HISTOLOGY

This is the study of tissues. A tissue is a group of physically linked cells specialised to perform a particular function.

ANIMAL TISSUES

There are several animal tissues including epithelial, connective, muscle, nervous and blood tissue

Epithelial tissues

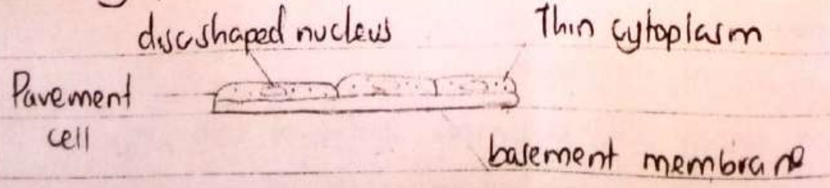
These line internally some surfaces of the body. They may be arranged in a single layer of cells or multiple layers of cells
The cells are held together by an intercellular substance and they rest on the basement membrane.
Epithelial cells are not supplied with blood vessels so exchange occurs by simple diffusion.
Epithelial tissue is mainly protective like the cornified epithelium of the skin though they may be modified to perform other functions.
Epithelial tissue is classified into three categories:
i) Simple epithelial tissue (One cell thick)
ii) Compound epithelial tissue (more than one layer of cells)
iii) Glandular epithelial tissue (secretory function)

SIMPLE EPITHELIAL TISSUES

These are tissues made up of one layer of cells. There are various types of simple epithelial tissues named according to the shape of the cells or the surface modifications.
Tissues in this category include

a) Squamous/Pavement Epithelium

It is compared of thin flattened cells with little cytoplasm enclosing a centrally placed disc shaped nucleus

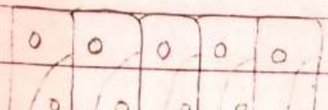


e) Pseudostratified epithelium

When observed in section, the cells of the pseudostratified epithelium appear to have two layers of nuclei.

However when examined closely, it appears to have two layers of cell both sitting on the basement membrane.

It gives an impression of compound epithelium but because both layers of cells sit on the basement membrane, it is best described as pseudostratified.



It is unspecialised and lines Urinary tubules for support.

COMPOUND EPITHELIUM TISSUES

This is made up of two major types

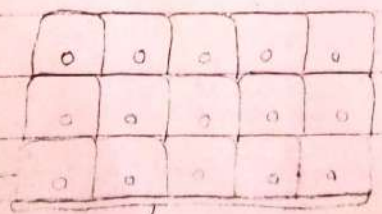
i) stratified epithelium

ii) Transitional epithelium

Stratified epithelium comprises of a number of layers of cells making it thicker than the simple epithelium. It's found in areas where abrasion occurs like the skin, oesophagus and vaginal tract.

The layer of cells on the surface normally peels off periodically because of abbresion therefore needs to be replaced, Because of this, the first layer on the basement membrane is mitotic and is called the germinal layer which divides repeatedly to replace the last layer of cells.

In the cornified epithelium, the outermost layer is dead for protection of the underlined tissue. It is rich in keratin and is called cornified layer.

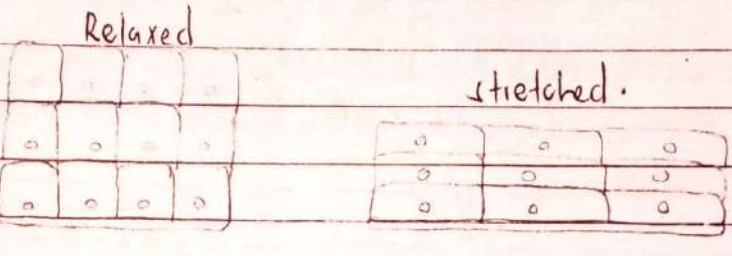


The stratified epithelium is described according to the shape of the cells giving three types ie stratified squamous, stratified cuboidal, stratified columnar.

In Transition epithelium, there are three to four layers of cells resting on the basement membrane.

This epithelium is found in areas which can be strong stretched and relaxed. so the cells show transition in shape ie they change shape

When the cells are subjected to a tension force, they stretch becoming longer and flattened. And when the tension is removed, they regain the original shape. This can occur in the urinary and gall bladders which are lined by this kind of epithelium.



GLANDULAR EPITHELIUM TISSUES.

Glandular tissue is secretory in function and is composed of specialised cells to fullfill the secretory function.

There are two major chemicals secreted by the glands ie hormones and enzymes.

Enzymes are secreted by exocrine glands which posses a duct through which the materials are released out of the gland. Such glands include salivary glands, gastric glands, pancreas etc.

Hormones are secreted by endocrine glands and through evolution, these have lost their ducts and release their secretion directly into the blood stream. Such glands include ovary, Pituitary, Adrenal glands, Testes etc.

Most glands are either exocrine or endocrine except the pancreas which has the exocrine parts that secrets pancreatic juice and endocrine part that secrets insulin and glucagon hormones. concerned with carbohydrate metabolism

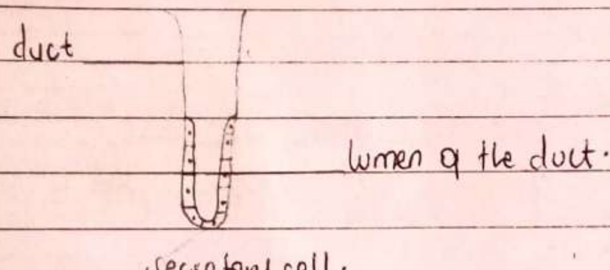
There are several exocrine glands which are classified basing on two parameters.
i) the shape of the secretory part
ii) the nature of the duct

If the secretory part forms the tube the gland is tubular. But if it forms a sack the gland is saccular/alveoli.

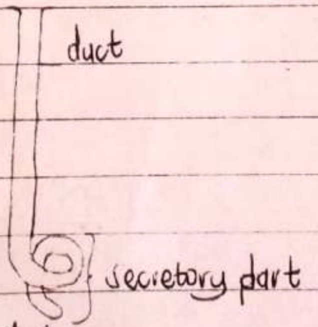
If the duct is unbranched, the gland is said to be simple and if branched the gland is said to be compound.

The exocrine glands may also be classified as simple compound depending on the nature of the ducts. If the duct is unbranched, the gland is simple and if it is branched the gland is compound.

i) Simple tubular glands eg the gastric glands which secretes gastric Juice in the stomach.

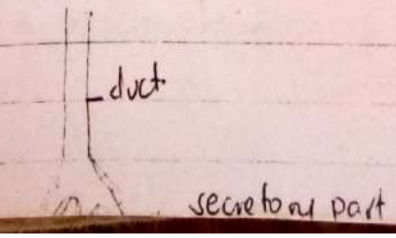


(ii) Simple coiled tubular glands eg the sweat gland in the skin



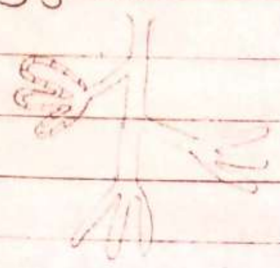
(iii) Simple branched tubular

These have their secretory parts branched but with a single unbranched duct eg in the Brunner's glands in the mammalian intestine that secretes mucus. The mucus protects the intestinal walls from the agressive nature of the digestive enzymes.



