**04. The Skeletal system**

The skeleton or skeletal system consists of the bones and the joints of the body.

The skeleton is a hard framework of 206 bones that supports and protects the muscles and organs of the human body. It is divided into two parts:

* **The axial skeleton:** this supports the head, neck and trunk (also known as torso). It consists of the skull, the vertebral column, the ribs and the sternum
* **The appendicular skeleton:** this supports the appendages or limbs and attaches them to the rest of the body. It consists of the shoulder girdle, the upper limbs, the pelvic girdle and the lower limbs.

**TOPIC 1: STRUCTURE AND FUNCTION**

**STRUCTURE**

The skeleton is made up of bones. There are 206 individual bones in the human body and five different types, defined according to their shape:

* **Long bones:** the body’s levers, they allow movement, particularly in the limbs e.g. the femur (thigh bone), tibia and fibula (lower leg bones), clavicle (collar bone), humerus (upper arm bone), the radius and the ulna (lower arm), metacarpals (hand bones), metatarsals (foot bones) and phalanges (finger and toe bones).
* **Short bones:** strong and compact bones, usually grouped in parts of the body where little movement is required e.g. tarsals (ankle bones) and carpals (wrist bones).
* **flat bones:** protective bones with broad flat surfaces for muscle attachment e.g. occipital, parietal, frontal, nasal, vomer, lacrimal (all of these are in the skull), scapula (shoulder bone), innominate bones (pelvis), sternum (breastbone), ribs.
* **Irregular bones:** bones that do not fit into the above categories and have different characteristics e.g. vertebrae, including the sacrum and coccyx (backbone), maxilla (upper jaw), mandible (lower jaw), ethmoid, palatine, sphenoid, zygomatic (cheek) and temporal (all bones of the face and head).
* **Sesamoid bones:** bones within tendons. There are two main sesamoid bones in the human body, the patella (kneecap), and the hyoid (base of the tongue). The hyoid is sometimes classified as an irregular bone because it is attached by ligaments and not 'floating' in a tendon like the patella.

**FUNCTIONS**

* **Supports the body:** all body tissues (apart from cartilage and bone) are soft so without the skeleton the body would be jelly-like and could not stand up. The bones and their arrangement give the body its shape.
* Allows and enables movement
* Protects delicate body organs e.g. the cranium, or skull, is a hard shell surrounding the soft brain and the thoracic cage (ribs and sternum) covers the heart and lungs
* Forms blood cells (in the red bone marrow)
* Forms joints which are essential for the movement of the body
* Provides attachment for muscles which move the joints: muscles are attached to bones and pull them into different positions, thus moving the body
* Provides a store of calcium salts and phosphorus.

**THE SKELETON**

An easy way to remember the differences between the axial and appendicular parts of the skeleton is to think of axes (i.e. the centre) versus appendage (i.e. the added bits). The centre is the head, neck and torso, the added bits are the arms and legs and the bones that attach them to the body.

**WHAT ARE BONES MADE OF?**

Bones are living tissue made from special cells called osteoblasts and osteoclasts. The tissue varies considerably in density and compactness: the closer to the surface of the bone the more compact it is. Many bones have a central cavity containing marrow, a tissue which is the source of mast of the cells of the blood and is also a site for the storage of fats. There are two main types of bone tissue:

* **Compact:** to the naked eye this looks like a solid structure but under a microscope it looks like honeycomb, i.e. full of holes. Haversian canals (see below) are passageways containing blood vessels, lymph capillaries and nerves which run through the tissue. Compact bone is found on the outside of most bones and in the shaft of long bones.
* **Cancellous:** this type of bone looks like a sponge and it is found at the ends of long bones and in irregular, flat and sesamoid bones. Bone marrow only exists in cancellous bone.

All bones have both types of tissue.

The amount of each depends on the type of bone.

**WHAT ARE HAVERSIAN CANALS?**

Haversian canals run lengthways through compact bone and contain blood and lymph capillaries and nerves. The larger the canal the less dense and compact the bones.

