8.1 Types of muscles

Skeletal muscles

- Move bones and enable us to walk, run and carry out a wide range of voluntary physical activities.
- These muscles are under conscious control and are attached to the bones of the skeleton.
- They give the body its form and contours, and allow it to maintain posture

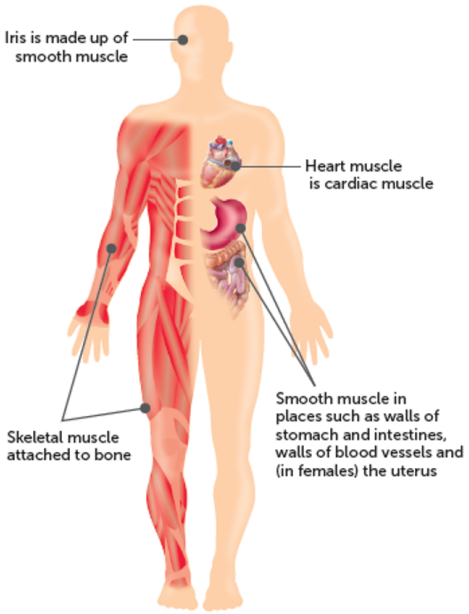
Smooth muscles

- AKA involuntary muscles
- Control movement within internal organs such as the stomach and intestines

Cardiac muscles

- is the heart muscle
- When cardiac muscle contracts, it reduces the space in the chambers of the heart and pushes the blood from the heart into the blood vessels

The properties of contracting lots, extensibility and elasticity allows muscles to work together to create movement

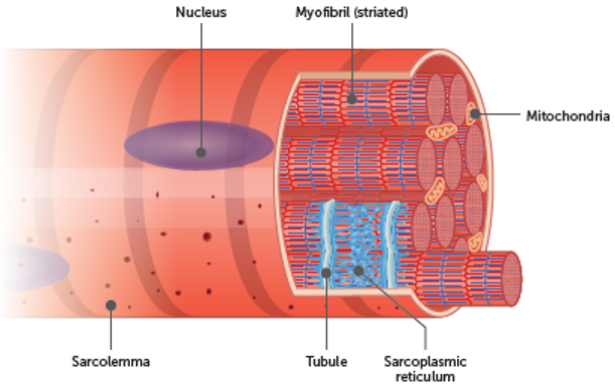


8.2 Structure of skeletal muscle

- Muscle cells are held together in bundles
- **A sheath of connective tissues** called **perimysium** surrounds each bundle so that it can function as an individual unit
- The connective tissues allow adjacent bundles to slide easily over one another as they contract
- **Sheaths of connective tissue** called **epimysium** also hold the bundles together, and towards the end of the muscle they taper and blend to form the tendon

Structure of skeletal muscle fibres

- Muscle bundles are composed of muscle cells that lie parallel to each other
- **Each muscle cell**, called a **muscle fibre**, is an elongated cylinder with many nuclei
- Around the cell is a thin, transplant plasma membrane, the sarcolemma, containing cytoplasm, called the sarcoplasm.
- Cells are between 10 to 100 micrometers in diameter and vary in length from a few millimeters to several centimetres