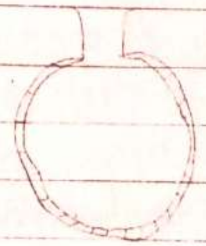
Compound branched tubular gland

This has the duct branched giving a compound glandular tissue eg the salivary glands



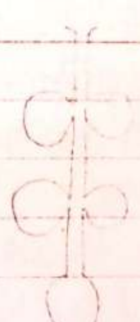
(iv) Simple alveolar/saccular gland

This has the secretory part sac-like in appearance eg the poison glands in the skin of amphibians.



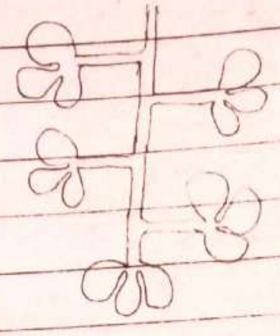
(v) Simple branched alveolar

This has a single duct with many sacs branching from the duct eg the sebaceous glands in the skin



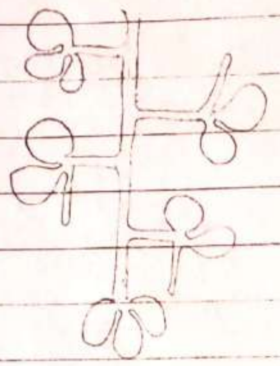
Compound branched Alveolar

This has the duct branched and each branch having a series of sacs all releasing their secretions into the various ducts eg mammary glands and the exocrine part of the pancreas.



compound branched tubular saccular gland.

This has many branched ducts possessing a mixture of tubes and sacs eg the salivary glands (sub-maxillary gland)



Glands that show branches in their secretory part whether simple or compound present a large surface area for secretion and is characteristic of glands where secretions are required continously and in large amounts eg salivary glands, mammary glands etc.

Glands like the poison glands of the amphibians release their secretions occasionally.

The surface area is a ~~m~~ not a major modification for their function.

Glandular Epithelial tissue releases its secretion in three ways:

1) Diffusion from the secretory cell.

Here, the secretion diffuses through the cell membrane into the lumen of the glands and is transported by the ducts. These glands are called Merocrine glands.

ii) By loss of part of the cytoplasm containing the secretion.

Here, a portion of the cytoplasm loaded with the ~~cytoplasm~~ secretion pinches off from the surface of the cell eg in mammary glands. These glands are called apocrine glands and they have high powers of regeneration eg mammary glands.

iii) Loss of the whole cell

This involves the whole cell leaving the basement membrane to release its secretion. These glands have high rate of mitosis to regenerate the lost cells. These glands are called Holocrine eg the sebaceous glands.

NOTE:

Some glands use 2 mechanisms to release their secretions and these are called mixed glands. They may use merocrine (one secretion) and apocrine to release another secretion eg Mammary glands secrete fats by apocrine and proteins by merocrine.

GENERAL FUNCTIONS OF EPITHELIAL TISSUE:

1. Absorption:

The Epithelium lining the ileum, Bowman's capsule, alveolar: is made up of one layer of flattened cells (squamous and is adapted for exchangle of materials by simple diffusion where short distance is required. Some epithelial cells have microvilli on their end increasing surface area for absorption.

2. Transport

The epithelium lining the oviduct and the respitory tract is ciliated. In the oviduct the beating of the cilia transports the fertilized egg towards the uterus.

In the respiratory tract, the beating of the cilia sweeps dust particles cleaning the air before reaching the lungs.

3. Protection.

The epithelium lining the skin is cornified and protective. It protects underline structures against mechanical damage and entry of ge

The melanin in the epithelium lining the skin protects the body against u.v light.

The epithelium lining the G.I.T (gastro intestinal tract) secrets mucus that protects the wall of the G.I.T against the effects of acid and enzymes

Sensitivity

The epithelium lining the retina in the eye has photo ~~auto~~ receptor cells (rods and cons) that receive light.
The epithelium lining the skin has numerous receptors for pain, heat, pressure, cold etc.
The epithelium lining the tongue has tastebuds while that lining the nasal region has olfactory receptors.

Secretions

Glandular epithelium is highly folded to increase surface area for secretion of materials.

Reproduction.

The epithelium lining the reproductive organs is modified for reproduction eg the germinal layer in the ovaries and testis undergoes mitosis and meosis to form the reproductive cells.

CONNECTIVE TISSUES

Connective tissue is the major supportive tissue of the body. It also binds organs together so as to perform their functions effectively.
It consists of a brown ~~ground~~ substrance called matrix in which a variety of structures are embedded including cells and fibres.
There are three major categories of connective tissue including
i) loose connective tissue / Areolar
ii) Dense connective tissue which ~~com~~ includes the tendons, ligaments and white fibrous tissue.
iii) Supportive connective tissue which includes bones ~~bonds~~ and cartilage.

1. LOOSE CONNECTIVE TISSUE (ALEOLAR TISSUE).

This is the most widely distributed tissue in the body and is found in the subcutaneous layer as well as in pt areas where it fills up spaces between organs

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iii) Supportive connective tissue which includes bones and cartilage.

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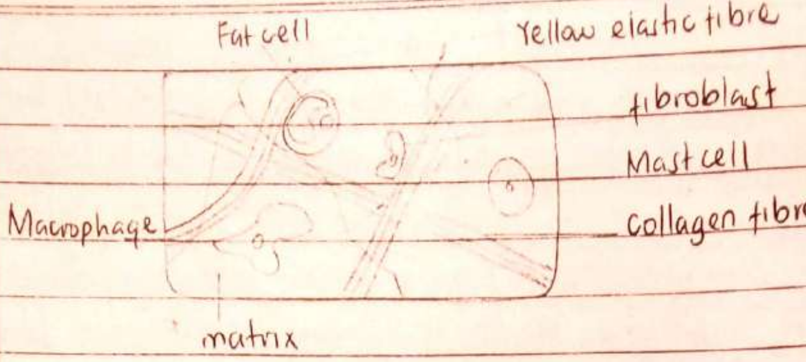


The aleolar connective tissue is made of a transperent semisolid matrix of glycoproteins within which there are various kinds of cells and fibres. The fibres include

i) White collagen fibres

These are long unbranched fibres existing in bundles. They have some degree of flexibility but are inelastic because of the presence of a protein colagen.

ii) Yellow elastic fibres

These are branched fibres arranged singly and forming a network within the matrix. They are flexible with a high degree of elasticity due to the presence of a protein elastin

The cells of aleolar tissue are many and highly specialised. They include:

i) Fibroblasts

These are elongated and flattened cells lying along the fibres and their function is to synthesise both fibres.

ii) Mast cells.

These secrete the matrix in which other structures are embedded. They also secrete anticoagulants that prevent cloating of blood within the tissue.

iii) Fat cells

These store fat hence they have a large fat globule that ~~produc~~. pushes the nucleus to the peripheral.

They are found abundant in the aleolar tissue within the dermis of the skin.

(v) Macrophages

These are amoeboidal in shape and they act as scavengers within the matrix identifying and ingesting any pathogens. by the process of phagocytosis.

FUNCTIONS OF ALEOLAR TISSUE.

The aleolar tissue binds organs together to resist displacement.

It stores fat within the fat cell. This insulates the body against heat loss. inaddition to the fat may be mobilised and respired to release energy.

