

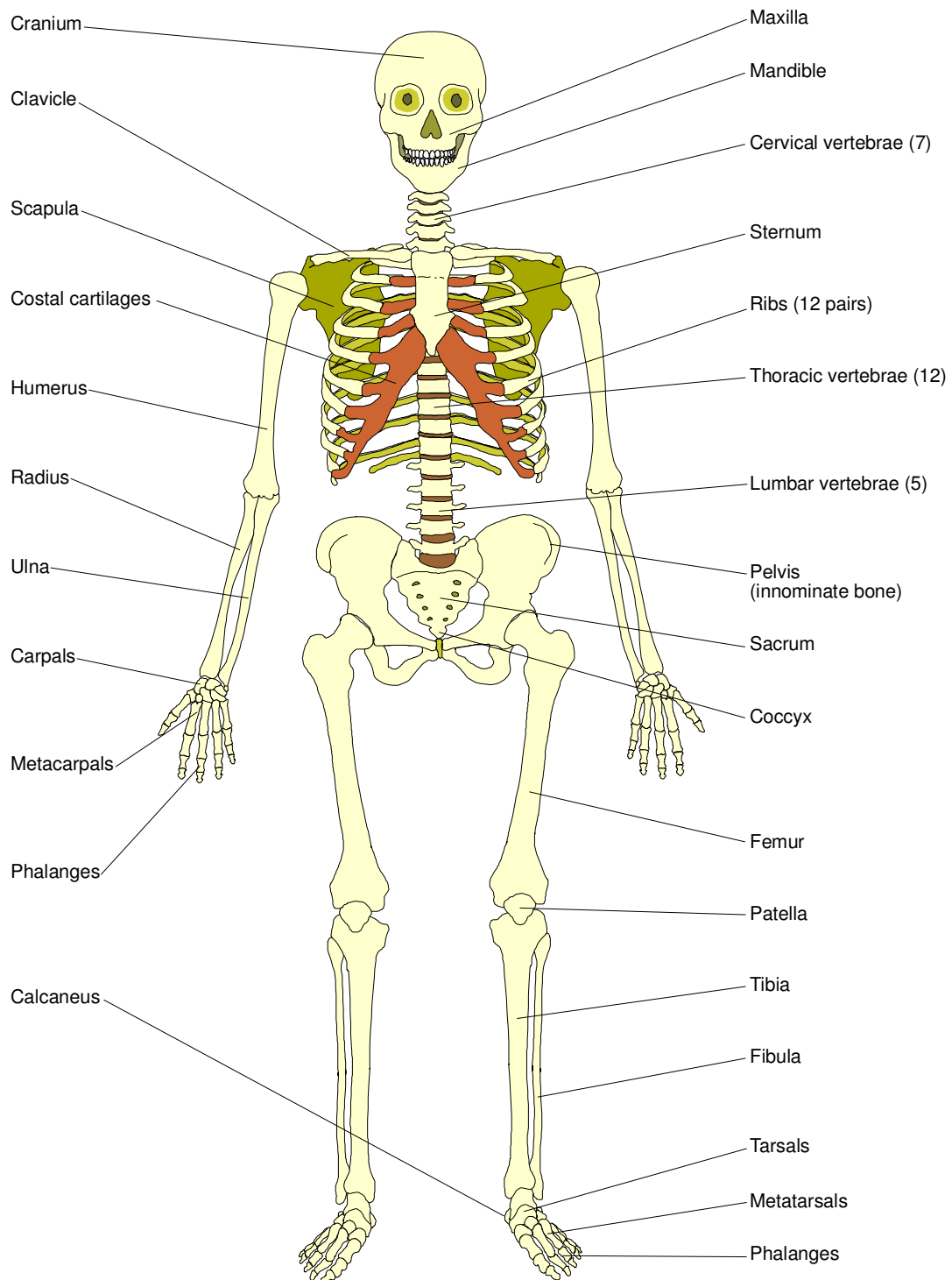
# The Skeletal System

## The Joints

# The Skeletal System

Figure 3 - 1 the skeleton

Frontal view, showing the principal bones of the skeleton



The *skeletal system*, or *skeleton*, [Figure 3 - 1] provides the main support for the body and the other systems. It maintains the body's shape, and provides protection for some organs. It also provides attachment points for the voluntary muscles, allowing movement, and giving rigidity where required.

In addition to this, marrow inside bones produces blood cells and acts as a reservoir for calcium.