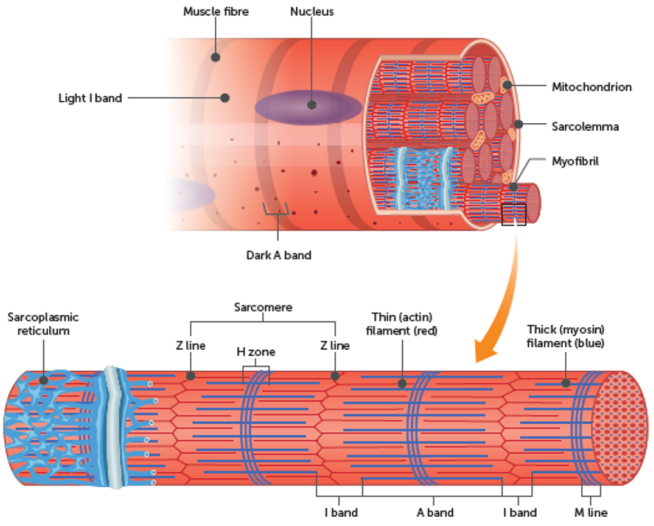


Structure of myofibrils

- Within the sarcoplasm of each fibre are thread-like myofibrils
    - These lie parallel to each other and run the length of the fibre
- There may be anywhere from hundreds to several thousands of these myofibrils in each fibre
- A **tubular network** called the **sarcoplasmic reticulum** surrounds the myofibrils.
    - This is a storage site for calcium ions, which are released during muscle contractions
- Each myofibrils is composed of many smaller myofilaments, made of protein, which are the actual units involved in contraction of the muscle.
- **Two types** of **myofilaments**
    - **Thick myofilaments**, composed mainly of the protein myosin
        - Myosin is attached to m line and is thick mm = thin
    - **Thin myofilaments**, composed mainly of the protein actin
        - Actin is attached to the Z line and is thin
- The arrangement of thick and thin filaments within a myofibril gives a banded effect to the muscle. These striations allow myofibrils to be divided into units called **sarcomeres**
- ATP ➔ ADP + Phosphate

Steps

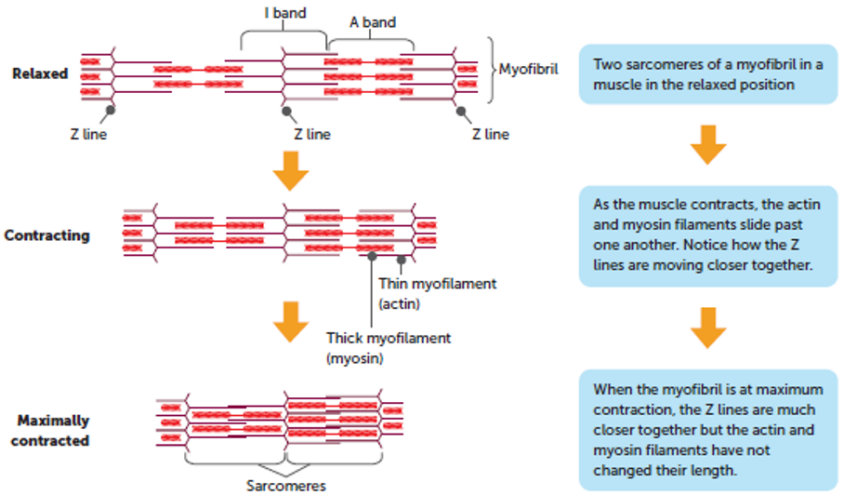
1. Nerve impulse at muscle
2. Release of neurotransmitter
3. Causes reaction at motor end plate (end of neuron)
4. Myosin filaments (thick) attach to Actin (thin) forming a bridge
5. Energy used to pull Actin filaments along, this shortens the muscle by bringing the Z lines closer together
6. Myosin detaches from actin, cross bridge broken, the attaches to the next Actin
    a. Ratchet mechanism (repeated over and over)
7. One impulse stops and the Actin returns to resting position
    a. Muscle lengthens



8.3 How muscles work

Sliding filament theory

- when muscles contract, the sarcomeres shorten
- The sliding filament theory suggests that this occurs because the actin and myosin filaments slide over one another



Skeletal muscles working together

- muscles are attached to the bones of the skeleton by fibrous, inelastic connective tissue called tendons
    - Tendons connect bone to muscle
    - Ligaments connect bone to bone
- Muscles work in pairs, with the muscles fulfilling opposite roles
- Coordination of the paired muscles provides body movement, with one of the pair producing movement of bones in one direction and the other producing movement in the opposite direction (agonists)

Muscle tone

- Is maintaining partial contraction of skeletal muscles
- At any one time, some muscle fibres are contracted while others are relaxed
- Such partial contraction tightens a muscle, but not enough fibres are contracting at the one time to produce movement
- Muscle tone is caused by many different fibres taking turns to contract
- The fibres relieve one another so smoothly that the contraction can be kept up for long periods of time