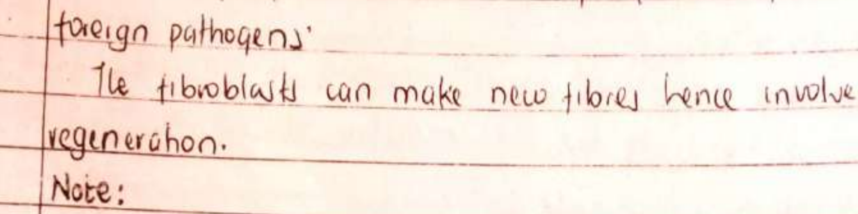
The macrophages defend the body against infection by phagocytosis of foreign pathogens.

The fibroblasts can make new fibres hence involved in repair and regeneration.

Note:

A modified form of aleolar tissue is the adipose tissue which is a loose connecting tissue containing a large number of fat cells called adiposites.

It is found abundant in the dermis of the skin making up the subcutaneous layer where it insulates the body against heat loss.



The adiposites are of two types:

Those containing a single large fat droplet called white adiposite and those containing a number of small fat droplets called the brown adiposites.

Adipose tissue is found around the kidneys, heart and the eye ball where it acts as a cushion resisting mechanical damage and injury.

DENSE CONNECTIVE TISSUE

In dense connective tissue, the fibres dominate over the cells and the matrix. There are three types of dense connective tissue.

i) White fibrous tissue

This consists of a dense network of collagen fibres running over each other and with numerous fibroblasts all over the fibres.

The dense network of fibres gives a greater degree of rigidity.

This fibrous tissue is found in the perichondrium of the cartilage, periosteum of the bone and the sclera of the eye.

The dominant fibres are the white collagen fibres though in some areas like the cartilage ~~et~~ and sclera of the eye where some ~~little~~ prior flexibility is required, a few elastic fibres may be present.

White fibrous tissue is also found between the joints of the skull where the inextensibility of the ~~+~~ collagen ~~fibrous~~ fibres makes the skull bones almost immovable.

ii) Tendons

These connect bone to muscle and are formed by thick bundles of collagen fibres running parallel to each other with numerous fibroblasts.

There are few elastic fibres provide slight flexibility.

iii) Ligaments

These join bone to bone at the joints. They have collagen fibres and loose network of elastic fibres.

The elastic fibres need some prior flexibility at the joints but the collagen fibres provide for strength

SUPPORTIVE CONNECTIVE TISSUE.

Cartilage

This is tough hard but flexible connective tissue. It is made up of a semisolid matrix called chondrium in which fibres and cartilage cells are embedded. The matrix is enclosed in a sheath of white fibrous tissue called perichondrium. Next to the perichondrium is a layer of chondroblasts which are secreting matrix.

The chondroblasts eventually differentiate into chondrocytes which are inactive cells.

Chondroblasts occur in fluid filled spaces called lacunae and each lacunae consists of a single chondroblast.

The chondrocytes are dispersed in the matrix and they are also found in the lacunae. However each lacunae may contain two, four or eight chondrocytes.

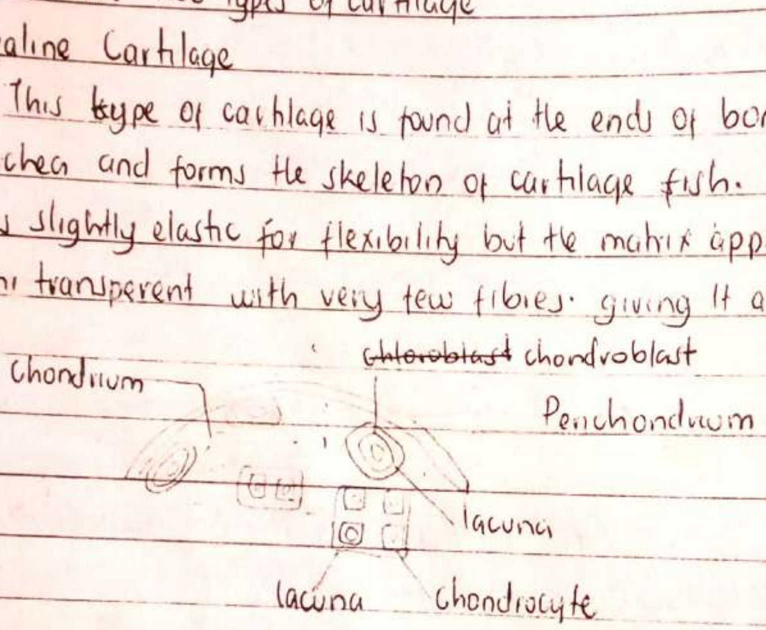
The matrix of cartilage lacks blood vessels and therefore exchange of materials between the cells and the matrix is by simple diffusion.

There are ~~two~~ three types of cartilage

1. Hyaline Cartilage

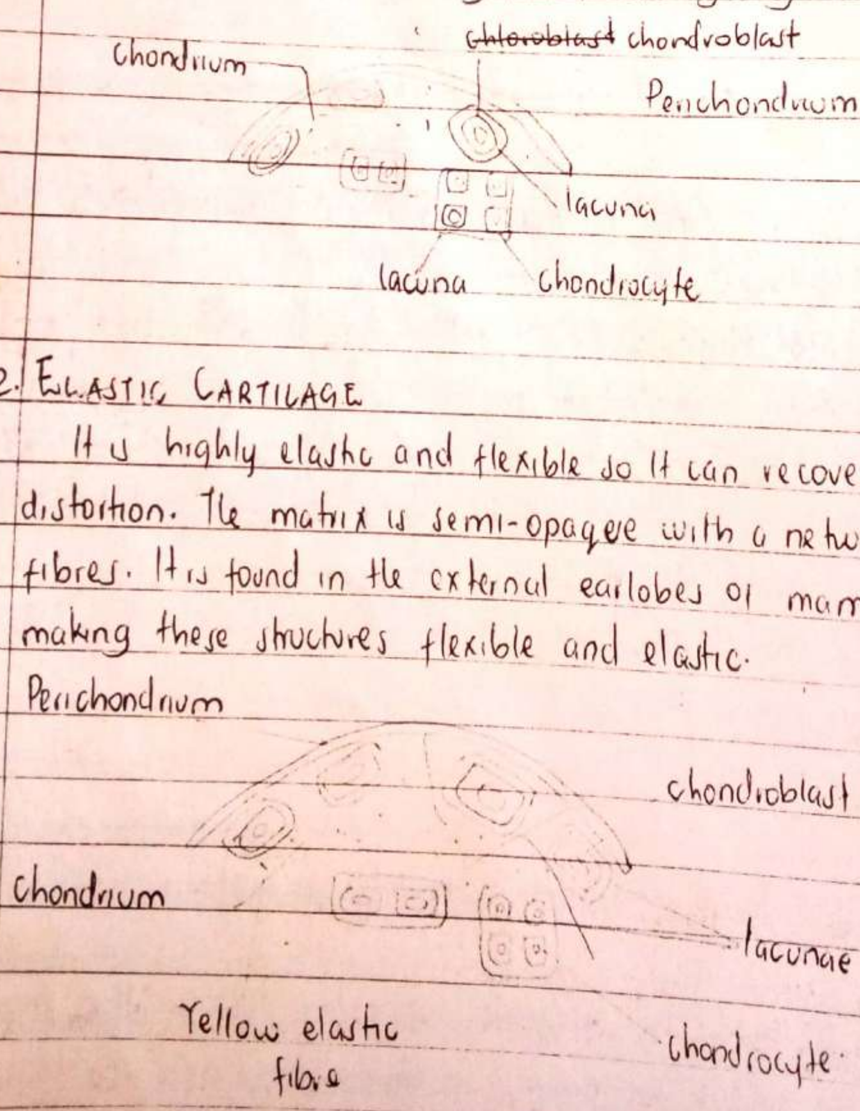
This type of cartilage is found at the ends of bones, voice box (larynx), trachea and forms the skeleton of cartilage fish.

