



HUMB1005

ORIENTATION LECTURE NOTES

Objectives

- Understand and use anatomical terminology (the language of anatomy)
- Understand and describe the anatomical position and planes of reference
- Understand and use terms of relationship and comparison, laterality and movement (the directions)
- Apply descriptions of anatomical planes and axes of motion when describing movement and key joints (the destination)
- Distinguish between key structures of the human locomotor system including; muscles, different types of bones, different types of joints, nerves, ligaments and tendons

Reference positions

- Anatomical position
 - Most widely used and accurate for all aspects of the body
- Fundamental position
 - Is essentially same as anatomical position except arms are at sides and palms facing the body

Features of anatomical position

- Stand erect
- Eyes facing forward
- Feet together and facing forward
- Arms by your side slightly abducted
- Palms facing forward

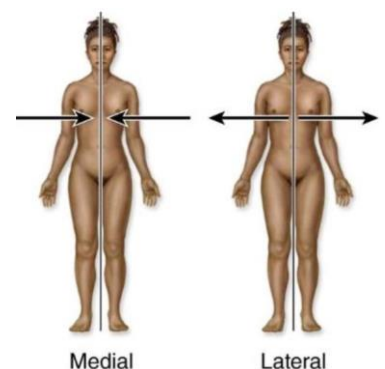
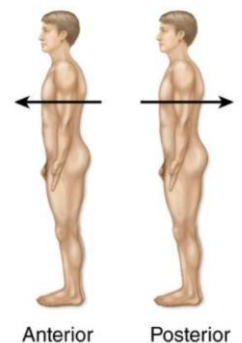
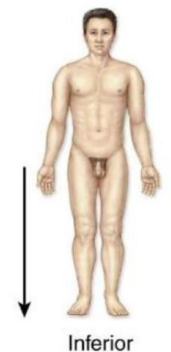
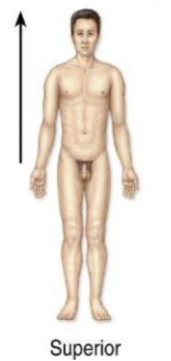


Body Positions

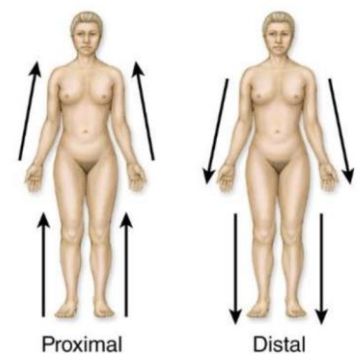
- Prone
 - The body lying face downward on the stomach
- Supine
 - Lying on the back face upward

Anatomical directional terminology

- Superior
 - Above in relation to another structure, higher
 - The chest is superior to the pelvis
- Inferior
 - Below in relation to another structure, lower
 - The stomach is inferior to the heart
- Cephalic/Cranial
 - Closer to the head
 - The shoulders are cranial to the feet
- Caudal
 - Towards the tail
 - The abdomen is caudal to the head
- Anterior
 - In front or in the front part
 - The stomach is anterior to the spinal cord
- Ventral
 - Relating to the belly or abdomen, on or toward the front, anterior part of
 - The belly button is on the ventral side of the body
- Posterior
 - Behind, the back of the body
 - The heart is posterior to the sternum
- Dorsal
 - Relating to the back; being or located near, on, or toward the back, posterior part of
 - The spinal cord is on the dorsal side of the body
- Lateral
 - On or to the side; outside, farther from the midline
 - The arms are lateral to the heart
- Medial



- Relating to the middle or center; nearer to the midline
 - The lungs are medial to the shoulders
- Median
 - Relating to the middle or center; midline
- Contralateral
 - Pertaining or relating to the opposite side
 - The right arm is contralateral to the left leg
- Ipsilateral
 - On the same side
 - The right arm is ipsilateral to the right leg
- Bilateral
 - Relating to the right and left sides of the body or of a body structure such as the right and left extremities
- Unilateral
 - Relating to one side of the body or body structure
- Deep
 - Beneath or below the surface; used to describe relative depth or location of muscles or tissue
 - The heart is deep to the rib cage
- Superficial
 - Near the surface; used to describe relative depth or location of muscles or tissue
 - The skin is superficial to the biceps brachii muscle
- Proximal
 - Nearest the trunk or the point of origin
 - The elbow is proximal to the hand
- Distal
 - Situated further from the trunk, or away from the point of origin
 - The wrist is distal to the elbow
- Palmar
 - Relating to the palm or volar aspect of the hand