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## Classifications of Bones

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Bones are classified according to their shape:

**Long bones.** These form the bones of the limbs. They have a length much greater than their widths.

**Short bones.** These are of approximately equal length, width, and thickness. They occur in the wrists and ankles. (carpal and tarsal bones)

**Flat bones.** These tend to be thin, and have relatively large surface areas. They are found as the scapulae, sternum, ribs, and in the skull.

**Irregular bones.** These have extensions (processes) for muscle attachment. They are found as vertebrae, facial bones, and pelvic bones.

**Sesamoid bones.** These are the small bones found at joints (such as the patella at the knee). They provide protection to the joints. They are usually located within the tendons which pass over the joints. They provide additional leverage to the muscles, thus increasing the efficiency of the joints and associated muscular movements.

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## Construction of Bones

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### Bone Tissue

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*Bones* are formed from a specialised connective tissue with immense strength for its weight.

The strength (and a small flexibility) is derived from a matrix structure of collagenous fibres within the bone tissue.

Bone tissue is grouped into two types:

**Compact bone.** This forms the hard, dense outer shell of a bone.

Compact bone is formed from layers of bone tissue, and although appearing solid, is perforated by a network of minute tunnels, known as *Haversian canals*, which carry blood vessels and nerves.

**Cancellous bone.** This forms the interior bone structure.

Cancellous bone takes the form of an open interlaced pattern of tissue which is able to withstand considerable stress.

All bones are encased in a fibrous membrane known as *periosteum*.

At moveable joints, the periosteum is replaced by *articular cartilage*, formed from hyaline cartilage.

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## Basic Anatomy of a Bone

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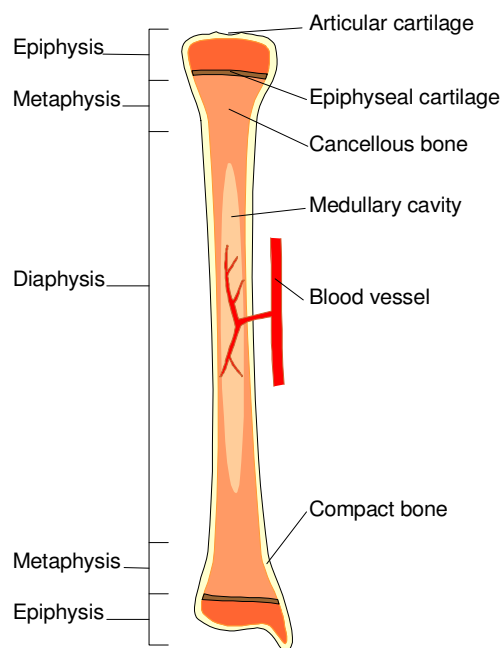
Long bones all have similar basic anatomy.

[Figure 3 - 2]

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**Figure 3 - 2** a long bone

A longitudinal section of a typical long bone



### Diaphysis

The *diaphysis* is a tube of compact bone. The inner area houses the medullary cavity which is filled with *yellow bone marrow*, composed mainly of adipose tissue.

### Epiphysis

The *epiphyses* form the ends of the bone. Where the bone articulates with another at a joint the surface of the epiphysis is covered with articular cartilage.

The inner area of the epiphysis is filled with cancellous bone tissue, the porous latticework of which contains red bone marrow. The *red bone marrow* is a production centre for blood cells.

### Metaphysis

The *metaphysis* forms a transitional area between the epiphysis and the diaphysis.

The *epiphyseal cartilage* separates the interiors of the two sections.

Other classes of bone are composed of outer layers of compact bone, enclosing cancellous bone, which contains red bone marrow.

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## Axial Skeleton

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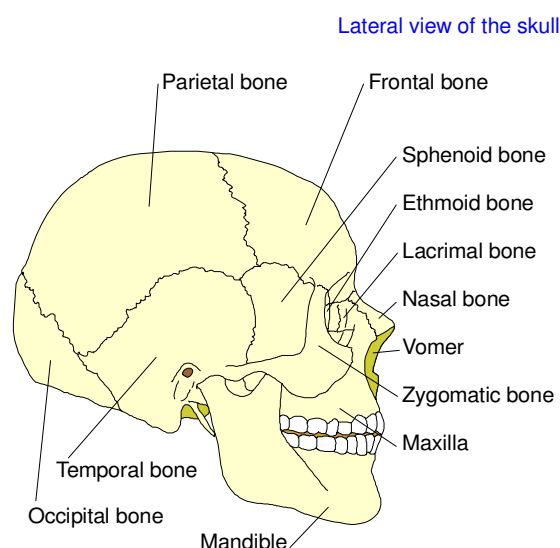
The *axial skeleton* comprises the bones of the skull, the spine, and the ribcage.