It is slightly elastic for flexibility but the matrix appears glass-like and semi transparent with very few fibres giving it a fibre free appearance.



2. ELASTIC CARTILAGE

It is highly elastic and flexible so it can recover its shape after distortion. The matrix is semi-opaque with a network of yellow elastic fibres. It is found in the external earlobes of mammals and the epiglottis making these structures flexible and elastic.



3. White fibrous cartilage

The matrix has bundles of densely packed white collagen fibres to provide great strength and little flexibility. It is present between adjacent vertebrae making up the intervertebral disks. It acts as a shock absorber by giving a cushioning effect in the vertebral column.

BONE.

The bone is much harder than cartilage and is basically a supportive and protective connective tissue.

The matrix is solid and rich in calcium salts eg calcium phosphate calcium chloride hence it is said to be calcified.

in addition there are small ammounts of sodium potassium in the matrix making the bone mineralised.

The minerals are responsible for the strength and hardness of the bone making it able to fullfil supportive and protective function.

The matrix is called osteum an is made up of a protein called ossein in which bone cells notably ostroeplasts, ostreocytes and ostreoblasts are embedded in addition to collagen fibres.

There two types of bone

1. Compact bone

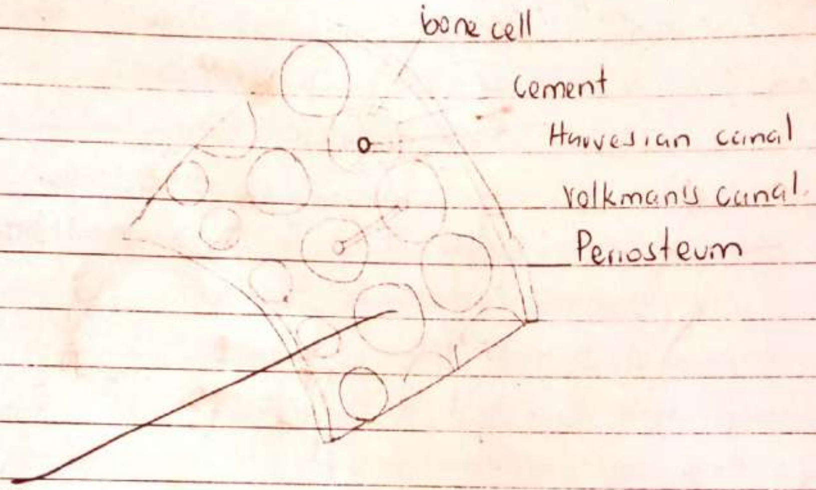
2. Spongy bone

Compact bone is found at the diaphyses of the long bones like the femur, scalp, skull, ribs, vatebrae,

Wall spongy bone ~~et~~ is found at the epiphyses of the long bones like the femur and is the dominant bone in the foetus.

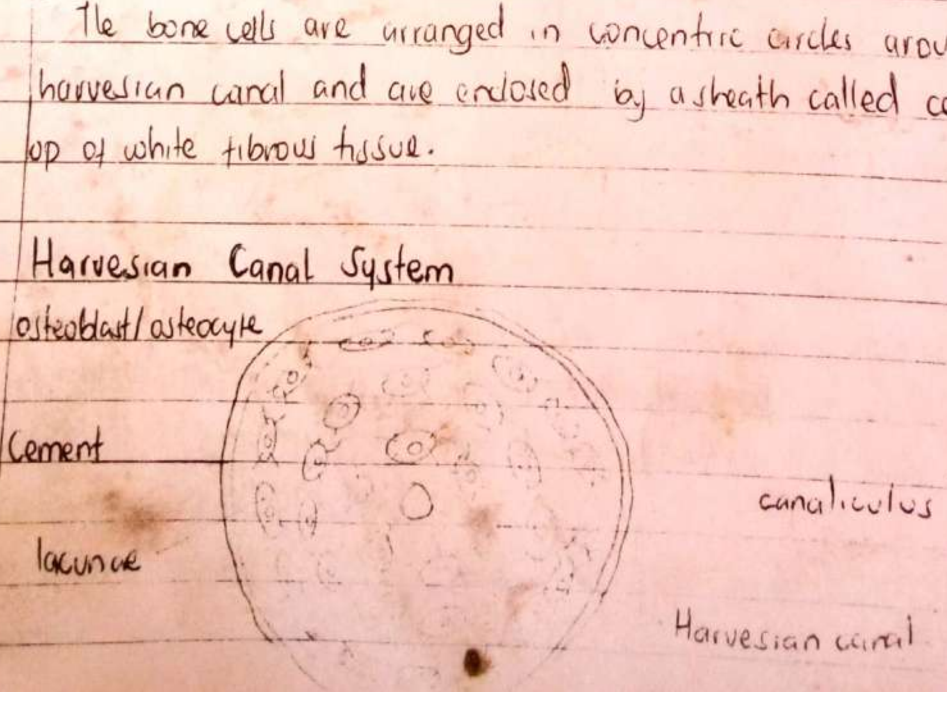
COMPACT BONE

Compact bone is made up of a system of harvesian canals arranged in concentric circles throughout the bone.
Compact bone has an outer layer of white fibrous tissue called periosteum and to the inside is called endosteum.
It is thru the endosteum that blood vessels and nerves pass to supply the bone cells
The harvesian canals communicate to each other through volkman's canals.



Each harvesian canal system is made up of bone cells called ostreoblasts which are reactive bone cells secreting the matrix, and the ostreocytes which are the resting ostreoblasts
The bone cells are found in fluid filled spaces called lacunae.
From the lacunae there are projections called canaliculi allowing for communication between bone cells.
The bone cells are arranged in concentric circles around the harvesian canal and are enclosed by a sheath called cement made up of white fibrous tissue.

Harvesian Canal System



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SPONGY BONE

Consists of a network of thin interconnecting bony struts called trabeculae hence this type of bone can also be called trabeculae. Its matrix contains less inorganic ~~ma~~ minerals compared to the compact bone.

Within the bony struts there are spaces filled with soft bone marrow called the red bone marrow. Therefore soft bone is important in the formation of red blood cells and white blood cells

It has ~~two ty~~ three types of cells

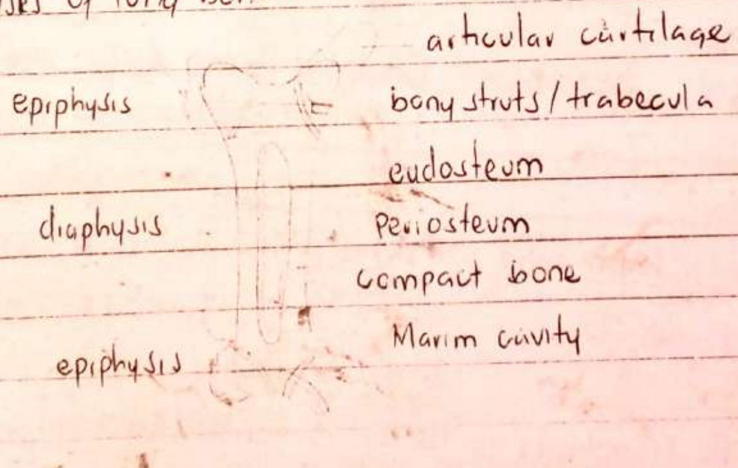
i) osteoblasts which are reactive cells synthesizing matrix

ii) osteocytes which are inactive or resting osteoblasts.

iii) osteoplasts which absorb calcium during bone formation to form a classified matrix.

