usually thinking of places in the skeleton where movement occurs. However, some joints are quite rigid and the bones do not move at all.

Joints may be classified by their structure and by the type of movement that can occur at the joint.

Types of joints

- **Fixed** or **fibrous joints** allow no movement between the bones. These joints occur between the bones of the skull and between the teeth and the jaw.
- **Slightly movable** or **cartilaginous joints** allow a little movement between the bones. These joints occur between the vertebrae, between the ribs and the breastbone, between the tibia and fibula in the lower leg and where the pelvis joins at the front.
- **Freely movable** or **synovial joints** allow large movements between the bones. Freely movable joints may be classified as **ball-and-socket**, **hinge**, **pivot** or **gliding joints**. These joints occur at the shoulder, elbow, wrist, fingers, hip, knee, ankle and toes.

X-rays of joints can be seen at http://www.accessexcellence.org/RC/VL/xrays/index.php

Descriptions of all of these joints are given in Figure 12.7.

Ligaments are the tough, elastic connective tissues that join the bones to one another.

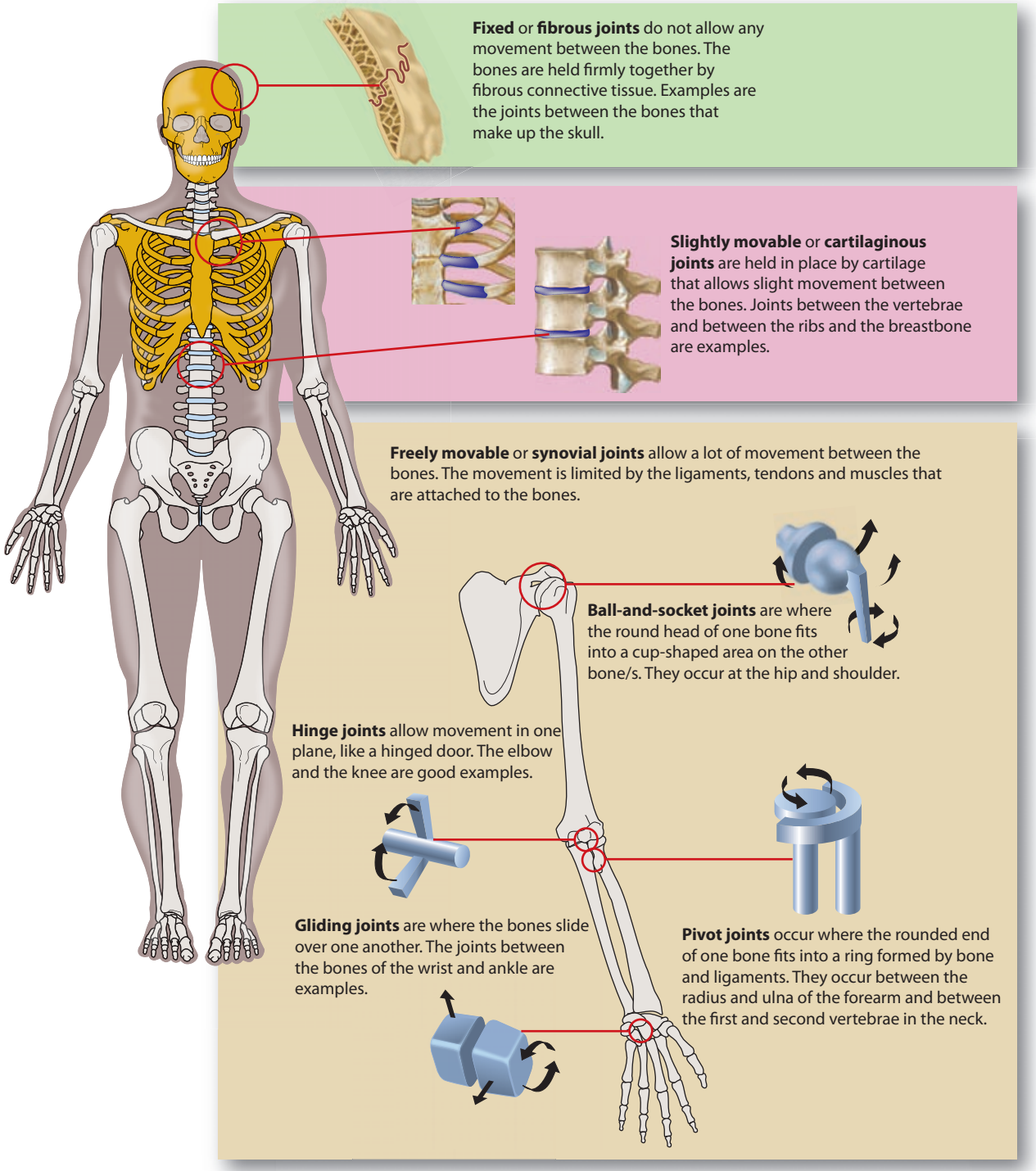


Figure 12.7 Types of joint

Structure of a synovial joint

Freely movable joints are also called synovial joints because there is a space, or **synovial cavity**, between the joint surfaces of the bones. The synovial cavity is surrounded by a **synovial membrane** that secretes synovial fluid. **Synovial fluid** fills the joint cavity. It lubricates the joint and also provides nutrients for the cells of the cartilage that covers the bones at the joint (see Fig. 12.10).