### Skull

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The *skull* [Figure 3 - 3] is made up from a series of bones, fitting closely together with immovable joints, or sutures.

**Figure 3 - 3** the skull



The skull may be divided into two areas: the cranium, and the face.

#### Cranium

The *cranium* is made up from the *frontal bone*, two *parietal bones*, two *temporal bones*, the *ethmoid bone*, the *sphenoid bone*, and the *occipital bone*.

The top of the structure is not solidly closed until the second year after birth.

#### Face

The *face* is made up from two *nasal bones*, two *lacrimal bones*, the *maxilla* (which is formed from two bones fused together), the *vomer*, and two *zygomatic bones*.

The interior nasal cavity is bordered by two *palatine bones*, and two *inferior conchae*.

The *mandible*, which forms the lower jaws is made up from two bones fused at the midline.

(The mandible is considered as part of the face as it is jointed to the skull).

The *condyloid processes* of the mandible articulate with the temporal bone on each side of the skull, forming the *temporomandibular joints*.

The lower maxilla and upper mandible edges provide the sockets for the teeth.

### Sinuses

The ethmoid, maxillary, frontal, and sphenoid bones all include cavities, or *sinuses*.

These sinuses - eight in total - contain air and connect to the nasal cavity. They are lined with ciliated mucous membrane.

Sinuses have the dual purpose of acting as resonance chambers in voice production, and of reducing the overall weight of the skull.

Also included with the skull are:

The *ossicles of the ear* - small bones which form part of the mechanism of hearing.

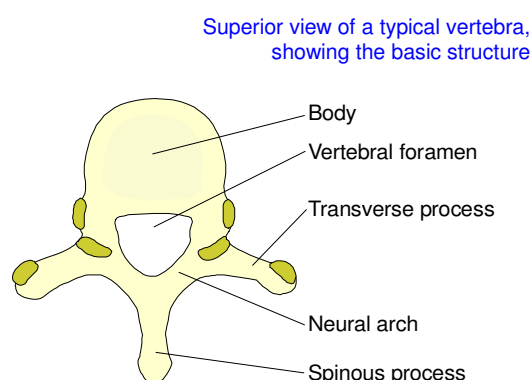
The *hyoid bone*, which is suspended above the larynx, and forms an attachment point for various muscles.

### Spine

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The *spine* is made up from 33 *vertebrae*. Although the vertebrae have varying shapes depending on their position in the spine, they all have the same basic structural features. [Figure 3 - 4]

**Figure 3 - 4** a vertebra



Each vertebra has a rounded body, anterior to a hollow ring, the *vertebral foramen*, which is enclosed by the *neural arch*. The vertebral foramina form a channel throughout the length of the spine. The spinal cord runs in this channel.

Lateral and posterior processes are attached to the neural arch.

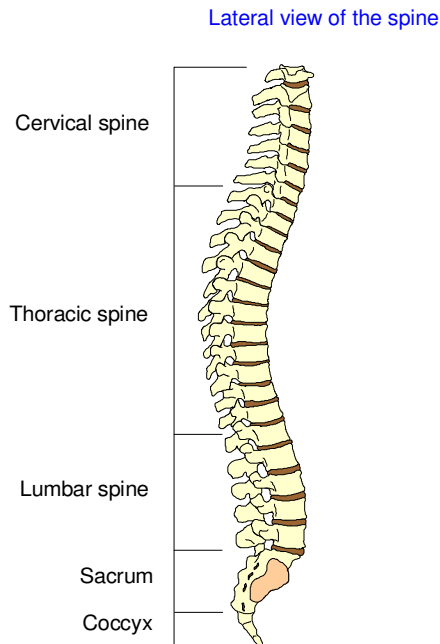
The spine is grouped into five regional sections; within each section, the vertebrae are numbered from the top downwards. [Figure 3 - 5]

#### Cervical spine

The *cervical spine* comprises seven vertebrae. The uppermost vertebra, known as the *atlas*, supports the skull and allows nodding movements. The second vertebra, known as the *axis*, has a process, the *odontoid process*, which passes through the atlas, and forms a joint with the occipital bone of the skull, allowing the head to rotate.

The seventh vertebra, which marks the lower end of the neck, has an exceptionally long spinous process.

**Figure 3 - 5** the spine



### Thoracic spine

The *thoracic spine* comprises twelve vertebrae. These vertebrae have lateral facets, and facets on their transverse processes. The facets form joints with the posterior curves of the ribs.

### Lumbar spine

The *lumbar spine* comprises five vertebrae, which have large bodies to allow them to support their relatively heavy load. They are the largest and strongest vertebrae.