Spongy bone lacks the organised harvesian canal systems and the matrix has many spaces with a network of bony struts which mantain rigidity but with reduced weight

Spongy bone is found in embryos, growing organisms and the epiphysis of long bones



Adaptation of the Femur and Its articular Cartilage to Function.

The femur is hollow so when a compressional force is exerted on one side of the bone, the other side becomes subjected to a tension of equal magnitude. These forces are neutralised along the central axis of the bone therefore the material in the centre of the bone does not need to contribute its strength.

The central axis of the bone is hollow filled with marrow cavity. This reduces on the overall weight of the bone

The perimeter of the femur is made up of compact bone which is a rigid material that can resist compressional and tensional forces

The articular cartilage at the end of the femur acts as a cootion cushion between articulating ~~bonds~~ bones at the joints. The cushion acts as a shock absorber to support the weight of the body. The cartilage also reduces friction between the smooth moving articular surfaces at the joints.

The spongy bone at the head of the femur as a network of interconnecting bony struts that maintain rigidity of the bone but with minimum weight.

DIFFERANCES BETWEEN COMPACT BONE AND SPONGY BONE.

Compact bone	Spongy bone
- The matrix is hard, solid and dense without any spaces.	- The matrix is web-like with a number of spaces and is relatively soft.
- It forms the diaphyses of the long bones	- Forms the epiphyses of long bones.
- It is filled with a fatty tissue called yellow marrow which stores fat cells.	- It is filled with a soft tissue called red marrow forming the white blood cells and red blood cells.
- Has organised system of harvesian canals	- lacks organised harvesian canal systems.

DIFFERANCES BETWEEN CARTILAGE AND BONE.

Cartilage	Bone
→ It is comperatively soft elastic and flexible	→ It is tough, rigid and inellastic
→ The matrix contain the protein chondrin	→ The matrix contain the protein ossein.
→ The matrix lacks deposition of calcium salts	→ The matrix is rich in calcium salts as calcium phosphate and carbonate.
→ The matrix lacks harvesian canal systems.	→ The matrix has harvesian canal systems.
→ Each lacuna has 2, 4 or 8 chondrocytes.	→ Each lacuna has one osteocyte.
→ The lacunae lack canaliculi so cartilage cells are not interconnected	→ The lacunae have canaliculi which act as bridges for communica between cells.
→ The matrix lacks blood vessels	→ The matrix has a network of blood vessels.
→ Enclosed in a fibrous sheath called pericondrium	→ Enclosed in a fibrous sheath called periosteum

BONE FORMATION

The process by which bone is formed is called ossification and involves replacement of the existing connective tissue with bone.

The two forms of connective tissue from which bone is formed include the Dermis of the skin and the cartilage

If bone arises from the dermis of the skin, it is called membrane bone and the process by which it is made is called membrane ossification / intramembrane ossification.

If bone arises from the pre-existing cartilage, it is called cartilage bone and it is made by cartilage ossification / endochondrial ossification.

During intermembrane ossification, membrane bone is formed on the dermis of the skin by aggregation of bone cells especially the osteoblasts which secrete the bone matrix by and the osteoplasts which absorb calcium forming calcified matrix. This results into formation of bony plates around the area of ossification. The bony plates sink through the connective tissue until they become part of the skeleton.

Membrane bone forms components of the skull, jaws, pelvic ~~guddles~~ girdles (hip bones) and the scapular

Cartilage (endochondrial) ossification begins from the pre existing cartilage by bone cells aggregating along the axis of the cartilage in rows. These absorb calcium and secrete bony matrix. The process spreads from the centre outwards forming calcified cartilage which transforms into bone. The perichondrion forms the periosteum and gradually compact bone is formed. Bones formed by this process include bones of the limbs, vertebrae and the pectoral girdles.

FUNCTIONS OF BONE TISSUE

- stores calcium and releases it into the blood stream at required levels. - The marrow contained in bone at the epiphyses is responsible for the formation of the blood cells.
- It serves as a rigid structure of the body giving the body shape.
- Due to its hardness, it provides protection to the vital organs like the heart, lungs and the brain.
- It provides for the attachment of muscles allowing for movements especially at the joints.

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MUSCLE TISSUE

Muscle tissue is made up of highly specialised thin and elongated cells; called muscle fibres with the capacity to contract and relax - This property of contractability is due to presence of two proteinaous filaments called myosin and actin, which are the contractile proteins.

Muscle cells are supplied with blood vessels which provide nutrition and take away metabolic wastes.

Each muscle fibre cell has its own nerve supply which sends the signal either to contract or relax.

Histologically, three types of muscles are recognised:

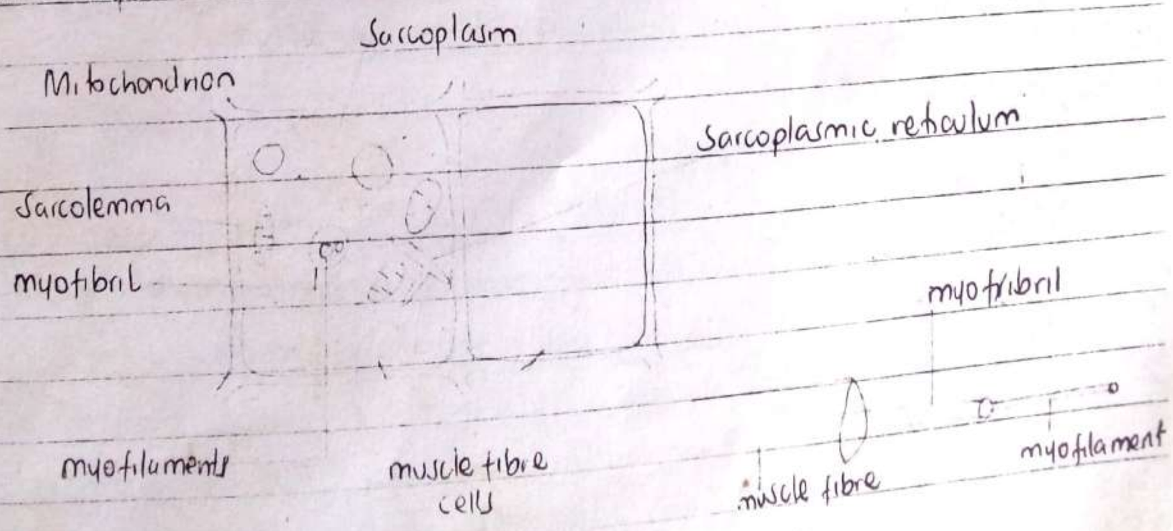
1. skeletal muscle
2. Smooth muscle
3. Cardiac muscle.

