WJEC (Wales) Biology A-level

Unit 4.B - Human musculoskeletal anatomy

Flashcards

What is cartilage?

What is cartilage?

- Smooth, elastic connective tissue found in many areas of the body (e.g. joints) that provides structural support
- Consists of **chondrocytes**, surrounded by an extracellular matrix

Name the three types of cartilage.

Name the three types of cartilage.

- **Hyaline** cartilage
- **Yellow elastic** cartilage
- **White fibrous** cartilage

Where is hyaline cartilage found?

Where is hyaline cartilage found?

At the ends of bones and in the nose and trachea.

Describe the structure of hyaline cartilage.

Describe the structure of hyaline cartilage.

Contains a lot of collagen but no nerves or blood vessels.

Where is yellow elastic cartilage found?

Where is yellow elastic cartilage found?

Found in the external ear and epiglottis.

What does yellow elastic cartilage consist of?

What does yellow elastic cartilage consist of?

Yellow elastic fibres

Where is white fibrous cartilage found?

Where is white fibrous cartilage found?

Located in the discs between vertebrae.

Describe the composition of white fibrous cartilage.

Describe the composition of white fibrous cartilage.

It is made of up cartilaginous tissue with white fibrous tissue and collagen, giving a high tensile strength.

Outline the components of compact bone.

Outline the components of compact bone.

Matrix consisting of 30% organic material (primarily collagen) and 70% inorganic material (mainly hydroxyapatite).

What is the function of the organic and inorganic material in compact bone?

What is the function of the organic and inorganic material in compact bone?

- **Organic material** - prevents shear stress, helping to resist fractures
- **Inorganic material** - helps to stop compression

Name two types of specialised bone cells.

Name two types of specialised bone cells.

- Osteoblasts
- Osteoclasts

What are osteoblasts?

What are osteoblasts?

Groups of connected cells embedded in the matrix of bone that lay down new bone during development of the skeleton and remodelling.

What are osteoclasts?

What are osteoclasts?

Bone cells that break down bone tissue. This is important in the repair and remodeling of bone.

What is the functional unit of compact bone?

What is the functional unit of compact bone?

Haversian system

Describe the structure of Haversian systems.

Describe the structure of Haversian systems.

- Small, cylindrical structures
- Consist of layers of bone tissue around a central canal (Haversian canal) which contains the blood supply

What is the function of Haversian systems?

What is the function of Haversian systems?

Provide a transport system in bone, facilitating the supply of nutrients and oxygen to bone cells.

Give some examples of bone disorders.

Give some examples of bone disorders.

- Osteomalacia
- Rickets
- Osteoporosis
- Brittle bone disease

What deficiencies may cause rickets and osteomalacia?

What deficiencies may cause rickets and osteomalacia?

Calcium or vitamin D deficiency.

What is vitamin D?

What is vitamin D?

- Fat-soluble vitamin present in a variety of foods (e.g. butter, eggs, fish liver oils)
- Also produced by the body in response to sunlight exposure
- Required for calcium absorption in the gut

Describe the effects of calcium or vitamin D deficiency in rickets and osteomalacia.

Describe the effects of calcium or vitamin D deficiency in rickets and osteomalacia.

- Defective bone mineralisation
- Results in soft, weak bones and bone deformities

What is the cause of osteoporosis?

What is the cause of osteoporosis?

- Low peak bone mass or high bone loss
- Due to a range of factors including age, gender, diet, genetics etc.

Describe the symptoms and treatment of osteoporosis.

Describe the symptoms and treatment of osteoporosis.

- **Symptoms** - weak bones that can easily break resulting in chronic pain
- **Treatment** - endurance exercises, fall prevention and prescription of bisphosphonates

What are bisphosphonates?

What are bisphosphonates?

A class of drugs that are used to treat bone disorders by increasing mineral density.

Describe brittle bone disease.

Describe brittle bone disease.

A genetic disorder characterised by brittle bones that are prone to fracture.

What is the cause of brittle bone disease?

What is the cause of brittle bone disease?

A gene mutation prevents collagen production, causing an imbalance in the components of the matrix in bone.

How is brittle bone disease treated?

How is brittle bone disease treated?

- Insertion of metal rods in long bones
- Physiotherapy
- Bisphosphonate drugs

What is skeletal muscle?

What is skeletal muscle?

A voluntary muscle responsible for movement. It makes up the majority of body muscle and is attached to the skeleton by tendons.

Describe the gross structure of skeletal muscle.

Describe the gross structure of skeletal muscle.