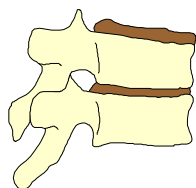
### Sacral spine

The *sacral spine* or *sacrum* comprises five vertebrae fused together, and forms the posterior segment of the pelvic girdle.

### Coccyx

The *coccyx* comprises four small vertebrae fused together, and constitutes a vestigial tail appendage.

### Intervertebral discs



The bodies of adjacent vertebrae are separated by *discs* of soft gelatinous material contained within capsules of fibrocartilage. These discs provide a facility for movement, and act as shock absorbers.

The overall integrity of the spinal column is maintained by a series of ligaments, which hold the vertebrae and discs in position.

### Intervertebral foramina

A foramen is formed at each side of the joint between two adjacent vertebrae. These foramina provide access for the spinal nerves and blood vessels.

## Chest

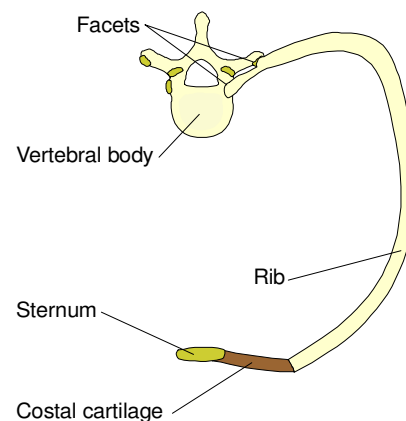
### Ribs

The lungs, and other organs of the chest, are protected by twelve pairs of *ribs*, numbered one to twelve from the superior pair downwards. The ribs all articulate with the spine at their posterior ends. The majority of ribs then connect to the sternum at their anterior ends, via costal cartilages.

[Figure 3 - 6]

**Figure 3 - 6** a rib

Superior view of a rib, showing the typical arrangement



Ribs one to seven connect directly via cartilage to the sternum. They are known as *true ribs*.

Ribs eight to ten connect together at their anterior ends via cartilage, and then connect to the inferior end of the sternum. They are known as *false ribs*.

Ribs eleven and twelve are unconnected at their anterior ends, being attached only to the spine. They are known as *floating ribs*.

### Sternum

The *sternum*, or breastbone, is a dagger shaped bone in three sections:

**Manubrium.** (superior section) This articulates with the clavicles and the first pair of ribs. It forms a moveable joint with the body of the sternum.

**Body.** (central section) This is the largest section, and articulates with ribs two to seven.

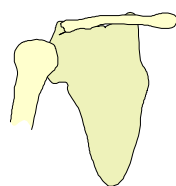
**Xiphoid process.** (inferior section) This small downward projecting process forms an attachment point for abdominal muscles, including the diaphragm.

## Appendicular Skeleton

The *appendicular skeleton* comprises the shoulder girdles and upper limbs (arms), together with the pelvis and lower limbs (legs).

### Shoulder Girdles

Each *shoulder girdle* is formed by the combination of a clavicle and a scapula.



The *scapulae* are flat bones, positioned one each side on the posterior chest wall.

The scapula articulates with the humerus at the shoulder joint, and forms an attachment for various muscles and ligaments.

The *clavicles* are long curved bones, positioned one each side, between and articulating with, the manubrium of the sternum, and the scapulae.

### Upper Limbs

The *upper limbs* are each formed from three bones:

**Humerus.** This is the single bone of the upper arm.

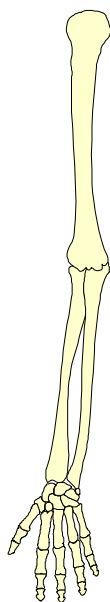
**Radius and ulna.** These together form the lower arm. The slightly shorter, but thicker radius lies on the outer (thumb) side of the ulna.

Both bones articulate with the humerus at the elbow joint; only the radius articulates with the carpal bones at the wrist joint.

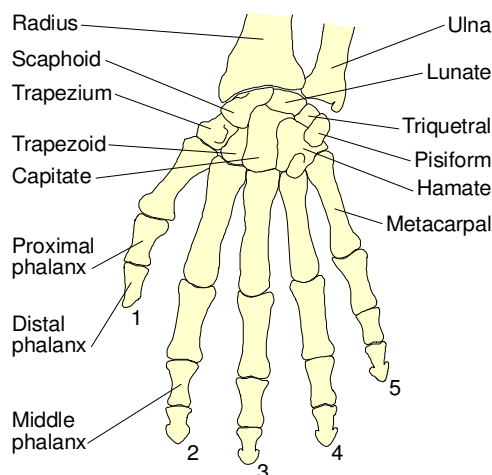
#### Wrists

Each *wrist* [Figure 3 - 7] is made up from eight *carpal bones*, arranged in two rows of four bones, to form a complex joint capable of considerable movement.