- Volar
 - Relating to palm of the hand or sole of the foot
- Plantar
 - Relating to the sole or under surface of the foot

Body Regions

- Axial
 - Cephalic (head)
 - Cervical (neck)
 - Trunk
- Appendicular
 - Upper limbs
 - Lower limbs

Planes of Motion

- Imaginary two-dimensional surface through which a limb or body segment is moved
- Motion through a plane revolves around an axis
- There is a ninety-degree relationship between a plane of motion and its axis

Axes of rotation

- For movement to occur in a plane, it must turn or rotate about a perpendicular axis
- The axes are named in relation to their orientation

Cardinal planes of motion

- 3 basic or traditional
 - Sagittal or anteroposterior plane
 - Frontal/Coronal or lateral plane
 - Transverse or horizontal plane
- Sagittal

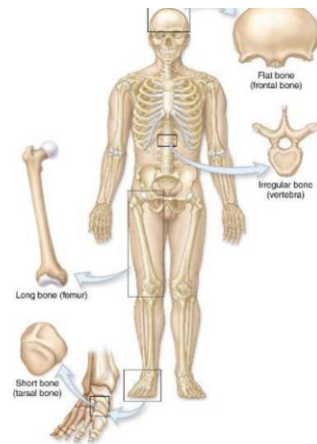
- Divides the body into left and right
 - Midsagittal plane divides the body into equal halves
- Frontal
 - Divides the body into anterior (front) and posterior (back)
- Transverse
 - Divides the body into superior (top) and inferior (bottom) when the individual is in anatomical position

Skeleton divided into two parts

- Adult skeleton has 206 bones
- Axial
 - Cranium, vertebrae, ribs and sternum
 - 80 bones
- Appendicular
 - Upper limb, lower limb and their girdles
 - 126 bones

Skeletal Functions

- 1. Protection of heart, lungs, brain etc.
- 2. Support to maintain posture
- 3. Movement by serving as points of attachment for muscles and acting as levers
- 4. Mineral storage such as calcium & phosphorus
- 5. Hemopoiesis – in vertebral bodies, femurs, humerus, ribs and sternum
 - Process of blood cell formation in the red bone marrow



Cartilage

- Found throughout the body
- Semirigid connective tissue that is weaker than bone but more flexible and resilient
- Contains a population of cells scattered throughout a matrix of protein fibres embedded within a gel-like ground substance

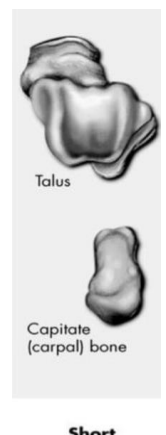
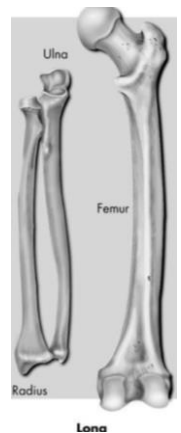
- Chondroblasts are the cells that produce the matrix of cartilage
- Once they become encased within the matrix they have produced and secreted, the cells are called chondrocytes and occupy small spaces named lacunae
- These mature cartilage cells maintain the matrix and ensure it remains healthy and viable
- Mature cartilage is avascular, so nutrients must diffuse through the matrix
- Three types of cartilage – hyaline, elastic and fibrocartilage

Functions of cartilage

- Supporting tissue
- Providing a gliding surface at articulations (joints) where two bones meet
- Providing a model for the formation of most of the bones in the body.