1. SKELETAL MUSCLE

It consists of elongated, cylindrical, multinucleate cells called muscle fibres filled with a special cytoplasm called sarcoplasm enclosed in a membrane called Sarcolemma The muscle fibre cells contain numerous mitochondria for ATP provision needed to release energy for muscle contraction and the system of Sarcoplasmic reticulum forming the T-systems.

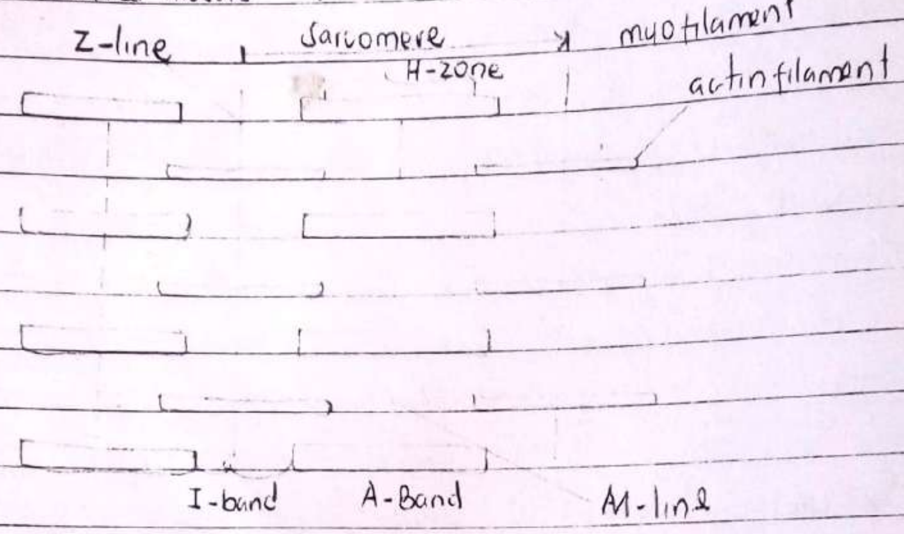
Each muscle fibre cell is composed of numerous smaller cylindrical structures called myofibrils which inturn are composed of elongated cylindrical myofilaments.

The myofilaments are made up of two proteins: The thin actin and the thick myosin



STRUCTURE OF A MYOFILAMENT

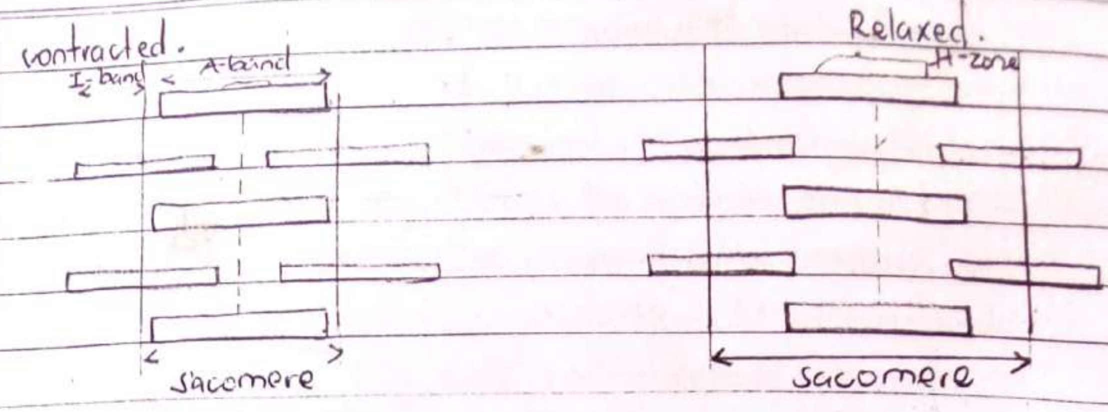
The myofilament is made up of thick myosin and thin actin filaments which interdictate in their arrangement giving alternate arrangement of light and dark bands. When observed under the microscope, these bands appear as stripes hence the name striped muscle and due to the interdictating nature of the filaments, they appear as cross striations hence the name striated muscle.



When observed under the microscope, the dark band made up of myosin and some overlap of actin filaments gives the anisotropic band, or the A-band. Within the A-band there is a region of no overlap called the H-zone and is relatively lighter.
The light band is made up of only one type of filaments and is called the isotropic band. Running through the actin filaments is a thick Z-line while running through the myosin filaments is a lighter line called the m-line.
The section between one Z-line and another is called a sacomere and is the functional unit of the skeletal muscle tissue.

Mechanism Of Skeletal Muscle Contraction.

When the contracted sacomere is compared with the relaxed sacomere, the following observations are made.

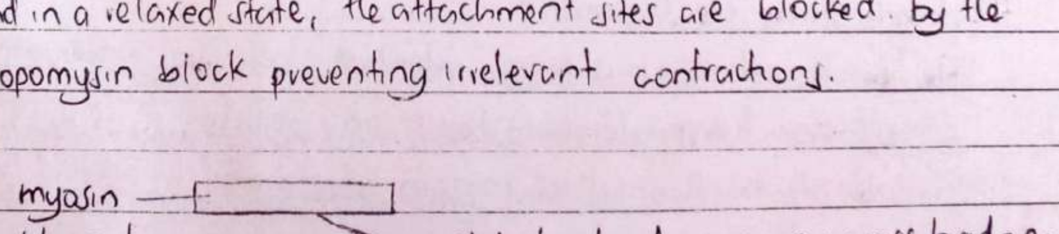


- The A-band remains the same both in contracted and relaxed states.
- The H-zone is reduced and may disappear in contracted state but increases in relaxed state.
- The I-band reduces in size when contracted but increases in size when relaxed.
- The sacomere length shortens when contracted but it lengthens when relaxed.

It is upon this observations that the siding filament theory is based to explain the mechanism of skeletal muscle contraction. No shortening of either filaments occurs but the actin filaments slide past the myosin filaments shortening the sacomere length.

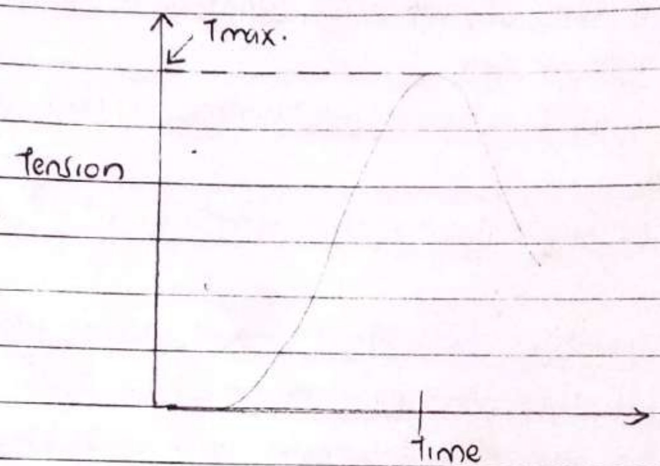
The exact mechanism by which the skeletal muscle contracts has been explained interms of cross bridges with globular heads arising from the myosin filaments and the regulatory proteins, Troponin and Tropomysin inaddition to calcium ions.