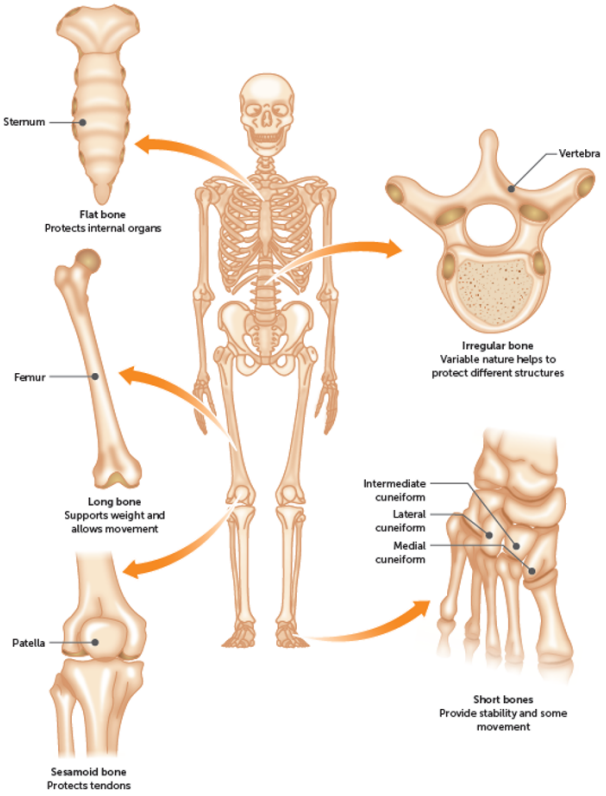
8.4 Overview of the skeletal system

- The skeletal system is made up of the bones and their associated structures: tendons, ligaments and joints

Functions of the skeletal system

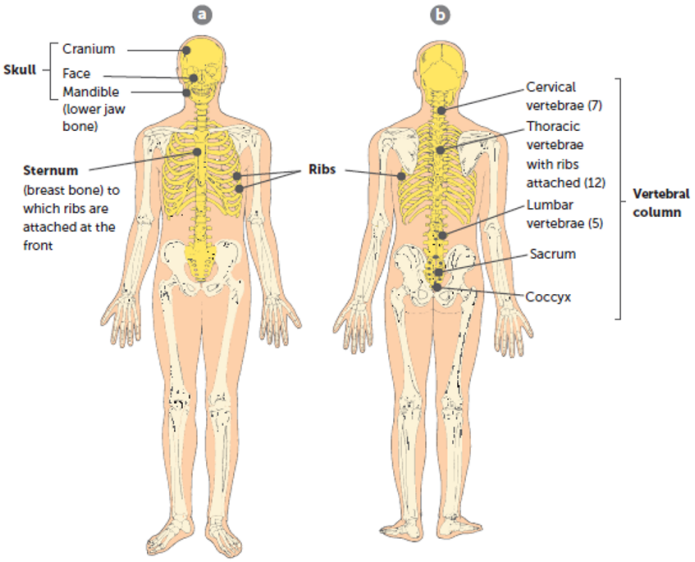
- Provides a scaffold to support the weight of the rest of the body
- Facilitates movement by being points of attachment for muscles
- Protects vital internal organs
- Produces red blood cells
- Stores and releases minerals and fats

Types of bone

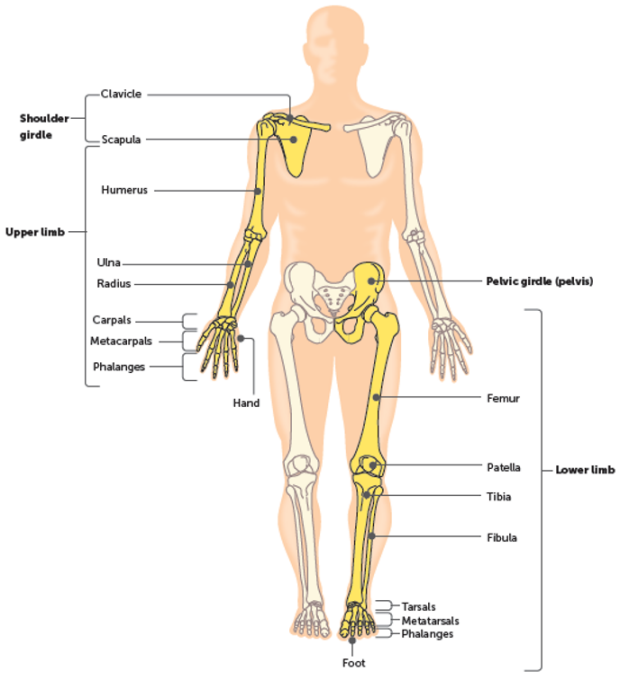


Bones of the skeleton

- Axial skeleton
    - consists of the bones that lie around the central axis of the body.
    - It provides main support for erect posture and protection of the central nervous system and organs contained within the thorax
    - The bones that form the skull, vertebral column, ribs and sternum (breast bone) make up the axial skeleton
- Appendicular skeleton
    - Consists of the bones of the upper and lower limbs, the pectoral girdle (shoulder) and pelvic (hip) girdle.
    - These two girdles allow for the articulation of the limbs with the axial skeleton