Figure 12.8 An X-ray of the knee joint, an example of a hinge joint

Figure 12.9 An X-ray of the hip joint, an example of a ball-and-socket joint

The cartilage covering the joint surfaces of the bones protects the bone. It is very smooth, and with lubrication from the synovial fluid it reduces friction when the bones move.

Joint disorders

Arthritis

Arthritis is a general term that covers many different types of inflammation of the joints. The most common forms of arthritis are rheumatoid arthritis and osteoarthritis.

Rheumatoid arthritis is a severe form of arthritis, involving inflammation of the joint, swelling, pain and loss of movement. It tends to affect the small joints of the body, such as those of the hands, feet, knees, ankles, elbows and wrists. Rheumatoid arthritis begins with inflammation of the synovial membrane of the joint, causing swelling and pain. Abnormal tissue is produced by the synovial membrane. It grows over the surface of the joint cartilage and can destroy the cartilage completely or, in some cases, erode the bone itself. Movement at the joint becomes very restricted.

Osteoarthritis is a gradual change in the joints that occurs far more frequently than rheumatoid arthritis. However, it is usually less damaging and appears to result from a combination of factors, including ageing, irritation of the joints, wear and abrasion. In this disease the joint cartilage deteriorates and bony spurs develop from the exposed ends of the bone forming the joint. These spurs decrease the space within the joint cavity, restricting the movement of the joint.