- Muscle cells are fused together to form bundles of parallel muscle fibres (**myofibrils**)
- Arrangement ensures there is no point of weakness between cells
- Each bundle is surrounded by **endomysium**, loose connective tissue with many capillaries

Describe the ultrastructure of skeletal muscle.

Describe the ultrastructure of skeletal muscle.

- **Myofibrils** - tiny contractile muscle fibres which group together
- **Sarcoplasm** - shared nuclei and cytoplasm with lots of mitochondria and endoplasmic reticulum
- **Sarcolemma** - folds inwards towards sarcoplasm to form transverse (T) tubules

What is the sarcoplasmic reticulum?

What is the sarcoplasmic reticulum?

A membrane-bound structure in muscle cells that stores calcium ions.

Name the two protein filaments that make up myofibrils.

Name the two protein filaments that make up myofibrils.

- Actin
- Myosin

Describe the structure of actin.

Describe the structure of actin.

- Forms **thin** filaments consisting of two long twisted chains
- Two accessory pigments:
  - **Troponin** - protein complex bound at regular intervals
  - **Tropomyosin** - fibrous strand wrapped around actin filament

Describe the structure of myosin.

Describe the structure of myosin.

Forms thick filaments, consisting of long tails with bulbous heads, positioned to the side.

What is a sarcomere?

What is a sarcomere?

Each repeating unit of striations between adjacent Z-lines.

Draw a diagram to show the ultrastructure of a myofibril.

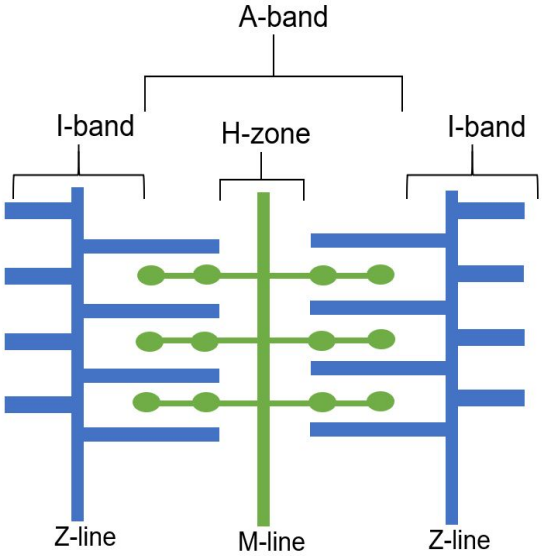
Draw a diagram to show the ultrastructure of a myofibril.

Z-line - boundary between sarcomeres

I-bands - light bands, actin only

A-band - dark bands, overlap of actin and myosin

H-zone - centre of A-band, only myosin



Explain the role of Ca^{2+} ions in muscle contraction.

Explain the role of Ca^{2+} ions in muscle contraction.

1. Action potential moves through T-tubules in the sarcoplasm causing Ca^{2+} channels in the sarcoplasmic reticulum open
2. Ca^{2+} binds to troponin causing it to change shape and displace tropomyosin
3. Exposes binding sites on actin filaments so actin-myosin cross-bridges can form

What is the sliding filament theory?

What is the sliding filament theory?

The mechanism by which a muscle contracts.

Outline the ‘sliding filament theory’.

Outline the ‘sliding filament theory’.

1. Myosin head with ADP attached forms **cross-bridge** with actin
2. Myosin head changes shape and loses ADP, pulling actin over, myosin - **power stroke**
3. ATP attaches to myosin head, causing it to detach from actin
4. ATPase hydrolyses ATP to ADP (+Pi) so myosin head can return to original position
5. Myosin head re-attaches to actin further along filament and the cycle repeats

How does sliding filament action cause a myofibril to shorten?

How does sliding filament action cause a myofibril to shorten?

- Myosin heads flex in opposite directions. Actin filaments are pulled towards each other
- Distance between adjacent sarcomere Z lines shortens
- Sliding filament action occurs up to 100 times per second in multiple sarcomeres

Describe the changes in a sarcomere during muscle contraction.

Describe the changes in a sarcomere during muscle contraction.

Sarcomere shortens:

- A-band stays the same
- I-band shortens
- H-zone shortens

What happens during muscle relaxation?

What happens during muscle relaxation?

- Ca^{2+} ions are pumped back into the sarcoplasmic reticulum
- Tropomyosin blocks actin binding site

Name the two types of fibre in striated muscle.

Name the two types of fibre in striated muscle.

- Slow twitch fibres
- Fast twitch fibres

Where are slow and fast twitch muscle fibres found in the body?

Where are slow and fast twitch muscle fibres found in the body?