The carpals are bound together by ligaments which maintain the integrity of the joint.



**Figure 3 - 7** bones of the wrist and hand



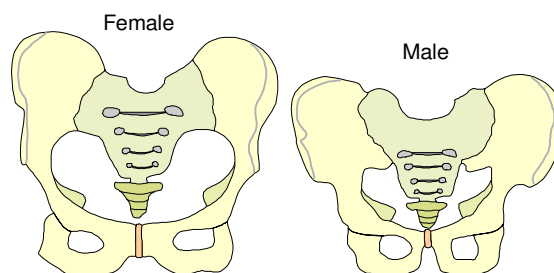
### Hands

Each *hand* [Figure 3 - 7] is made up from two sets of bones:

**Metacarpals.** (5) These form the palm of the hand.

**Phalanges.** (14) These form the fingers (three phalanges each) and the thumb (two phalanges).

### Pelvic Girdle



The *pelvic girdle*, or *pelvis*, is formed from two hipbones, or *innominate bones*, and the sacrum.

The innominate bones articulate anteriorly at the *symphysis pubis*, and posteriorly with the sacrum, at the *sacroiliac joints*.

The innominate bones are formed from three fused bones:

**Ilium.** This forms the main lateral and posterior parts of the pelvis.

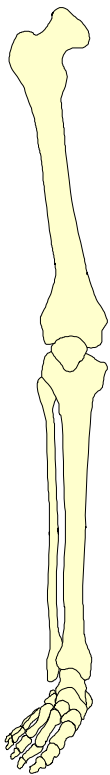
**Pubis.** This forms the superior frontal part of the pelvis.

**Ischium.** This forms the inferior frontal part of the pelvis.

The three bones join at the *acetabulum*, which is the position of the socket joint with the femur.

The pelvis of the female is wider than that of the male, to allow for childbirth.

## Lower Limbs



The *lower limbs* are each formed from four bones:

**Femur.** This is the largest bone in the body, and forms the thigh.

The head of the femur is displaced to the side of the shaft so that it can articulate with the acetabulum of the pelvis. A relatively thin neck connects the head to the shaft.

**Patella.** This forms the kneecap, and is the largest sesamoid bone in the body. It protects the knee joint, and acts as an attachment point for the muscles of the thigh, increasing their leverage.

**Tibia and fibula.** Together, these form the lower leg.

The tibia is much the larger of the two, and carries the body weight.

The fibula bears little weight, and is not involved in the knee joint, articulating with the head of the tibia at its proximal end. However, it does provide an important contribution to the security of the ankle joint.

## Feet

Each *foot* [Figure 3 - 8] is made up from three sets of bones:

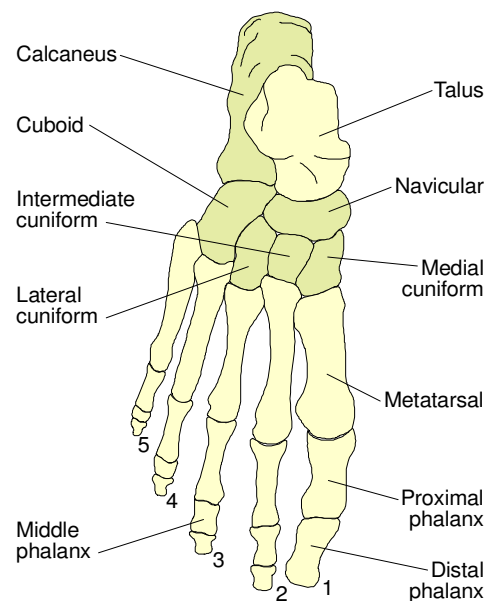
**Tarsals.** (7) These form the ankle joint, the heel, and the posterior part of the foot.

The *calcaneus*, or heelbone, is the largest tarsal bone.

**Metatarsals.** (5) These form the anterior part of the foot.

**Phalanges.** (14) These form the toes, with the great toe having two phalanges, and the other toes having three phalanges.

**Figure 3 - 8** bones of the ankle and foot



### Fractures

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A *fracture* is an unnatural break in a bone.

Fractures are always caused by application of force - usually external, but in situations where bone tissue has been weakened by degeneration or disease, violent muscular action may be sufficient to cause a fracture.