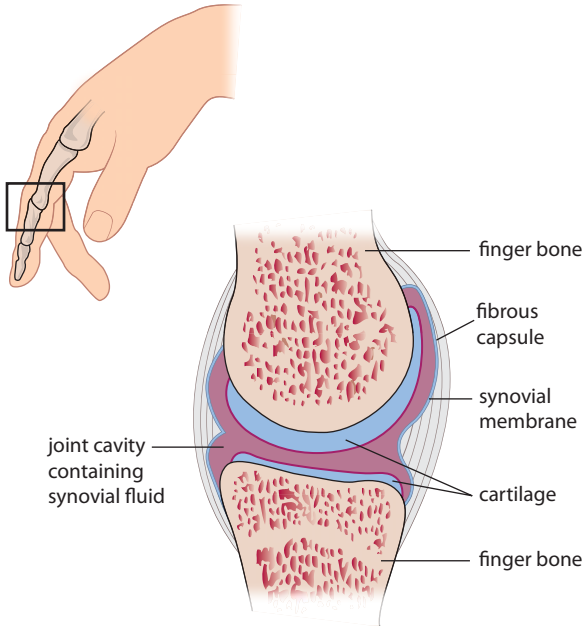


Figure 12.10 Structure of a simple synovial joint

Figure 12.11 Rheumatoid arthritis

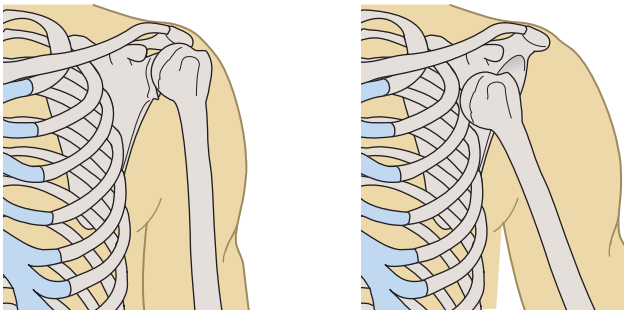


Figure 12.12 A normal (left) and a dislocated shoulder (right)

Dislocations

A **dislocation** occurs when a bone is displaced from a joint with the tearing of ligaments, tendons or the joint capsule. The most commonly dislocated joints are those of the shoulder (see Fig. 12.12), thumb and fingers. Symptoms include loss of motion, temporary paralysis of the joint, pain and swelling. Dislocations usually follow a severe blow or heavy fall.

Sprains

Twisting or forced movement at a joint may cause a ligament to tear or separate from its bony attachment, resulting in a **sprain**. There may also be damage to the associated blood vessels, muscles, tendons, ligaments and nerves. Usually there is considerable swelling and pain, with a reddish or blue colour due to bruising. The ankle joint is the most frequently sprained, followed by the lower back area.

Movement at a joint

The bones act as levers that can be pulled by the muscles (see Fig. 12.13). Muscles are attached to the bones of the skeleton by connective tissue called **tendons**. Tendons are not elastic; they cannot be stretched.

Where the bones meet at joints, muscles are attached to the bones in such a way that they bridge the joints. When muscle contraction occurs the bones move. Remember, though, that muscles can only contract.

> Muscles can pull bones together but they cannot push them apart. If muscles contract, pulling a bone in one direction, another set of muscles must contract to pull the bone in the opposite direction. Thus, the muscles that move the parts of the skeleton are always grouped in pairs.

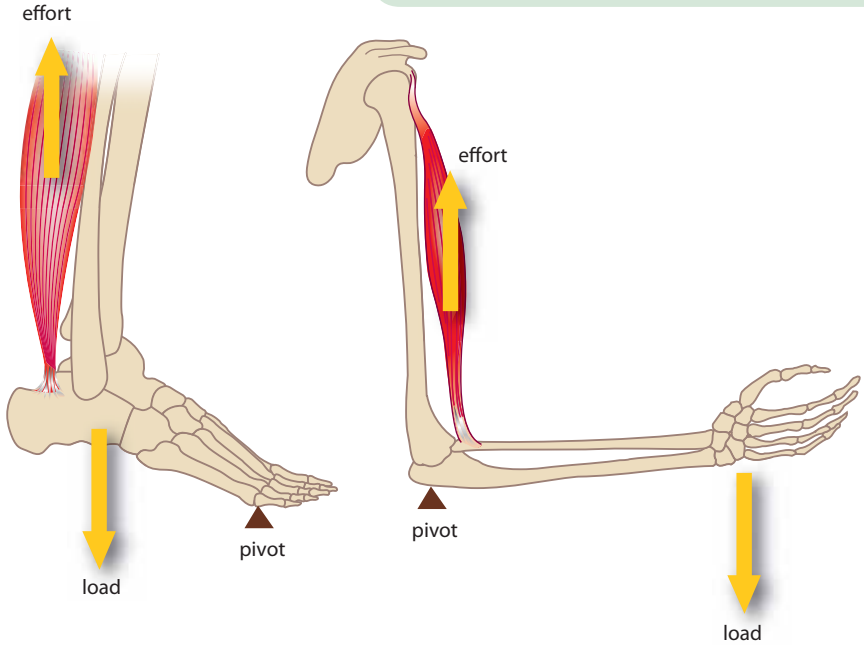


Figure 12.13 Bones are arranged to work as levers; two different types of lever are shown here