The globular heads have attachment sites on the actin filaments and in a relaxed state, the attachment sites are blocked by the tropomysin block preventing irrelevant contractions.



when The muscle fibre is stimulated, calcium ions are released from the sacoplasm or the sarcoplasmic reticulum that form the T-system. The calcium ions combine with the regulatory protein Troponin forming calcium ion - Troponin complex / couple. This complex displaces the tropomysin block from the attachment sites. The globular heads get attached, pull to some length, detarch, retarch and pull again. They do this 100 times per second, and the net effect is shortening of the sarcomere which translates into shortening of the muscle fibre in the process called contraction.

When contraction, in the muscle fibre develops a tension and the highest tension is obtained when the largest number of cross bridges are attached.



After the maximum tension, the muscle fibre begins to relax releasing the tension. Relaxation involves uncoupling of calcium and Troponin. The calcium ions are pumped back into the sarcoplasm and or the sarcoplasmic reticulum using energy from ATP hydrolysis. The Tropomysin blocks cover the attachment sites and the muscle fibre loses the tension by the actin filaments sliding back increasing the length of the sarcomere.

Muscle relaxation is energy intensive because uncoupling requires energy from ATP hydrolysis. This is only possible in cells of living organisms so upon death, the muscles remain contracted in a condition called rigor mortis.

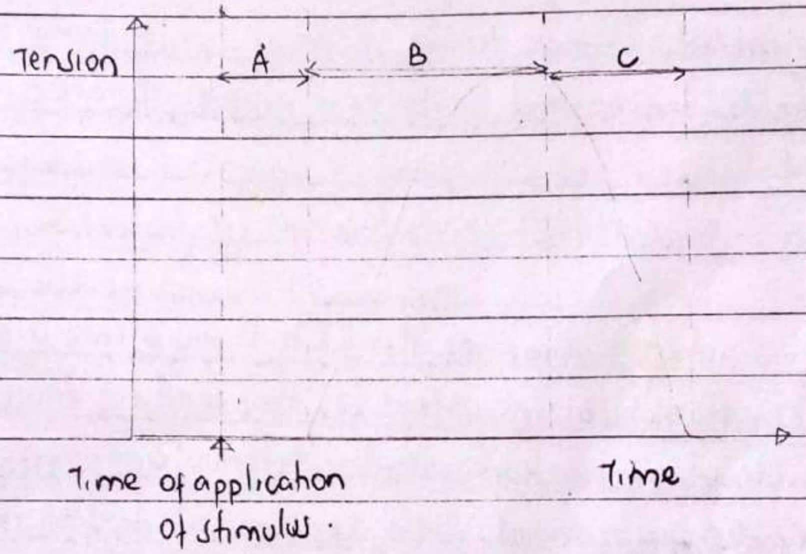
X-tics Of Skeletal fibres.

The characteristics of skeletal muscles can be investigated by stimulating the muscle fibre directly using a brief electric shock. This include:.

(1) - <u>Single twitch</u>:- This is a quick sharp contraction of the muscle fibre followed by a relaxation ~~contraction~~ when a single electric shock of sufficient intensity is subjected to a muscle fibre. Normally there is a very short period called latent period which is a delay ~~wh~~ between the point of application of the stimulus and the time when the muscle fibre begins to contract.

It is caused by two factors:

- General inertia of the apparatus ie relactance to respond when switched on.
- The conversion of electrical energy in the stimulus to mechanical energy of a contraction.



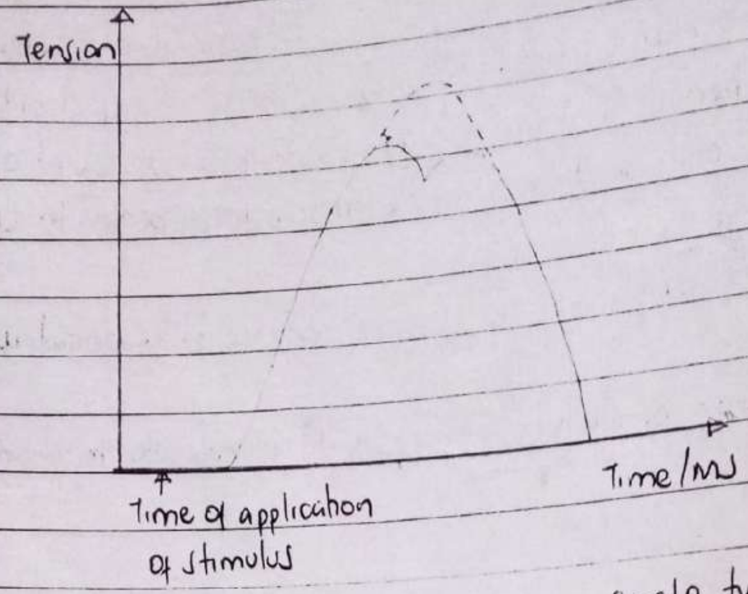
A - latent Period

B - Phase of contraction

C - Phase of relaxation.

(2) <u>SUMMATION</u>

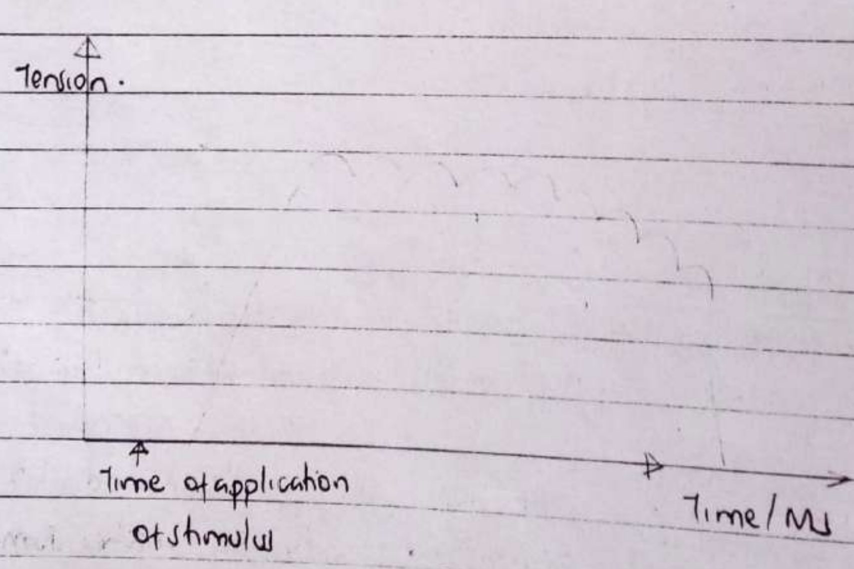
This occurs when two shocks are delivered into the muscle fibre in quick succession. if the time interval between the two shocks is long enough, two distinguishable twitches are given. However if the time interval is very short, such that the second shock is applied before the muscle fibre begins to relax, the two twitches summate to give a smooth contraction followed by relaxation like in a single twitc



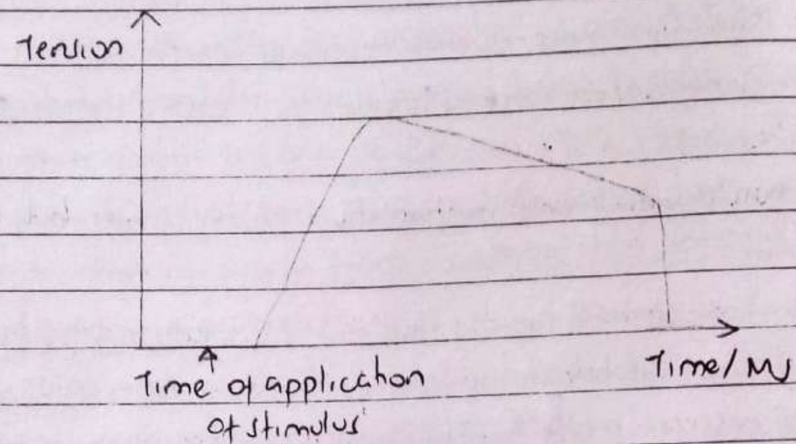
The summated response differs from a single twitch by having a greater tension and being of a greater duration.