Types of bones

- Long bones – humerus, fibula
 - Composed of a long cylindrical shaft with relatively wide, protruding ends
 - Shaft contains the medullary canal
- Short bones – carpals, tarsals
 - Small, cuboidal shaped, solid bones that usually have a proportionally large articular surface in order to articulate with more than one bone
- Flat bones – skull, scapula
 - Usually have a curved surface and vary from thickness, where tendons attach tend to very thin

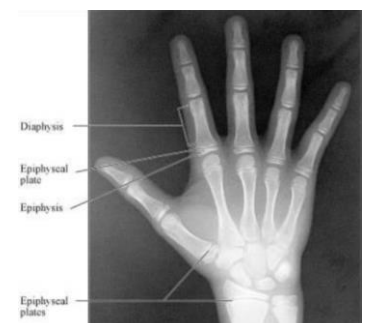
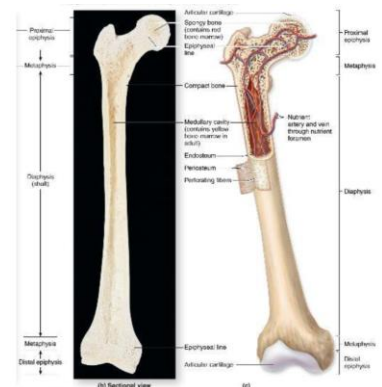
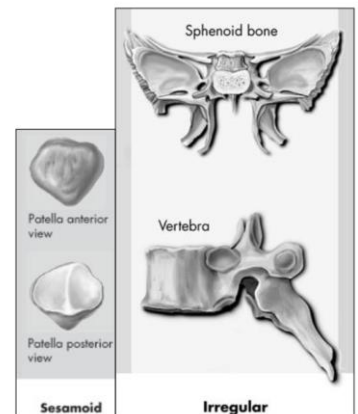
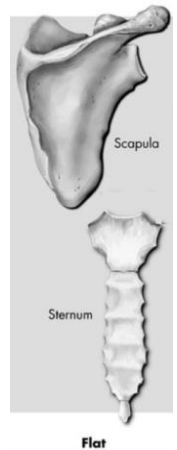


Short

- Irregular bones – pelvis, ethmoid, ear ossicles
- Sesamoid bones – patella

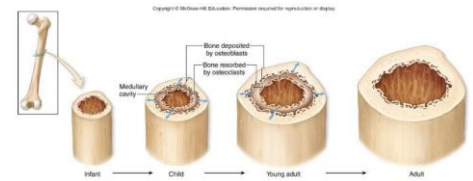
Typical bony features

- Diaphysis
 - Long cylindrical shaft
- Metaphysis
 - The widened portion at the end of each long bone
 - In between the diaphysis and the epiphysis
- Epiphysis
 - Ends of long bones formed from cancellous bone
- Epiphyseal plate
 - Growth plate
 - Thin cartilage plate separates diaphysis & epiphyses
- Cortex
 - Hard, dense compact bone forming walls of diaphysis
- Periosteum
 - Dense, fibrous membrane covering outer surface of diaphysis
 - Rich capillary network – key source of bone blood supply
- Endosteum
 - Fibrous membrane that lines the inside of the cortex
- Medullary cavity
 - Within the walls of the diaphysis
 - Contains red or yellow marrow
- Articular cartilage
 - Covering the epiphysis to provide cushioning effect and reduce friction



Bone Growth

- Internal layer of periosteum builds new concentric layers on old layers
- Simultaneously, bone around sides of the medullary cavity is reabsorbed so that the diameter is continually increased
- Osteoblasts – cells that form new bone
- Osteoclasts – cells that resorb old bone



Bone properties

- Composed of calcium carbonate, calcium phosphate, collagen and water
 - 60-70% of bone weight – calcium carbonate and calcium phosphate
 - 25-30% of bone weight – water
- Collagen provides some flexibility and strength in resisting tension
- Aging causes progressive loss of collagen and increases brittleness
- Most outer bone is cortical with cancellous underneath
- Cortical bone – low porosity, 5 to 30% non-mineralised tissue
- Cancellous – spongy, high porosity 30 to 90%
- Cortical is stiffer and can withstand greater stress but less strain than cancellous
- Cancellous is spongier and can undergo greater strain before fracturing
- Bone size and shape are influenced by the direction and magnitude of forces that are habitually applied to them
- Bones reshape themselves based upon the stresses placed upon them
- Bones mass increases over time with increased stress