- **Slow twitch** - sites of sustained contraction, e.g. calf muscle
- **Fast twitch** - sites of short-term, rapid, powerful contraction, e.g. biceps

Explain the role of slow and fast twitch muscle fibres.

Explain the role of slow and fast twitch muscle fibres.

- **Slow twitch** - long-duration contraction; well-adapted to aerobic respiration to prevent lactate build-up
- **Fast twitch** - powerful short-term contraction; well-adapted to anaerobic respiration

Compare slow and fast twitch muscle fibres.

Compare slow and fast twitch muscle fibres.

Slow twitch	Fast twitch
Fire slowly, contract for a long time, fatigue slowly	Fire quickly, contract for a shorter time, fatigue quickly
Mainly carry out aerobic respiration	Mainly carry out anaerobic respiration
Dense network of capillaries	Fewer capillaries
High numbers of mitochondria	Lower numbers of mitochondria
High myoglobin levels	Lower myoglobin levels
Lower density of myofibrils	High density of myofibrils
Low resistance to lactic acid	High resistance to lactic acid

Describe the different types of anaerobic respiration that take place in muscles.

Describe the different types of anaerobic respiration that take place in muscles.

- **Glycolysis** - produces a small yield of ATP, lactic acid build-up
- Breakdown of **creatine phosphate** into creatine, releasing ATP

Describe the effect of lactic acid build-up in muscles.

Describe the effect of lactic acid build-up in muscles.

Leads to muscle cramp and fatigue.

What is creatine phosphate?

What is creatine phosphate?

- Compound stored in muscles that serves as a phosphate reserve, enabling ATP regeneration
- Made under aerobic conditions

Write an equation to show the break down of creatine phosphate under anaerobic conditions.

Write an equation to show the break down of creatine phosphate under anaerobic conditions.

ADP + **PCr** → ATP + Cr

What are the main sources of energy during muscle contraction?

What are the main sources of energy during muscle contraction?

Mainly glycogen and some protein.

What is carbohydrate loading?

What is carbohydrate loading?

A strategy used by athletes to increase glycogen storage in muscles.

Outline the functions of the human skeleton.

Outline the functions of the human skeleton.

- Support
- Protection
- Attachment of muscles
- Production of red blood cells
- Calcium store

State the two divisions of the human skeleton.

State the two divisions of the human skeleton.

- Axial skeleton
- Appendicular skeleton

What is the axial skeleton?

What is the axial skeleton?

The part of the skeleton that forms the central axis of the body.

Name the bones that make up the axial skeleton.

Name the bones that make up the axial skeleton.

- Skull
- Vertebral column
- Sternum
- Ribcage
- Sacrum

What is the appendicular skeleton?

What is the appendicular skeleton?

The part of the skeleton made up of bones that support the appendages.

Name the bones that make up the appendicular skeleton.

Name the bones that make up the appendicular skeleton.

- Forelimb
- Hind limb
- Pectoral girdle
- Pelvic girdle

What is a fracture?

What is a fracture?

A broken bone that can occur due to impact, stress or disease.

State the five different types of fracture.

State the five different types of fracture.

- Displaced
- Non-displaced
- Simple
- Compound
- Comminuted

Give some examples of medical conditions that may lead to bone fractures.

Give some examples of medical conditions that may lead to bone fractures.

- Osteoporosis
- Brittle bone disease
- Bone cancer

Describe a displaced fracture.

Describe a displaced fracture.

Type of fracture in which the bone breaks and moves so that the two parts no longer align.

Describe a non-displaced fracture.

Describe a non-displaced fracture.

Type of fracture in which the bone cracks but does not move, maintaining its alignment.

What type of fracture involves the breakage of a bone into several pieces?

What type of fracture involves the breakage of a bone into several pieces?

Comminuted fracture

What is a simple fracture?

What is a simple fracture?

A fracture of the bone only. Surrounding tissues and organs are not damaged.

What type of fracture involves a bone that breaks through the skin?

What type of fracture involves a bone that breaks through the skin?

Compound fracture

How are fractures treated?

How are fractures treated?

- Realignment and fixation with a splint or cast
- Surgery to insert metal screws or plates

What is the vertebral column?

What is the vertebral column?

- Flexible column in the axial skeleton that provides support and protection to the spinal cord
- Consists of individual vertebra

Describe the general structure of a vertebra.

Describe the general structure of a vertebra.

Each vertebra consists of…

- Vertebral body
- Transverse processes
- Spinal canal

Name three different types of vertebra.

Name three different types of vertebra.

- Cervical
- Lumbar
- Thoracic

Name the smallest vertebrae.