**SECTION 01. THE AXIAL SKELETON**

The axial skeleton includes:

* **Skull:** cranium 8 bones; face 14 bones
* **hyoid:** 1 bone
* **Vertebral column:** 33 vertebrae, some fused, so 26 bones in total
* **Sternum:** 3 bones
* **Ribs:** 12 pairs (24 bones)

**WHAT IS THE VERTEBRAL COLUMN?**

A more common name for the vertebral column is the spine. It is the central part of the skeleton, supporting the head and enclosing the spinal cord and it is constructed to combine great strength with a moderate degree of mobility. It is made of 33 vertebrae - irregular, interlocking bones. Some of these are fused so there are only 26 individual bones. There are 5 different types of vertebrae:

* **Cervical** ( 7 bones in the neck )
* **Thoracic** ( 12 bones carrying the ribs in the centre of the body )
* **Lumbar** ( 5 bones in the lower back )
* **Sacral** ( 5 bones in the pelvis, fused to form the sacrum )
* **Coccygeal** ( 4 bones below the sacrum, forming the coccyx )

**DID YOU KNOW?**

Laughing and coughing put more pressure on the spine than walking or standing.

**THE APPENDICULAR SKELETON**

The appendicular skeleton includes:

* **Shoulder girdle:** 2 scapulae and 2 clavicles
* **Arm:** 1 humerus,1 ulna, 1 radius (each arm)
* **Wrist:** 8 carpal bones (each wrist)
* **Hand:** 5 metacarpal bones (each palm of hand)
* **Fingers:** 14 phalanges in each hand, 2 in a thumb and 3 each in the other fingers
* **Pelvic girdle:** 2 innominate bones (each one including an ilium, ischium and pubis)
* **Leg:** 1 femur, 1 tibia, 1 fibula and 1 patella (each leg)
* **Ankle and foot:** 7 tarsals and 5 metatarsals (each foot)
* **Toes:** 14 phalanges in each foot, 2 in a big toe and 3 each in the other toes.

**THE SHOULDER GIRDLE**

The shoulder girdle consists of two scapulae (shoulder blades) and two clavicles (collar bones). These four bones form an incomplete ring, articulating with the manubrium - the flat part at the top of the sternum (breast bone) - at the front, hence the name girdle.

**THE PELVIC GIRDLE**

The pelvic girdle is formed by two large innominate bones which meet in front at the symphysis pubis and articulate with the sacrum in the back to form a ring of bone. The innominate bones, with the sacrum and coccyx, form the pelvis which surrounds the pelvic cavity. The pelvis of the female is wider and shallower than that of the male. Each innominate bone is formed by the fusion of three parts - an ilium, an ischium and a pubis. At the junction of these is a socket for the head of the femur.

**TOPIC 2: THE LIMBS**

**THE UPPER LIMB/ARM AND HAND**

Arms and legs have the same basic layout of bones within them but different names are given to the bones.

**Key to carpals**

1. SCAPHOID

2. LUNATE

3. TRIQUETRAL

4. PISIFORM

5. TRAPEZIUM

6. TRAPEZOID

7. CAPITATE

8. HAMATE

**Arm and Hand**

**Carpals (wrist bones):** 8 in each wrist arranged in 2 rows of 4: upper row (nearest arm) are called the scaphoid, lunate, triquetral and pisiform; the lower row (joining the metacarpal bones) are called the trapezium, the trapezoid, the capitate and the hamate.

**Metacarpals (palm bones):** 5 in each hand.

**Phalanges (finger bones):** 14 in each hand; 2 in each thumb and 3 in each of the other fingers.

**THE LOWER LIMB/LEG AND FOOT**

**Key to tarsals**

1. Talus

2. Calcaneum

3. Navicular

4. Cuboid

5. Lateral Cuneiform

6. Intermediate Cuneiform

7. Medial Cuneiform

**Ankle and Foot**

**Tarsals:** 7 in each ankle/heel: the talus joins the foot to the leg and is a principal part of the ankle joint, the calcaneus (the heel bone) projects backwards; the navicular bone lies between the talus and cuneiform bones, there are 3 wedge-shaped cuneiform bones, the medial, intermediate and lateral and finally the cuboid bone on the lateral side of the foot, which is between the calcaneus and the metatarsals.

**Metatarsals:** 5 in each foot.

**Phalanges:** 14 in each foot, 2 in each big toe and 3 in each of the other toes.

**DID YOU KNOW?**

The thigh bone (femur) is the longest and strongest bone in the whole body.