Functions of bone

- Support and protection
 - Provide structural support and serve as a framework for the entire body

- Protect many delicate tissues and organs from injury and trauma
- Movement
 - Attachment sites for skeletal muscles, other soft tissues and some organs
 - Muscles attached to the bones of the skeleton contract and exert a pull on the skeleton that then function as a system of levers
 - The bones of the skeleton can alter the direction and magnitude of the forces generated by skeletal muscles
 - Potential movements range from powerful contractions needed for running and jumping to delicate precise movements required to remove a splinter from a finger
- Hemopoiesis
 - The process of blood cell production
 - Occurs in connective tissue called red bone marrow, which is located in some spongy bone
 - Red bone marrow contains stem cells that form all blood cells and platelets
 - The location of red bone marrow differs between children and adults
 - In children, red bone marrow is located in the spongy bone and the medullary cavity of most bones in the body
 - As children turn into adults, much of the red bone marrow degenerates and turns into fatty tissue called yellow bone marrow
 - As a result, adults have red bone marrow only in selected portions of the axial skeleton, such as flat bones of the skull, the vertebrae, the ribs, the sternum and the ossa coxae (hip bones)
 - Adults also have red bone marrow in the proximal epiphyses of each humerus and femur
- Storage of mineral and energy reserves
 - More than 90% of the body's reserves of minerals calcium and phosphate are stored within and released by bone

- Calcium is an essential mineral for body functions such as muscle contraction, blood clotting and nerve impulse transmission
- Phosphate is a structural component of ATP, nucleotides and phospholipids
- When calcium or phosphate is needed by the body, some bone connective tissue is broken down, and the minerals are released into the blood
- In addition, potential energy in the form of lipids is stored in yellow bone marrow, which is located in the shafts of adult long bones

Cells of Bone

- Four types of cells occur in bone connective tissue;
- Osteoprogenitor cells
 - Stem cells derived from mesenchyme
 - When they divide, they produce another stem cell and a “committed cell” that matures to become an osteoblast
 - These stem cells are located in both the periosteum and the endosteum
- Osteoblasts
 - Formed from osteoprogenitor stem cells
 - Often osteoblasts exhibit a somewhat cuboidal structure
 - They secrete the initial semisolid, organic form of bone matrix called osteoid
 - Osteoid later calcifies and hardens as a result of calcium salt deposition
 - Osteoblasts produce new bone, and once osteoblasts become entrapped in the matrix they produce and secrete, they differentiate into osteocytes
- Osteocytes
 - Mature bone cells derived from osteoblasts that have become entrapped in the matrix they have secreted
 - They reside in small places within the matrix called lacunae

- Osteocytes maintain the bone matrix and detect mechanical stress on a bone
- This information is communicated to osteoblasts, and may result in the deposition of new bone matrix at the surface
- Osteoclasts
 - Are large, multinuclear, phagocytic cells
 - They are derived from fused bone marrow cells similar to those that produce monocytes
 - These cells exhibit a ruffled border where they contact the bone, which increases their surface area exposure to the bone
 - An osteoclast is often located within or adjacent to a depression or pit on the bone surface area called a resorption lacuna
 - Osteoclasts are involved in an important process called bone resorption that takes place as follows: osteoclasts secrete hydrochloric acid, which dissolves the mineral parts of the bone matrix, while lysosomes within the osteoclasts secrete enzymes that dissolve the organic part of the bone matrix
 - The release of the stored calcium and phosphate from the bone matrix is called osteolysis
 - The liberated calcium and phosphate ions enter the tissue fluid and then the blood

Composition of the bone matrix

- The matrix of bone connective tissue has both organic and inorganic components
- About one-third of bone mass is composed of organic components called osteoid
- It includes cells, collagen fibers and ground substance
- The collagen fibers give a bone tensile strength by resisting stretching and twisting and contribute to its overall flexibility
- The inorganic components of the bone provide its compressional strength