Fractures may be classified according to their nature:

**Stable fracture.** This is a fracture where the broken bone ends are meshed together or held in place by surrounding tissues.

**Unstable fracture.** This is a fracture where the broken bone ends are not fully restrained and may move relative to each other.

**Closed fracture.** This is a fracture where the broken bone ends have not penetrated the skin.

**Open fracture.** This is a fracture where a broken bone end has penetrated the skin, causing a wound.

**Simple fracture.** This is a fracture where a bone is broken in a single place, with no other significant organ or tissue damage.

**Complicated fracture.** This is a fracture where the broken ends of the bones have caused significant other tissue or organ damage.

**Comminuted fracture.** This is a fracture where there are multiple bone fragments at the site of the fracture.

**Greenstick fracture.** This tends only to occur in children, and is a fracture where the break is not complete.

#### Complications

The main complications of fractures are that surrounding tissue will always be damaged - to a greater or lesser extent.

If a vertebra is fractured, spinal cord damage may lead to paralysis.

If the skull is fractured, brain damage may result.

If ribs are fractured, especially in more than one place, breathing may be rendered difficult.

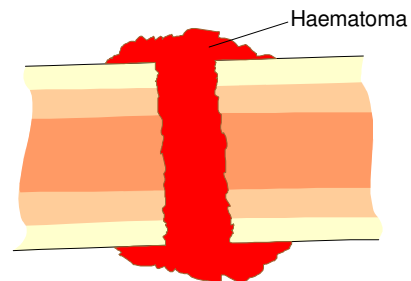
An open fracture causes a wound, through which contamination and infection may enter deep into body tissues.

#### Healing of a fracture

After a bone has been fractured, new bone tissue develops to re-unite the fractured bone ends. The healing process occurs in four main stages.

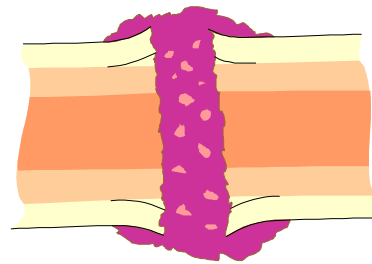
#### Stage 1

Blood loss from broken blood vessels in and around the area of the fracture leads to a haematoma (and inflammation) around the fracture site.



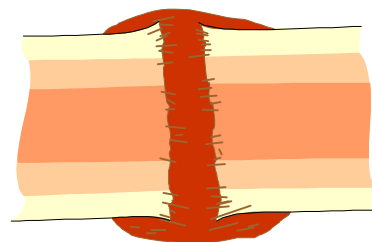
#### Stage 2

New connective tissue cells enter the fracture area and phagocytose the haematoma and any small bone fragments. New tissue growth begins from *osteoblasts* (bone forming cells).



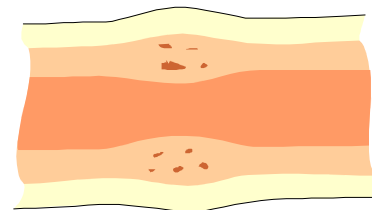
#### Stage 3

New bone cells develop and begin to bridge the fracture with new bone tissue, or *callus*.



#### Stage 4

The new bone is shaped, and excess callus is removed, restoring the medullary canal. New compact bone seals the two, previously separate, segments of bone together.



## Osteogenesis Imperfecta

*Osteogenesis imperfecta*, commonly known as *brittle bone disease*, is a hereditary problem involving an abnormality of collagen. This results in the bones being extremely fragile and liable to break at the slightest abnormal force, including the sufferer's own muscular action.

This leads to frequent fractures and often results in physical deformities.

## Osteoporosis

*Osteoporosis* is a degeneration of bone tissue which occurs when bone cells are absorbed by the body faster than they are created.

The underlying cause for this is not fully understood, although contributory factors include changes to hormonal balance - either following the menopause in females, or during long term steroid therapy.

Illness and injury may also cause localised osteoporosis as may long term immobility of a limb.

The degeneration of bone tissue may continue, or may be reversed - particularly if the causal factor is removed.

Osteoporosis reduces the bone density, leaving affected bones brittle and liable to fracture more easily than they otherwise would.

## The Joints

A *joint* is a point at which two or more bones come together.

Joints are classified into three types:

**Fibrous joints** or 'fixed joints'. These are simple connections between adjacent bone components, and do not facilitate movement.