Axial skeleton: **a** anterior view; **b** posterior view



Appendicular skeleton

8.5 structure of bone and cartilage

Macroscopic structure of long bones

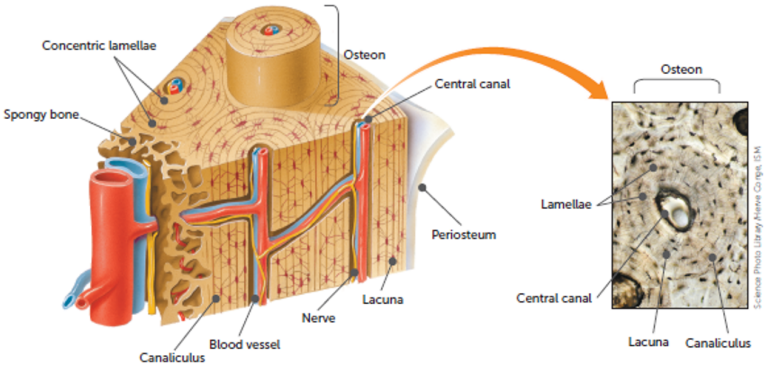
- Consists of
  - Diaphysis
    - The shaft making up the main portion of the bone.
    - A hollow cylinder of compact bone surrounding a medullary cavity
  - Epiphyses
    - Enlarged ends of the bone, covered with a thin layer of articular cartilage
    - Have compact bone on the outside, but their central regions contain spongy or cancellous bone
  - Periosteum
    - Dense, white, fibrous outer covering of the bone
    - No periosteum at the joints, where the bone is covered with an articular cartilage

Microscopic structure of bones

- classified as a connective tissue
- Connective tissues consist of cells separated from each other by large amounts of non cellular material called **matrix**
- In bone, inorganic salts of calcium and phosphate are deposited in the matrix. These increase its rigidity and strength, and make it the hardest of the connective tissues

Structure of compact bone

- Compact bone consists of many similar units called **osteons** or **Haversian systems** that run parallel to the long axis of the bone. This gives the bone its maximum strength
- Each osteon has:
  - A central canal (or Haversian canal) at its centre
  - Concentric layers of bony matrix called lamellae surrounding the central canal
  - Lacunae, which are small spaces in the matrix between the lamellae
  - A bone cell, or osteocyte, occupying each lacuna
  - Tiny canals, knows as canaliculi, running between the lacunae
  - Projections from the bone cells entering the canaliculi and making contact with adjacent bone cells, allowing materials to be passed from cell to cell
  - At least one blood capillary, and possibly nerves and lymph capillaries, in the central canal of each osteon



8.5 Structure of bone and cartilage

Structure of spongy bone

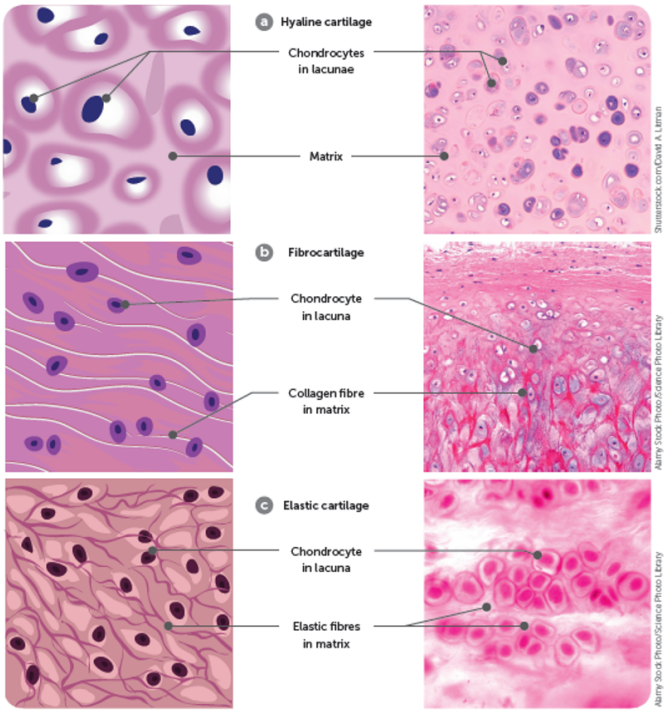
- consists of an irregular arrangement of thin, bony plates called **trabeculae**
- The bone cells occupy spaces in the trabeculae, and nervEs and blood vessels pass through irregular spaces in the matrix