- Calcium phosphate accounts for most of the inorganic components of bone
- Calcium phosphate and calcium hydroxide interact to form crystals of hydroxyapatite
- These crystals deposit around the collagen fibers leading to hardening of the extracellular matrix

Comparison of compact and spongy bone

- Compact bone is solid and relatively dense
- Spongy bone appears more porous
- The arrangement of compact bone and spongy bone components differs at the microscopic level
- In a long bone, compact bone forms the solid external walls of the bone, and spongy bone forms an open lattice of narrow plates of bone called trabeculae
- In a flat bone of the skull, spongy bone is sandwiched between two layers of compact bone

Wolff's Law

- Bones are thickest where muscles attach
 - Large forces act here
 - Robust blood supply at these sites
- Long bones are thick in the middle of the shaft
- Curved bones are thickest in areas where they are most likely to break
- An area where trabecular bone is abundant is where mechanical forces are the greatest

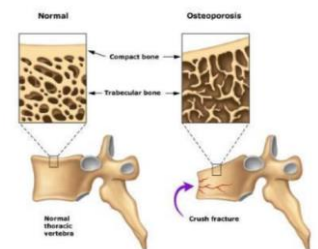
Aging of the skeletal system

- Aging effects bone connective tissue in two ways
- First the tensile strength of bone decreases due to a reduced rate of protein synthesis, which in turn results in decreased ability to produce the organic portion of bone matrix

- Consequently, the percentage of inorganic minerals in the bone matrix increases and the bones of the skeleton become brittle and susceptible to fracture
- Second bone loses calcium and other minerals
- The bones of the skeleton become thinner and weaker, resulting in insufficient ossification
- Osteoblast activity declines and osteoclast activity continues at previous levels

What happens with Osteoporosis?

- Imbalance bone resorption and bone formation
- Loss of bone matrix and bone density
- Structural integrity trabecular bone impaired
- Causes; endocrine dysfunction and age



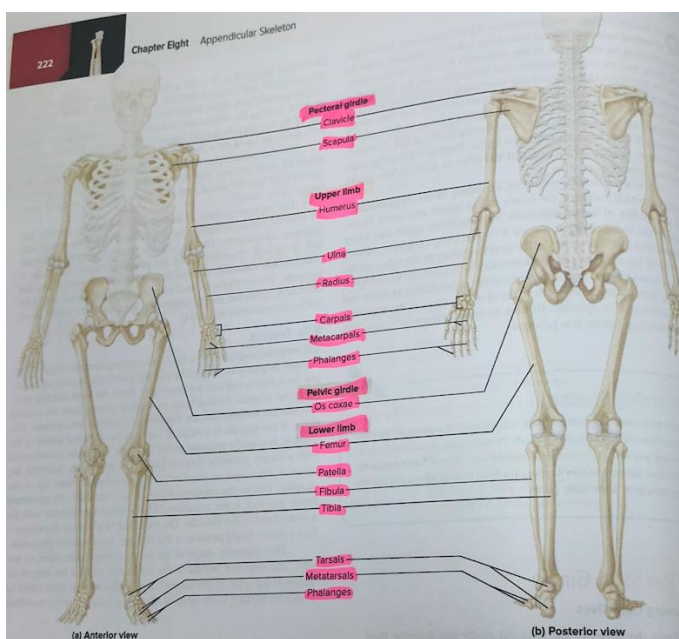
Bone Markings

- Distinctive bone markings characterise each bone in the body
- Projections from the bone surface mark the point where tendons and ligaments attach
- Sites of articulation between adjacent bones are smooth areas
- Depressions, grooves and tunnels through bones indicate sites where blood vessels and nerves travel
- Processes (include elevations and projections)
 - Processes to which ligaments, muscles or tendons attach
 - Crest
 - Epicondyle
 - Line