Such pairs of muscles are called **antagonists** because they have opposite actions. A good example of an antagonistic pair of muscles is the muscles of the upper arm. Figure 12.14 shows how the muscles in the upper arm work together to bend and straighten the arm at the elbow.

Muscles that bend a limb are called **flexors**. Muscles that straighten a limb are called **extensors**. The end of a muscle that is joined to the stationary bone is the **origin**. The end of a muscle that is attached to the moving bone is the **insertion**.

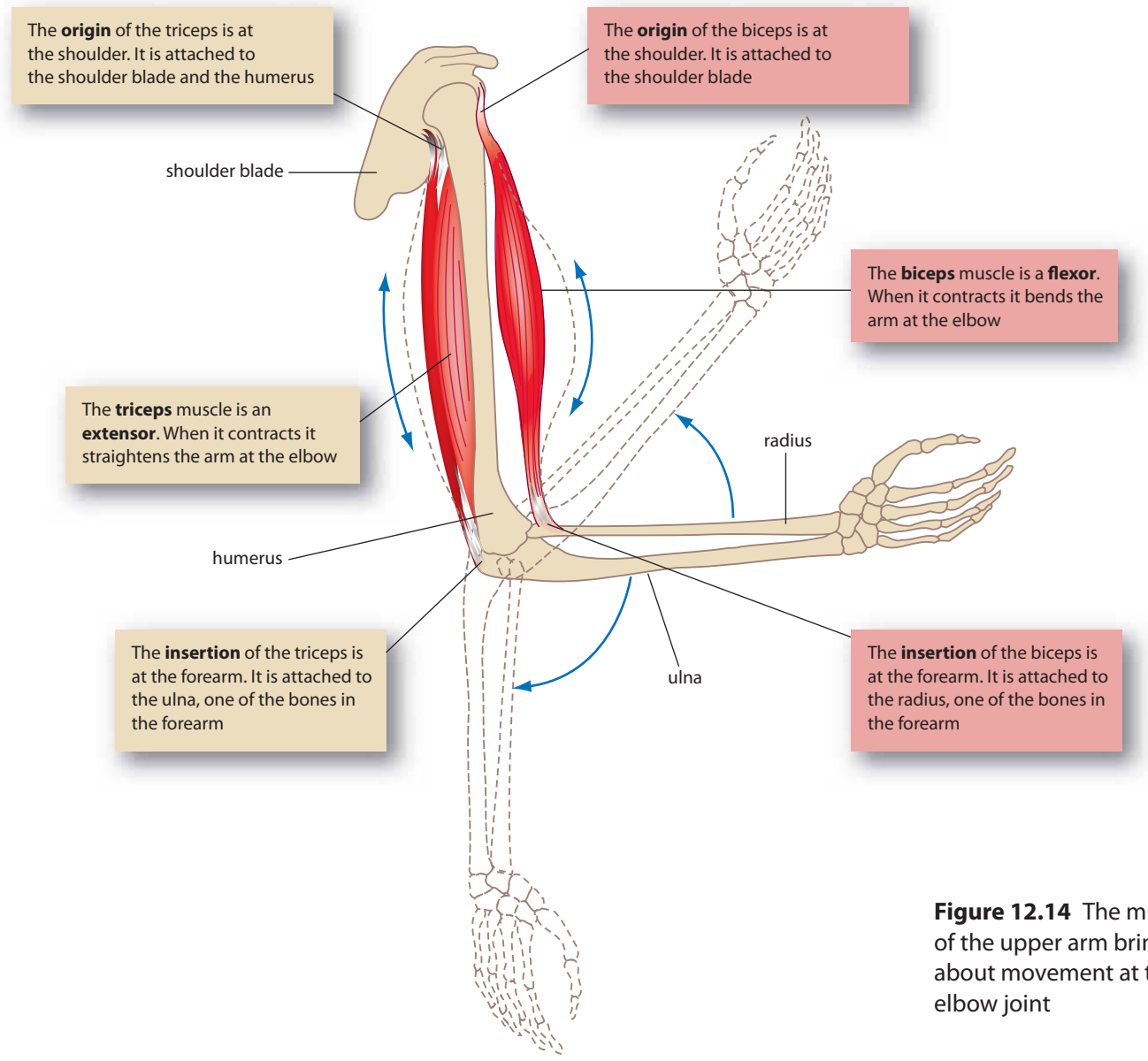


Figure 12.14 The muscles of the upper arm bring about movement at the elbow joint

Systems working together

Although we divide the body up into systems such as the digestive system, circulatory system and nervous system, none of these systems work in isolation. They all work together and depend on each other.

Movement of body parts, such as when walking or lifting, is a good example of body systems working together. The muscles of the *muscular system* pull on the bones of the *skeletal system* so that movement occurs at the joints. Muscles need energy from cellular respiration to contract. The glucose and oxygen for respiration is delivered by blood in the *circulatory system*. The blood gets its oxygen via the *respiratory system* and its glucose via the *digestive system*. Wastes produced by the contracting muscles are removed by the *excretory system*. The muscles are made to contract and relax by nerve impulses from the *nervous system*. You may be able to think of other links between the body systems.

Working scientifically

Activity 12.1 A long bone