Name the smallest vertebrae.

Cervical vertebrae

Describe the cervical vertebrae.

Describe the cervical vertebrae.

- Small vertebrae of the neck which lie directly below the skull
- Vertebral artery passes through a foramen in each transverse process

Name the largest vertebrae.

Name the largest vertebrae.

Lumbar vertebrae

Describe the lumbar vertebrae.

Describe the lumbar vertebrae.

- Five largest vertebrae found between the rib cage and the pelvis
- Form the spine in the lower back
- Support the upper body's weight, provide flexibility and enable movement

Describe the thoracic vertebrae.

Describe the thoracic vertebrae.

- 12 vertebrae located in the middle of the vertebral column between the cervical and lumbar vertebrae
- They have transverse processes and facets for attachment of the ribs

Give some examples of postural deformities.

Give some examples of postural deformities.

- Scoliosis
- Knock knees
- Flat foot

What is scoliosis?

What is scoliosis?

A postural deformity characterised by a curvature of the spine, which often appears as an S or C shape.

Outline the causes of scoliosis.

Outline the causes of scoliosis.

- Gene mutation
- Muscle problems
- Tumours
- Cerebral palsy

How is scoliosis treated?

How is scoliosis treated?

- Painkillers
- Physiotherapy
- Back braces
- Surgery

Describe the causes and treatment of flat foot.

Describe the causes and treatment of flat foot.

- No or low arch in the foot
- Treated using specialised footwear

What is knock knees?

What is knock knees?

A postural deformity in which a large gap can be observed between the feet when an affected individual stands with their knees together.

What is the cause of knock knees?

What is the cause of knock knees?

Calcium or vitamin D deficiency.

Name the four types of joint.

Name the four types of joint.

- Immovable
- Gliding
- Ball and socket
- Hinge

What is an immovable joint?

What is an immovable joint?

- An articulation between two bones where no movement is possible
- Also called a fused joint

Give an example of an immovable joint.

Give an example of an immovable joint.

Cranium

What is a gliding joint?

What is a gliding joint?

- An articulation between bones that meet at flat surfaces
- Bones can glide past each other along the plane of the joint in any direction

Give an example of a gliding joint.

Give an example of a gliding joint.

Ankle and wrist bones

Describe a hinge joint.

Describe a hinge joint.

An articulation between two bones in which movement can occur in one plane.

Give an example of a hinge joint.

Give an example of a hinge joint.

Knee and elbow

What is a ball and socket joint?

What is a ball and socket joint?

- A joint in which the rounded end of one bone moves within the ‘socket’ of another
- Movement can occur in multiple planes

Give an example of a ball and socket joint.

Give an example of a ball and socket joint.

Hip and shoulder

Describe osteoarthritis.

Describe osteoarthritis.

A degenerative disease caused by the loss of articular cartilage in a joint due to changes in its constituent collagen and glycoprotein.

Outline the risk factors for osteoarthritis.

Outline the risk factors for osteoarthritis.

- Joint damage
- Vigorous bending of a joint
- Being overweight

How is osteoarthritis treated?

How is osteoarthritis treated?

- Non-steroidal anti-inflammatory drugs
- Surgery to replace a joint

What is rheumatoid arthritis?

What is rheumatoid arthritis?

An autoimmune disease that is characterised by stiff, swollen joints with restricted movement (due to an inflammatory response).

Outline the risk factors for rheumatoid arthritis.

Outline the risk factors for rheumatoid arthritis.

- Smoking
- Diet high in red meat or coffee
- Cold and damp weather
- Genetics

How is rheumatoid arthritis treated?

How is rheumatoid arthritis treated?

- Steroidal anti-inflammatory drugs
- Physiotherapy
- Surgery

Describe the advantages and disadvantages of joint replacement surgery.

Describe the advantages and disadvantages of joint replacement surgery.

Advantages	Disadvantages
Relief from pain	Risk of blood clots or infection
Greater mobility	Greater risk of hip dislocation (hip replacement)
Increased quality of life	Long recovery time
Patient has to take fewer drugs	Limited lifespan of replacement join. Increased risk with further replacements.

What is a first order lever? Give an example.

What is a first order lever? Give an example.

- Fulcrum between the effort and the load
- E.g. joint between the head and the first vertebrae

What is a second order lever? Give an example.

What is a second order lever? Give an example.

- Load between the effort and the fulcrum
- E.g. lower leg on tiptoes

What is a third order lever? Give an example.

What is a third order lever? Give an example.

- Effort between the fulcrum and the load
- E.g. elbow joint

What is a synovial joint?

What is a synovial joint?