General Structure	Anatomic Term	Description
Articulating surfaces	Condyle	Large, smooth, rounded oval structure
	Facet	Small, flat, shallow surface
	Head	Prominent, rounded epiphysis
	Trochlea	Smooth, grooved, pulley-like process
Depressions	Alveolus (pl., alveoli)	Deep pit or socket in the maxillae or mandible
	Fossa (pl., fossae)	Flattened or shallow depression
	Sulcus	Narrow groove
Projections for tendon and ligament attachment	Crest	Narrow, prominent, ridgelike projection
	Epicondyle	Projection adjacent to a condyle
	Line	Low ridge
	Process	Any marked bony prominence
	Ramus (pl., rami)	Angular extension of a bone relative to the rest of the structure
	Spine	Pointed, slender process
	Trochanter	Massive, rough projection found only on the femur
	Tubercle	Small, round projection
Openings and spaces	Tuberosity	Large, rough projection
	Canal	Passageway through a bone
	Fissure	Narrow, slitlike opening through a bone
	Foramen (pl., foramina)	Rounded passageway through a bone
	Meatus	Passageway through a bone
	Sinus	Cavity or hollow space in a bone

- Process
- Spine
- Suture
- Trochanter
- Tubercle
- Tuberosity
- Processes that form joints
 - Condyle
 - Facet
 - Head
- Cavities - Including openings and grooves
 - Facet
 - Foramen
 - Fossa
 - Fovea
 - Meatus
 - Sinus
 - Sulcus

Appendicular skeleton

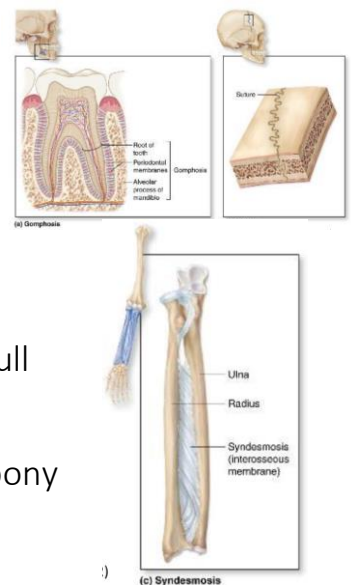


Articulations

- Classifications of joints
- Articulation – connection of bones at a joint usually to allow movement between surfaces of bones
- A joint of articulation is the place of contact between bones, between bone and cartilage or between bones and teeth
- Bones are said to articulate each other at a joint
- 3 major classifications according to structure and movement characteristics
 - Fibrous
 - Cartilaginous
 - Synovial

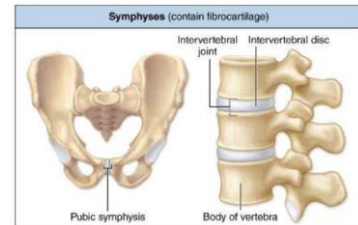
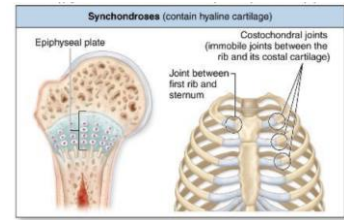
Fibrous

- Immovable joints
- Bones are held together by dense regular connective tissue
- Fibrous joints have no joint cavity
- Structural categories:
 - Suture – dense regular connective tissue connects skull bones
 - Gomphosis – periodontal membranes hold tooth to bony jaw such as teeth fitting into mandible or maxilla.
 - Syndesmosis
 - Two bones joined together by a strong ligament or an interosseous membrane that allows minimal movement between the bones
 - Bones may or may not touch each other at the actual joint



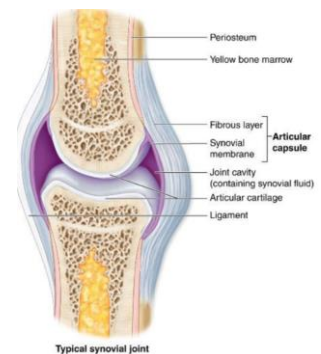
Cartilaginous

- Where bones are joined together by cartilage
- Synchondrosis/Primary cartilaginous joints
 - Type of joint separated by hyaline cartilage that allows very slight movement between the bones
- Symphysis/Secondary cartilaginous joints
 - Joint separated by a fibrocartilage pad that allows very slight movement between the bones