We often think of bone as being dry and non-living. This is not the case. In this activity you will study the structure of a long bone to see how well it is suited to its functions of support and movement when pulled by the muscles attached to it.

You will need

An uncooked long bone (from a cow or a sheep); a long bone cut lengthwise (in longitudinal section); a hand lens or magi-lamp

What to do

1. Examine the bone carefully and observe the smooth, bluish-white coverings on the ends. This is the joint cartilage.
2. Around the bone is a sheath of fibrous tissue. Locate any blood vessels in the fibrous sheath and any places where muscles may have been attached. Muscles will appear as red meat attached to the sheath.
3. Examine the longitudinal section of bone with a lens and identify the marrow cavity, the spongy bone and the compact bone.

Studying your observations

1. Describe the function of the joint cartilage. How does the location of the cartilage, and its texture, suit it to its function?
2. What is the purpose of the blood vessels in the sheath around the bone? Why does bone require a blood supply?
3. Describe how muscles are attached to the bone.
4. Explain the differences in location and structure of the spongy bone and the compact bone. Relate these differences to the functions of the two types of bone.
5. Why aren't long bones solid? What is the purpose of the marrow cavity? Describe the marrow that fills the marrow cavity.
6. Draw a diagram of a longitudinal section of a long bone. Label the following structures on your diagram: sheath, joint cartilage, head, shaft, compact bone, spongy bone, marrow cavity.

Activity 12.2 Where bones meet

Joints occur wherever one bone meets another.

You will need

Model skeleton; X-rays of joints (if available)

What to do

Examine the skeleton for places where bones meet each other and answer the questions below.