**TOPIC 3: JOINTS**

**WHAT ARE JOINTS?**

Joints are the body's hinges. There are three types:

* Freely moveable, or synovial joints.
* Slightly moveable, or cartilaginous joints
* Fixed, or fibrous joints

**FREELY MOVEABLE, OR SYNOVIAL JOINTS**

**Characteristics:** varied degrees of movement depending on sub-type

**Structure:** All contain hyaline (articular) cartilage, a joint capsule, synovial membrane and synovial fluid. Some may also have bursae, fat pads and/or ligaments blending with the capsule.

**Five different types:** ball and socket; hinge; gliding; pivot; saddle.

* **Ball and socket:** most moveable of all joints. Allow flexion, extension, adduction, abduction, rotation and circumduction e.g. shoulder and hip joints.
* **Gliding:** the bones glide over each other; the least moveable of joints e.g. between tarsals and carpals.
* **Hinge:** movement in one direction (plane) only. Movements are flexion and extension e.g. elbow, knee, ankle, joints between phalanges of fingers and toes.
* **Saddle:** movement around two axes allowing flexion, extension, adduction, abduction, circumduction. Found between trapezium of carpus (wrist) and metacarpal of thumb.
* **Pivot:** movement around one axis only and a rotary movement e.g. first two cervical vertebrae (atlas and axis) which allow the head to rotate and proximal ends of radius and ulna.

**SLIGHTLY MOVEABLE, OR CARTILAGINOUS JOINTS**

**Characteristics:** slightly moveable, moves by compression of the cartilage

**Structure:** pad of white fibrocartilage between the bones, e.g. spine.

**FIXED, OR FIBROUS JOINTS**

**Characteristics:** no movement

**Structure:** fibrous tissue between the ends of the bones e.g. sutures in the skull, innominate (pelvic girdle) bones.

**WHAT ARE POSTURAL DEFORMITIES?**

The spine has two natural curves: an inward curve in the lower back (lumbar area: put your hand there and try it) and a slight outward curve in the upper back (the thoracic area). In certain cases, the spine's natural curves become exaggerated, causing unnatural curves, or postural deformities. There are three causes for these:

* **Congenital:** those which are present at birth or are hereditary.
* **Environmental:** sitting and standing incorrectly can cause long-term damage to the spine. Many people in sedentary work are affected by these causes.
* **Traumatic:** caused by accidents.

What do postural deformities look like?

* **Kyphosis:** an exaggerated outward (toward the posterior) curvature of the thoracic spine.
* **Scoliosis:** a sideways curvature of the spine
* **Lordosis:** an exaggerated inward (towards the anterior) curvature of the lumbar spine

**WHAT IS A FRACTURE?**

A fracture is the breakage of a bone due either to injury or disease. There are six main types:

* **Simple:** (sometimes called closed) a bone has broken in one place and not damaged the tissue around it
* **Compound:** (sometimes called open) a fracture in which the broken bone pierces the skin and/or communicates with the surface of the skin through an open wound
* **Comminuted:** a bone broken in several places
* **Greenstick:** more common in soft and flexible bones, especially children's, this is an incomplete fracture of a long bone
* **Impacted:** a bone which has been broken and then one end is driven into the other (like one car shunting into the back of another)
* **Complicated (not pictured):** broken bone which damages tissue and/or organs around it.

**TOPIC 4: DISEASES AND DISORDERS (PATHOLOGIES)**

**ARTHRITIS**

Arthritis is an inflammation of the joints. Monoarticular arthritis is an inflammation of one joint and poly-arthritis is an inflammation of many. It can be acute or chronic:

* Acute: symptoms are heat, redness, and visible inflammation of the affected joints accompanied by severe pain.
* Chronic: involves loss of cartilage, deposition of bone tissue around the joint margins and lesser degrees of pain and inflammation.

**GOUT**

A form of arthritis that can occur in any part of the body but often affects the big toe; more common in men than women.

* Cause: deposition of uric acid crystals within the joint capsule and cartilage.
* Effect: attacks of acute gouty arthritis, chronic destruction of joints.

**OSTEO-ARTHRITIS** (also known as degenerative)

**Cause:** may be injury of the joint or, if widespread, may be associated with the ageing process.

**Effect:** chronic arthritis of degenerative type - cartilage of joint breaks down; usually affects weight-bearing joints like knees, feet and back.