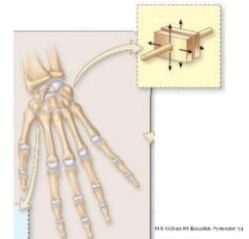
Synovial joints

- Freely movable
- fluid filled joint cavity that separates the cartilage-covered articulating surfaces of the bones
- The articulating surfaces are enclosed within a capsule, and the bones are also joined by various ligaments
- Composed of sleeve-like joint capsule
- Synovial fluid secretion to lubricate joint cavity
- Capsule thickenings form tough, non-elastic ligaments that provide additional support against abnormal movement or joint opening
- Articular or hyaline cartilage covers the articular surface ends of the bones inside the joint cavity
 - Absorbs shock
 - Protects the bone
- Slowly absorbs synovial fluid during joint unloading or distraction
- Secretes synovial fluid during subsequent weight bearing and compression
- Some synovial joints have specialised fibrocartilage discs
- Degrees of freedom
 - Motion in 1 plane = 1 DOF = Uniaxial
 - Motion in 2 planes = 2 DOF = Biaxial
 - Motion in 3 planes = 3 DOF = Multiaxial

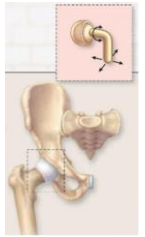


Types of synovial joints

- Gliding joints
 - Uniaxial – 1 DOF
 - 2 plane or flat bony surfaces which butt against each other
 - Little motion possible in any 1 joint articulation
 - Usually work together in series of articulations
 - E.g. Vertebral facets in spinal column, intercarpal and interarsal joints
 - Motions can be flexion, extension, abduction, adduction, diagonal adduction and rotation
- Hinge
 - Uniaxial articulation - 1 DOF
 - Articular surfaces allow motion in only one plane
 - E.g. elbow, ankle joint
- Pivot joint
 - Uniaxial articulation – 1 DOF
 - E.g. atlantoaxial joint – odontoid process which turns in a bony ring, proximal and distal radio-ulnar joints
- Condylloid joint
 - Biaxial ball and socket joint – 2 DOF
 - One bone with an oval concave surface received by another bone with an oval convex surface
 - Knuckles, wrist
 - Flexion, extension, abduction and adduction
- Saddle joints
 - Unique bi-axial joint – 2 DOF
 - 2 reciprocally concave and convex articular surfaces
 - 1st carpometacarpal joint at thumb, sternoclavicular joint
 - Flexion, extension, adduction and abduction



- Ball and socket
 - Multiaxial joints – 3 DOF
 - Bony rounded head fitting into a concave articular surface
 - E.g. hip and shoulder joint
 - Motions are flexion, extension, abduction, adduction, rotation



Movements in joints

- Some joints permit only flexion and extension
- Others permit a wide range of movements depending largely on the joint structure
- A goniometer is used to measure amount of movement in a joint or measure joint angles
- Goniometer axis is placed even with the axis of rotation at the joint line
- As joint is moved, goniometer arms are held in place either along or parallel to long axis of bones on either side of joint
- Joint angle is then read from goniometer
- Normal range of motion for a particular joint varies in people
- Terms are used to describe actual change in position of bones relative to each other
- Angles between bones change
- Movement occurs between articular surfaces of joint
 - 'flexing the knee' results in leg moving closer to thigh
- Movement terms describe movement occurring throughout the full range of motion or through a very small range
 - i.e. flex knee through full range beginning in full knee extension and flex it fully so that the heel comes in contact with buttocks, which is approximately 140 degrees of flexion
- some movement terms describe motion at several joints throughout the body
- some terms are relatively specific to a joint or group of joints
 - additionally, prefixes may be combined with these terms to emphasize excessive or reduced motion

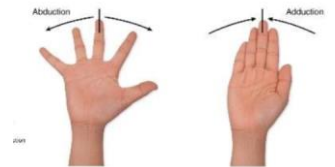
- hyper or hypo
- hyperextension is the most commonly used with regards to position