Structure of cartilage

- Cartilage is also a connective tissue
- It contains numerous fibres made of a protein called **collagen**
- These protein fibres are embedded in a firm matrix of a protein - carbohydrate complex called **chondrin**
- This firm matrix enables cartilage to function as a structural support, while the presence of fibres gives cartilage a certain amount of flexibility
    - Due to those properties, it's found on the surface of bones at the joints, in the trachea and bronchi, and forms the nose, larynx and outer ear
- Has a firm matrix in which collagen fibres are embedded
- Within the matrix are spaces that contain the cartilage cells called **chondroblasts**
- These cells produce a matrix and gradually become surrounded by it until they are trapped in small spaces called lacunae.
- Once this has occurred, the cells are considered to be mature and are referred to as **chondrocytes**

Microscopic structures of cartilage

- Collagen fibres in the matrix range from extremely fine to quite coarse
- This variation in the fibrous structure of cartilage is used to classify it into three types:
    - **Hyaline cartilage**
        - Contains many fine, closely packed collagenous fibres throughout the matrix
        - The fine fibres give the cartilage strength and flexibility.
        - Makes up the rings of the trachea and bronchi
    - **Elastic cartilage**
        - Has conspicuous elastic fibres.
        - Also contains collagenous fibres similar to those in hyaline cartilage, but they are not so closely packed
        - Elastic cartilage provides flexible elastic support in places such as the external ear
    - **Fibrocartilage**
        - Has a coarse appearance from the parallel bundles of thick collagenous fibres that make up the tissue
        - The fibres are not compacted as much as in hyaline cartilage, and can be compressed slightly
        - Ideal for regions where the weight of the body is being supported or where there is a need to withstand heavy pressure
            - E.g. in the intervertebral discs of the spinal column, where it provides a cushion between the vertebrae



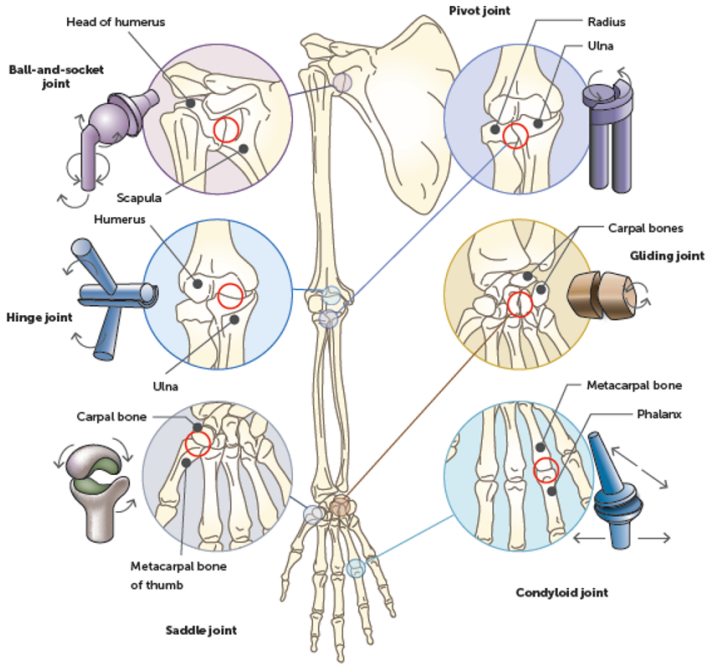
8.6 Movement of bones

Types of joints

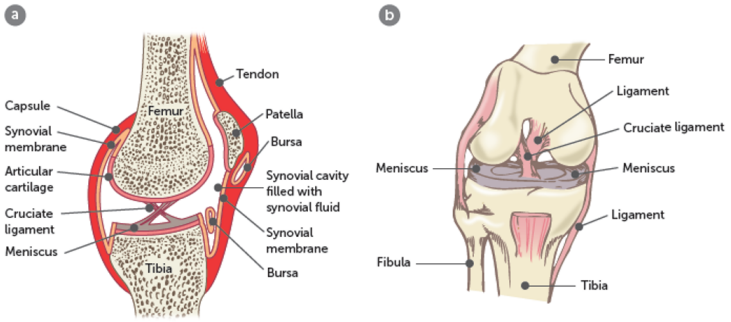
- Fibrous or fixed joints
    - When no movement occurs between the bones concerned, the joint is described as fibrous (or fixed or immovable).
    - The bones are held in place by fibrous connective tissue, as is the case with sutures of the skull
- Cartilaginous or slightly movable joints
    - Cartilaginous joints are held in place by cartilage, which allows slight movement to occur
    - The junction of the two pelvic bones (the pubic symphysis), joints between adjacent vertebrae, and the joints between the ribs and the sternum are examples of slightly movable or cartilaginous joints