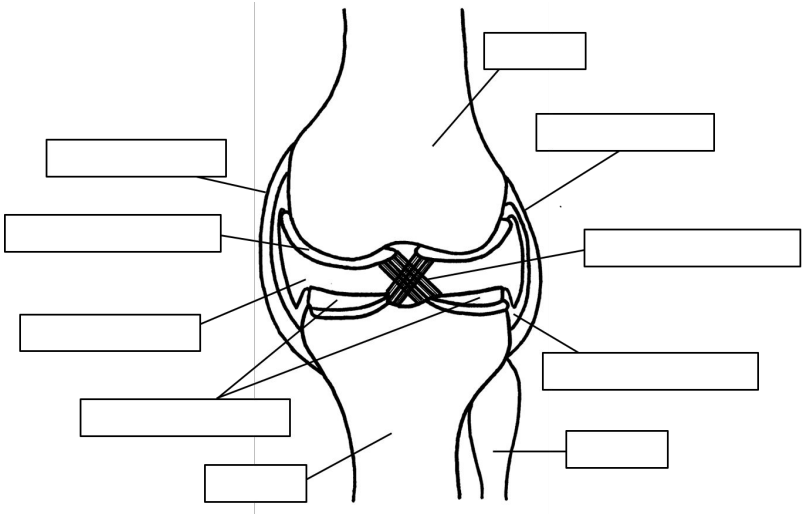
- Most common joint in mammals
- Characterised by the presence of a fluid-filled cavity enclosed in a fibrous capsule

State the key features of a synovial joint.

State the key features of a synovial joint.

- Cartilage
- Synovial membrane
- Synovial fluid
- Ligaments

Fill in the missing labels in the diagram of a synovial joint below.



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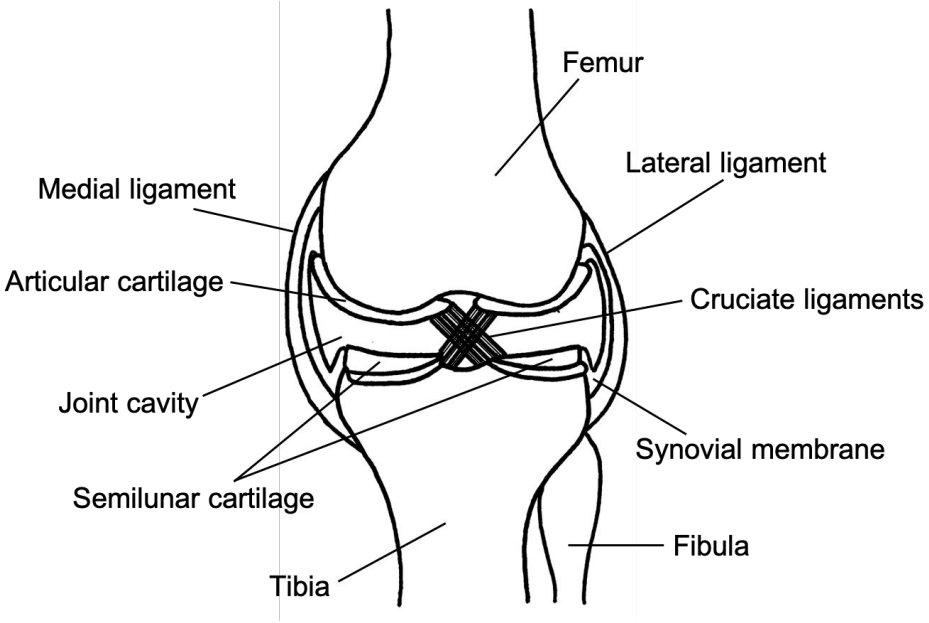

Describe the role of cartilage in the synovial joint.

Describe the role of cartilage in the synovial joint.

- Absorbs shock
- Acts as a lubricant, reducing friction when the joint moves

What is the function of the synovial membrane?

What is the function of the synovial membrane?

Secretion of synovial fluid.

What is synovial fluid?

What is synovial fluid?

A viscous fluid that reduces friction between the articular cartilage of joints during movement.

What are ligaments?

What are ligaments?

Fibrous bands of connective tissue that connect two bones to form a joint.

What are antagonistic muscles?

What are antagonistic muscles?

Pairs of muscles that work in opposite directions, e.g. biceps and triceps in the human arm.

Describe the actions of biceps and triceps in the arm.

Describe the actions of biceps and triceps in the arm.

- Biceps contracts, forearm pulled upwards, triceps relax
- Triceps contracts, forearm pulled downwards, biceps relax