Studying your observations

1. Describe any places where immovable joints occur in the skeleton.
2. Describe how movement is prevented between the bones of the skull.
3. The joints between each vertebra are only slightly movable but the vertebral column is able to bend quite a lot. Explain how this bending is possible.
4. How is excessive movement prevented between the bones of the vertebrae?
5. Two bones of the pelvis meet at the front in a joint which, in males, is almost immovable. In females, the same joint has cartilage, which is more elastic and which allows greater flexibility. Suggest a reason for this difference between males and females.
6. Which bones are involved in the ball and socket joint at the shoulder?
7. Move your arm at the shoulder. Is there any movement that the shoulder joint does not permit?
8. Examine the structure of the ball and socket joint at the hip and explain why its freedom of movement differs from the shoulder joint.
9. Bend and straighten your arm at the elbow. Through what angle is movement possible? What prevents movement through a greater angle?
10. Why are there such a large number of small bones in the wrist and ankle?
11. Describe the structure of the joint that allows you to nod your head.
12. Describe the structure of the joint that allows you to turn your head from side to side.

Activity 12.3 Muscles working together

Refer to Figure 12.14 and note that one end of the biceps muscle is fixed to the shoulder blade while the other end is attached to the bone in the forearm. The muscle at the back of the upper arm, called the triceps, is fixed to the shoulder blade and to the upper arm bone at one end, and to a forearm bone at the other. To move the forearm at the elbow joint, these two muscles must cooperate. When the biceps contracts to bend the arm, the triceps must relax; the opposite occurs when the arm is straightened.

This activity gives you the opportunity to investigate the operation of the upper arm muscles yourself.

1. Hold a book in one hand with your arm by your side. Place your other hand around your biceps muscle. Bend your arm at the elbow until your arm is fully bent.
   - **(a)** Describe any change in the shape and feel of the biceps muscle as you bend your arm.
   - **(b)** Which end of the muscle remained stationary as you bent the arm? (This is the origin of the muscle.)
   - **(c)** Which end of the muscle moved (the insertion)?
2. With your arm still fully bent, and still holding the book, place your other hand underneath your upper arm to feel the triceps muscle.
   - **(a)** Describe the shape of the triceps and what it feels like.

   Straighten your arm. The triceps will then contract while the biceps relaxes.
   - **(b)** Describe the shape of each muscle and how each feels as the arm straightens.
3. Bend your arm halfway and clench your fist tightly as if holding a very heavy weight. Both muscles are now contracting together. Describe the shape of the muscles and how they feel in this situation.

4. Bend your elbow once more and with your free hand feel inside of your elbow. You will feel the tendon that attaches the biceps to the bone in the forearm. Describe the feel of the tendon. How does its feel and shape differ from that of the muscle?
5. Clench your fist and feel the tendons on the inside of your arm just above the wrist.
   (a) Where are the muscles to which these tendons attach?
   (b) To which bones would those tendons be connected?

REVIEW QUESTIONS

1. **(a)** How are bones classified?
   (b) Describe the types of bone and give an example of each.
2. **(a)** Describe how cartilage differs from bone.
   (b) List places in the body where cartilage occurs.
3. Describe the three main types of joint.
4. **(a)** Draw and label a diagram of a synovial joint.
   (b) What is the function of the fluid in a synovial joint?
5. What is the difference in function between tendons and ligaments?
6. Explain the difference between a dislocation and a sprain.
7. Why do skeletal muscles work in pairs?
8. What is the difference between:
   (a) a flexor muscle and an extensor muscle?
   (b) the origin and insertion of a muscle?

APPLY YOUR KNOWLEDGE

1. Why is it necessary for the human skeleton to have joints?
2. Six types of joints are described in this chapter. Rank them from the type that allows the least movement between bones to that which allows the greatest movement.
3. Draw up a four column table to compare the types of joints—fixed, slightly movable and the four types of freely movable joints. Compare the joints under the following headings: type of joint, characteristics of the joint, examples, diagram.
4. The ribs are joined to the breastbone with cartilage. Suggest why this is so.
5. Many footballers and other sportspersons undergo a knee reconstruction. Use the Internet to find out why knee reconstructions are necessary. Find out what is done to reconstruct the knee.
6. Many older people, suffering from arthritis, need a hip or knee replacement. Use the Internet to find out what is done in a hip or knee replacement.