**RHEUMATOID ARTHRITIS** (type of poly-arthritis)

**Cause:** an auto immune disease that attacks the synovial membranes and goes on to degrade and malform the articular surfaces of the bones.

**Effect:** acute and chronic phases with varying degrees of damage and deformity.

**Ankylosing spondylitis:** type of arthritis with acute and chronic phases which results in fusion of the joints of the spine causing severe deformity and immobility.

**FRACTURES**

* **Simple -** When the bone is cracked and then separates, causing little damage to the soft tissue.
* **Compound -** A bone fracture associated with lacerated soft tissue or an open wound.
* **Comminuted -** A fracture in which the bone is splintered or crushed.
* **Greenstick -** A partial fracture of a bone (usually in children); the bone is bent but broken on one side only.
* **Complicated -** A fracture in which the broken bone penetrates an organ or important structures surrounding it.

**OSTEOPOROSIS** (also known as brittle bone disease)

**Cause:** calcium deficiency; accelerated bone loss especially in post-menopausal women.

**Effect:** porosity and brittleness of bones.

**SLIPPED DISC**

**Cause:** the weakening or tearing of one of the intervertebral discs.

**Effect:** disc bulges or sticks out and this may press on the spinal nerve causing pain.

**STRESS**

Stress is any factor which affects mental or physical health. When stressed, muscle tension increases and this causes poor posture (for example hunched shoulders or a clenched jaw), stiff joints and problems with the spinal vertebrae.

**GENERAL**

* **Carpal Tunnel Syndrome -** A painful disorder caused by compression of a nerve in the carpal tunnel; characterized by discomfort and weakness in the hands and fingers and by sensations of tingling, burning or numbness.
* **Systemic Lupus Erythematosus (SLE) -** An inflammatory disease of connective tissue with variable features including fever, weakness, fatigue, joint pains and skin lesions.
* **Cervical spondylitis -** Is degenerative arthritis of the joints between cervical vertebrae. If severe, it may cause pressure on nerve roots with subsequent pain or parasthesia in the limbs.
* **Synovitis -** An inflammation of the synovial membrane that lines a synovial joint; results in pain and swelling.
* **Whiplash -** An injury to the neck (the cervical vertebrae) resulting from rapid acceleration or deceleration (as in an automobile accident).
* **Loss of limb -** Prosthesis - Is an artificial extension that replaces a missing body part.
* **Osteomalacia -** Abnormal softening of bones caused by deficiencies of phosphorus, calcium or vitamin D. This can also be known as rickets.
* **Osteogenesis imperfecta -** A disorder of connective tissue characterized by brittle bones that fracture easily.
* **Psoriatic Arthritis -** An immune system disorder that includes both psoriatic skin lesions and joint inflammation, although they may not necessarily occur at the same time.
* **Paget's disease -** A condition characterized by excessive overgrowth of bone, especially in the spine, pelvis, skull and femur caused by an increase in the osteoclastic and osteoblastic activity of the bone cells.
* **Rickets -** A bone softening and deforming disease, particularly in children, caused by a deficiency of vitamin D and sunlight associated with impaired metabolism of calcium and phosphorus that causes bowed legs, knock-knees, or other deformities of the skeleton.
* **Scleroderma -** A chronic auto-immune disease characterized by a hardening or sclerosis in the skin or other organs.
* **Spinal stenosis -** A medical condition in which the spinal canal narrows and compresses the spinal cord and nerves.

**INTERRELATIONSHIPS**

Skeletal system links to:

* **Muscular:** muscles always cross joints and thus rely on the framework of the skeleton for leverage and movement.
* **Circulatory:** erythrocytes are produced in the bone marrow of long bones.
* **Nervous:** muscles require a nerve impulse to contract which produces movement in the skeleton.
* **Digestive:** breaks down foodstuffs and works with the circulatory system to transport nutrients to bone tissues.
* **Urinary:** a, hormone produced by the kidneys helps to stimulate the production of bone marrow in long bones.

**Summary**

**The skeletal system:**

* The skeleton is composed of bones and joints which form the axial (central head, neck and torso) skeleton and the appendicular (appendages - arms and legs) skeleton.
* It protects and supports the body, allows movement, produces blood cells (in red bone marrow), stores calcium and provides attachment for muscles.
* The skeleton is susceptible to breakage (fractures), and postural deformities caused by congenital or environmental factors.