**Cartilaginous joints** or 'slightly moveable joints'. These allow slight movement.

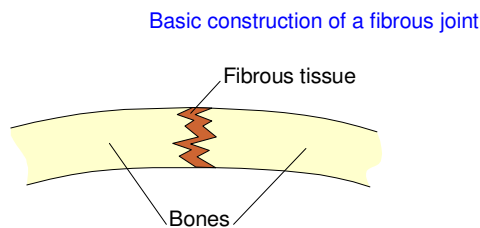
**Synovial joints** or 'moveable joints'. These allow considerable movement (depending on their exact nature).

### Fibrous Joints

Fibrous tissue forms between the bones in a fibrous joint, binding them firmly together. [Figure 3 - 9]

The main examples are the joints (known as *sutures*) between the bones of the skull.

**Figure 3 - 9** a fibrous joint



### Cartilaginous Joints

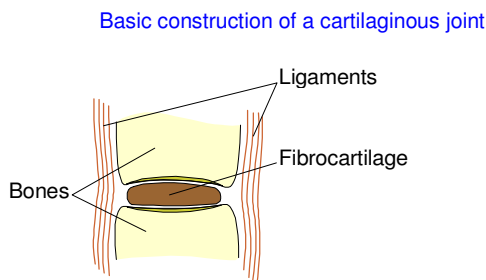
In a cartilaginous joint, a pad of fibrocartilage separates the two bone ends. [Figure 3 - 10]

The pad of fibrocartilage allows for slight movement by being partially compressible.

Ligaments maintain the integrity of the joint.

The main examples are the joints between the vertebrae in the spine.

**Figure 3 - 10** a cartilaginous joint



### Synovial Joints

*Synovial joints* tend to be more complex than cartilaginous joints, and differ throughout the body. However, they have certain common key features:

**Articular cartilage.** This is made from hyaline cartilage, and covers the ends of the bones where they form the joint.

**Capsular ligament.** This surrounds and encloses the joint in a fibrous sheath.

**Synovial membrane.** This covers those areas of the joint not covered by articular cartilage, and secretes synovial fluid into the joint area to act as a cushion and lubricant.

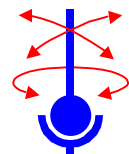
**Bursae.** These are small sacs of synovial fluid. They are found between bones, ligaments, and tendons. Their purposes are those of reducing the friction of movement, and of providing protective cushioning.

*Tendon sheaths* are similar to bursae, but are long cylindrical sacs of synovial fluid. They surround long tendons, such as in the arms, reducing friction where there is continual movement.

### Types of Synovial Joint

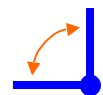
Synovial joints are classified generally according to their range of movement:

**Ball and socket joints.** These allow for rotation, flexion, abduction, and adduction.



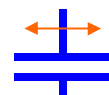
Examples are the hips and shoulders.

**Hinge joints.** These allow for flexion and extension only.



Examples are the elbows, knees, and inter-phalangeal joints of fingers and toes.

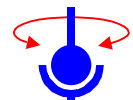
**Gliding joints.** These allow only for a slight sliding movement.



Examples are the carpal and tarsal joints.

**Pivot joints.** These allow only rotation.

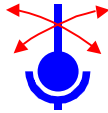
Examples are the radioulnar joints and atlantoaxial joint between the atlas and the odontoid process of the axis.



### Condyloid joints and saddle joints.

These allow flexion, extension, abduction, and adduction movements in two axes.

Examples are the wrist and temporomandibular joints.



### Shoulder and Knee Joints

The shoulder and knee joints provide good examples of synovial joints, as between them they involve all the basic elements of such joints.

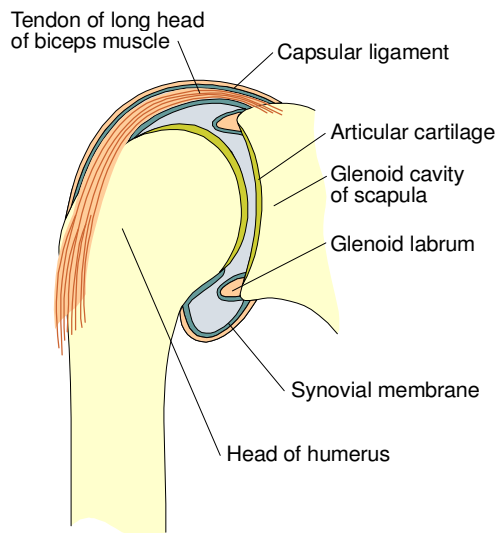
#### Shoulder joint

The *shoulder joint* [Figure 3 - 11] is a ball and socket joint between the head of the humerus (ball) and the glenoid cavity of the scapula (socket).