Range of motion

- Area through which a joint may normally be freely and painlessly moved
- Measurable degree of movement potential in joint or joints
- Measured with a goniometer in degrees 0 to 360

Movement terminology

- Abduction and adduction
 - E.g. Raising arms or legs to side horizontally and then returning towards the midline
- Flexion and extension
 - E.g. Elbow joint; when hand is drawn to shoulder and then moves back away from the shoulder
- Circumduction
 - Circular movement of a limb that delineates an arc or describes a cone
 - Combination of flexion, extension, abduction and adduction
 - E.g. when shoulder joint and hip joint move in a circular fashion around a fixed point
- Rotation
 - Rotary movement around longitudinal axis of a bone
 - Occurs in transverse plane
 - Head, neck, trunk – left rotation, right rotation
 - Limbs – medial/internal rotation, lateral/external rotation



Ankle and Foot movement terminology

- Eversion
 - Turning sole of foot outward or laterally
 - Standing with weight on inner edge of foot

- Inversion
 - Turning sole of foot inward or medially
 - Standing with weight on outer edge of foot
- Dorsiflexion
 - Flexion of ankle that results in top of foot moving forward anterior tibia bone
- Plantarflexion
 - Extension movement of ankle that results in foot moving away from the body

Shoulder girdle

- Elevation
 - Superior movement of shoulder girdle
 - Shrugging the shoulders
- Depression
 - Inferior movement of shoulder girdle
 - Returning to normal position from a shoulder shrug
- Protraction
 - Forward movement of shoulder girdle away from spine
 - Abduction of the scapula
- Retraction
 - Backward movement of shoulder girdle toward spine
 - Adduction of the scapula
- Rotation upward
 - Rotary movement of scapula with inferior angle/glenoid fossa of scapula moving laterally and upward
- Rotation downward
 - Rotary movement of scapula with inferior angle/glenoid fossa of scapula moving medially and downward

Shoulder joint

- Horizontal abduction

- Movement of humerus in horizontal plane away from midline of body
 - Also known as transverse abduction
- Horizontal adduction
 - Movement of humerus in horizontal plane toward midline of body
 - Also known as transverse adduction

Spine

- Lateral flexion (side bending)
 - Movement of head and/or trunk laterally away from midline
 - Abduction of spine
- Reduction
 - Return of spinal column to anatomic position from lateral flexion
 - Adduction of spine

Forearm

- Supination
 - Radius and ulnar are parallel
- Pronation
 - Radius and ulnar are crossed

Wrist and hand

- Radial flexion (radial deviation)
 - Abduction movement at wrist of thumb side of hand toward forearm
- Ulnar flexion (ulnar deviation)
 - Adduction movement at wrist of little finger side of hand toward forearm

Thumb

- Opposition of thumb

- Diagonal movement of thumb across palmar surface of hand to make contact with the hand and/or fingers
- Reposition of the thumb
 - Diagonal movement of the thumb as it returns to the anatomical position from opposition with the hand and/or fingers

Physiological movements v accessory motions

- Physiologic motion or osteokinematics
 - How the bones move, voluntary control
 - Flexion, extension, abduction, adduction and rotation
 - Occur by bones moving through planes of motion about an axis of rotation at joint
- Accessory motion or arthrokinematics
 - How the joints move, movements taking place within the joint, at joint surface, not under voluntary control
 - 3 types of motion
 - Spin
 - Roll
 - Glide
- If accessory motion is prevented from occurring, then physiological motion cannot occur to any substantial degree other than by joint compression or distraction
- Due to most synovial joints being composed of a concave surface articulating with a convex surface roll and glide must occur together to some degree

Planes and axes

	Plane	Axis	Movement
Divides body in to left and right	Sagittal plane	Frontal axis	Elbow flexion/extension, trunk flexion/extension
Divides body in to superior and inferior	Transverse/ Horizontal plane	Longitudinal axis	Rotation of head/neck, rotation shoulder
Divides body in to anterior posterior	Frontal/Coronal plane	Sagittal axis	Abduction/ Adduction of hip, lateral trunk flexion