Synovial or freely movable joints

- synovial joints are freely movable, with the amount of movement limited by ligaments, muscles, tendons and adjoining bones.
- Categorised by the type of movement that occurs between the articulating surfaces of the bones
    - **Ball and socket joints** form when the spherical head of one bone fits into a cup like cavity of another
    - **Hinge joints** allow movement in one plane only, much like a hinged door. They for, when the convex surface of one bone fits into the concave surface of another
    - **Pivot joints** are formed when the rounded, pointed or conical end of one bone articulates with a ring, formed partly by a ligament
    - **Gliding joints** allow movement in any direction in a side to side or back and forth motion, restricted only by ligaments or bony processes surrounding the joint
    - **Saddle joints** are where two bones forming the joint are both saddle shaped- that is, concave in one direction and convex in the other
    - **Condyloid (or ellipsoid)** joints have one surface of bone slightly convex that fits into a slightly concave depression in another bone



- there is space, or synovial cavity, between the articulating surfaces of the bones
- A synovial membrane surrounds the synovial cavity, and there is articular cartilage on the bone surfaces
- The knee joint, including the patella, is a typical example



The knee joint: **a** in section, viewed from the side; and **b** viewed from the front to show ligaments

Keeping joints together

- Factors that keep the articular surfaces of synovial joints together:
  - The fit of the articulating bones
    - E.g. the way the head of the humerus fits into the socket of the capsula to form the shoulder joint
  - The strength of the joint ligaments holding the bones together
    - E,g. The hip joint
  - The tension provided by the muscles around the joint
    - E.g. in the knee joint, the fibrous capsule is formed principally from tendons attached to the muscles acting on the joint

Movement at a joint

- each joint is capable of specific types of movements

Flexion and extension

- **flexion**, or **bending**, decreases the angle between the articulating bones, meaning the bones come closer together.
  - E.g. when the elbow is flexed, the lower arm (with the radius and ulna) moves closer to the upper arm (with the humerus)
- **Extension, or straightening**, increases the angle between the articulating bones, moving the bones further apart.
  - E.g. when the knee is extended, the lower leg (with the tibia and fibula) moves further away from the upper leg (with the femur)

Abduction and adduction

- **Abduction** is movement away from the midline of the body.

    - E.g. lifting the arms upwards and away from the body is abduction
- While movement towards the midline of the body is **adduction**
    - E.g. when returning the arms to the sides after abduction

Rotation

- The movement of a bone around its long axis
    - E.g, turning the head from left to right occurs due to rotation at the joint between the first two vertebrae

types of joints	example	motion
Saddle	- thumb	- gliding motion - circumduction
Synovial	- knee - Hip - Shoulders - Elbow	- freely moveable - Typically have articular cartilage - Encapsulated (capsule surrounding their joint)
Ball and socket	- hip - Shoulder	- moves in one place only - 180°C
Hinged	- knee - Elbow	- 360°C - Circumduction
Pivot	- neck	- 180°c
Condyloid	- fingers - Toes	-
Gliding	- wrist - Ankle	-

8.7 Effects of ageing on the musculoskeletal system

Osteoporosis

- When the loss of bone mass becomes sufficient to impair normal functioning
- As bone density decreases, the risk of fracture increases so that even minor bumps or falls can result in serious fractures
- Bones most likely to be affect are the vertebrae, ribs, pelvis, wrist and upper arm, although any bone can be affected

Prevention of osteoporosis

- adequate calcium intake in their diet
- adequate amount of vitamin D (either through exposure to sunlight or by dietary intake)
- Plenty of exercise

Treatment of osteoporosis

- lifestyle changes to increase calcium intake, vitamin D production and exercise
- Medication can sometimes be used to prevent this condition

Osteoarthritis

- gradual change in joints that occurs over time and is frequently associated with ageing.
- Other factors including irritation of the joints, wear and abrasion can also be involved.
- The joint cartilage deteriorates, and so the bone surfaces are no longer protected.
- The exposed bone begins to wear away and bony spurs or growth may develop from the exposed ends of the bone forming the joint
- These growths and spurs decrease the space within the joint cavity, restricting movement of the joint

Symptoms

- often appear in middle age, and almost everyone has some symptoms by the age of 70, but these symptoms may be minor

Treatment

- there is no known cure, but treatment may include medication to relieve pain
- Physiotherapist to strengthen muscles around the affected joints
- Surgery to realign bones or joint replacement surgery