**Figure 3 - 11** the shoulder joint

Frontal section of the shoulder joint

The space between the head of the humerus and the glenoid cavity has been exaggerated for clarity



The socket is made deeper by a rib of fibrocartilage, attached to the scapula, called the *glenoid labrum*.

The exterior of the joint is encased in a series of ligaments which maintain its stability.

The joint is further stabilised by the tendon of the long head of the biceps muscle which passes through the joint cavity in a covering of synovial membrane.

#### Knee joint

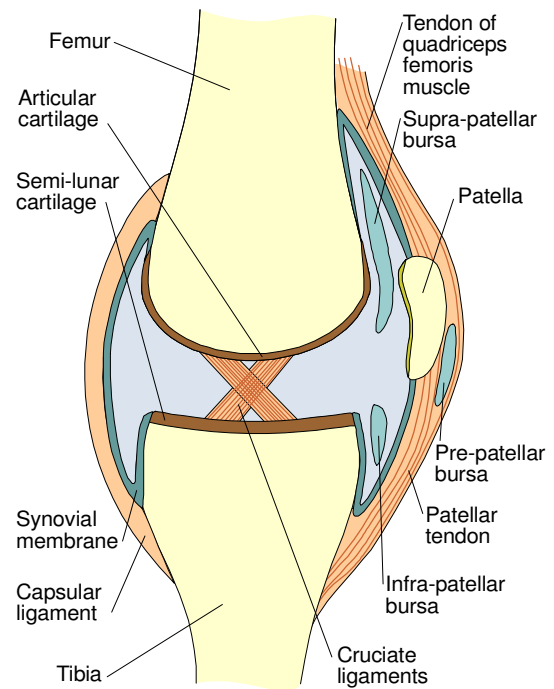
The *knee joint*, [Figure 3 - 12] between the distal end of the femur, and the proximal end of the tibia, is the largest and most complex joint in the body.

It is a modified hinge joint, being capable of small rotational movements as well as flexion and extension.

**Figure 3 - 12** the knee joint

Sagittal section of the knee joint

The space within the joint has been exaggerated for clarity



The patella protects the anterior of the joint.

Strong ligaments maintain the stability of the joint, in particular two internal ligaments which cross over, and are known as *cruciate ligaments*.

Three bursae, and a variety of fatty pads, provide for free movement.

### Arthritis

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The term *arthritis* covers a number of similar conditions, all of which lead to painful inflammation of the tissues within joints. Usually only some joints are affected.

#### *Osteoarthritis*

*Osteoarthritis* is a degeneration of the joints caused by damage to the articular cartilage through use. This causes the cartilage to shrink and may also damage the bone tissue at the affected joint.

#### *Rheumatoid arthritis*

*Rheumatoid arthritis* is a condition in which the synovial lining of the joints is progressively destroyed, leading to damage to bone tissue, ligaments and tendon sheaths. This, in turn, causes deformity, oedema and pain.

The extremities are most commonly affected, as are hip joints, knees, shoulders and the neck.

#### *Rheumatic fever*

*Rheumatic fever* begins as a complication of a bacterial respiratory infection, mainly in children and young adults.

As well as other problems, including possible heart valve damage, the fever leads to arthritis, which spreads from joint to joint.

#### *Gout*

*Gout* is a result of excessive uric acid in the body (usually because of a metabolic disorder). Sodium monourate collects in joints, and may cause acute attacks of extremely painful inflammation. The joints of the great toes are often affected first.

If not treated, the condition may become chronic, resulting in permanent joint damage.

### *Bursitis*

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A *bursitis* is a painful and swollen inflammation of a bursa,

This may be caused by infection, injury (including 'repetitive strain' types of injury), over-use of a joint, long term external pressure, or may occur without an identifiable cause.

### *Prolapsed Intervertebral Disc*

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Often known as a *slipped disc*, a *prolapsed intervertebral disc* usually occurs as a result of excessive strain - often long term - being placed on the spine.

Raised pressure on a disc causes the interior material to protrude through the outer fibrous sac. If this protrusion then puts pressure on a nerve, pain, abnormal sensation, loss of sensation, muscular weakness, or loss of reflex may result.

### *Spondylosis*

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*Spondylosis* is specifically a spinal condition. It arises when there is degeneration of the intervertebral discs. Small thorn-like projections of the surrounding vertebrae may develop.

Often the condition is asymptomatic, but pain and loss of movement may result.

### *Sprain*

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A *sprain* is an injury to a ligament at a joint. The cause is almost always a sudden over-stretching of the ligament, and although this does not generally sever the ligament, it leads to significant pain and inflammation - often sufficient for the injury to appear as a fracture.