③ TETANUS

This occurs when a chain of shocks is thrown into a muscle fibre. If the shocks are of sufficient intensity, they send the muscle fibre into a mantained contraction called a tetanus and relaxation occurs when the shocks are removed. There is a gradual decline in the tension due to continous stimulation because of reduced ATP supply.



If the frequency of stimulation is high enough, a smooth tetanus is obtained.



④. FATIGUE

A tetanic response can not go on indefinately and if the muscle fibre is continously stimulated, muscular responses decline and inventually dissapear, the muscle fibre is said to be fatigued and this is brought by exhaustion of the ATP supply, so muscle contraction can not be supported anymore.

Note: The contraction of the muscle fibre depends on the intensity of the stimulus which must reach a particular level to cause the muscle fibre to contract. This level is called the ~~thresh hold~~ threshold.
Any stimulus without a threshold is called a subliminal stimulus, a does not evock constractions in the muscle fibre.

The muscle fibre contraction is based on the all or non law.
The law states that the contraction of the muscle fibre is independent of the intensity of the stimulus provided it is above the threshold. Below the threshold, no contractions are given, at the threshold level, contractions are given. and above the threshold, there is no increase in the size of the contraction.

TYPES OF SKELETAL MUSCLE FIBRES.

There are two types of muscle fibres each with its own specific physiological properties ie the slow/Tonic fibres and the fast/Twitch fibres.

Some of the muscle fibres only contain twitch/tonic fibres but others contain both.

The twitch fibres contract rapidly but they easily get fatigued. They are important during fast musclular contraction for quick response eg the predator possesses many twitch fibres and uses them for fast reaction to capture the prey. Similarly the prey has many twitch fibres for fast reaction to escape predation.

The tonic fibres allow for sustained contractions over a long period of time since they dont easily get fatigued. In a resting position, the tonic fibres contract to sustain contractions over a long period of time.

Twitch fibres have high levels of mitochondria to provide energy rappidly, compared to the tonic fibres which have more myoglobin and glycogen to sustain contractions over a long period of time.

EFFECT OF EXERCISE ON MUSCLES AND MUSCULAR PERFOMANCE

Fit people have increased number and size of mitochondria, carry out rapid respiration releasing energy for muscle contraction and they rappidly oxidise glycogen.

Training may double the number and size of the mitochondria and their ability to generate energy in form of ATP.

Muscles of fit people have high levels of glycogen and myoglobin. Myoglobin is similar to haemoglobin and acts as an oxygen store in muscles reducing cases of anaerobic respiration.

However incase of anaerobic respiration, muscles of fit people can tolerate high levels of lactic acid with minimum pain. and such individua's can ~~be~~ incur high oxygen dates.

ENERGETICS OF MUSCLE CONTRACTION :

Energy for muscle contraction is provided by ATP from the respiratory breakdown of glucose during aerobic respiration. The supply of glucose is from the glycogen stores and fat stores in the muscles. Muscles have their own oxygen store called myoglobin and releases oxygen when the supply from haemoglobin becomes inadequate eg during heavy exercise.

Once formed, the ATP is hydrolised by the enzyme atpase to release energy for muscle contraction.

$$ATP \xrightarrow{ATPASE} ADP + Pi + \text{Energy for muscle contraction}$$

During heavy exercise, ATP supply may become inadequate to meet the energy demands of the muscles but a chemical substance called phosphocreatin (PCR) formed in muscles, readily combines with ADP to form ATP for immediate energy demands.

$$ADP + Pcr \longrightarrow ATP + Creatin$$

During straineous exercise, oxygen supply may become inadequate resulting into some anaerobic respiration causing accumulation of lactic acid. The person is said to have incurred an oxygen date, which is paid after exercise when oxygen supply becomes adequate. Lactic acid stops and is readily oxidised to carbondioxide and water after exercise. If not oxidised, it contributes to muscle pain and muscle tiredness.

After exercise, when ATP supply becomes adequate, phosphocreatin is resynthesised. This is done by reacting the available ATP with creatin to form phosphocreatin which is stored in the muscles 4 use again

$$ATP + Cr \longrightarrow Pcr + ADP$$

during exercise.

Muscles of fit people have high levels of phosphocreatin which improves muscular performance during straineous exercises.

SMOOTH MUSCLE

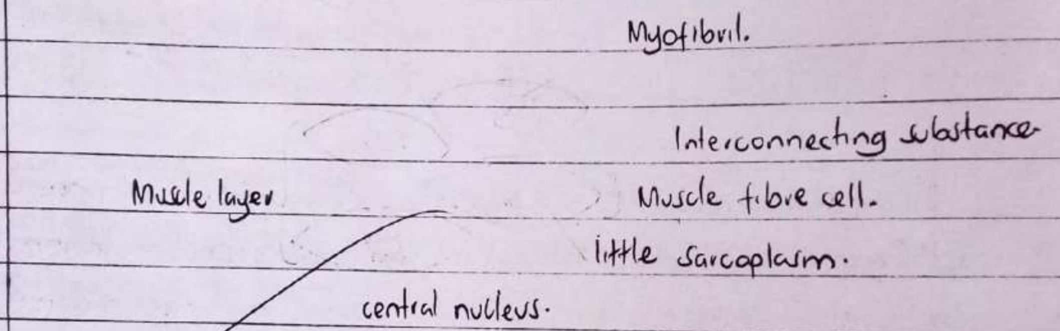
It is also called involuntary muscle because its contraction is not under the voluntary control of the brain.

It lacks a regular arrangement of actin and myosin filaments and hence there are no striations or stripes hence the name unstriated/unstriped muscle due to the absence of light and dark bands in a regular arrangement.

The muscle lines viceral organs, the old parts of the GIT (gastro intestinal tract), kidney or tubular structures like blood vessels, urinary tubules and tubules of the reproductive system hence the name viceral muscle.

It has a few myofibrils and myofilaments giving the impression of a plain tissue hence the name plain muscle.

Smooth muscle consists of sheets of densely packed, elongated, spindle shaped, muscle fibres with a centrally located nucleus enclosed in a little sacorplasm.



The muscle fibre cells are elongated, parallel to eachother, bound together by connective tissue usually aleolar. Each muscle fibre contains fine myofibrils arranged longitudinally. They have myofilaments actin and myosin but with irregular arrangement.

It has less numerous mitochondria and other organelles with much less sarcoplasmic reticulum.

The muscle fibres lack a sarcolemma, instead a myofilament encloses the contents of the cell.

The smooth muscles are innervated by the autonomic nervous system. They contract slowly over a long period of time without getting fatigued.

Cardiac Muscle

This is a specialised type of muscle found only in the heart. It is capable of contractions and relaxations following a particular rhythm (rhythmic contractions) without fatigue.

The contractions are initiated from the heart muscle itself and this is called myogenic.

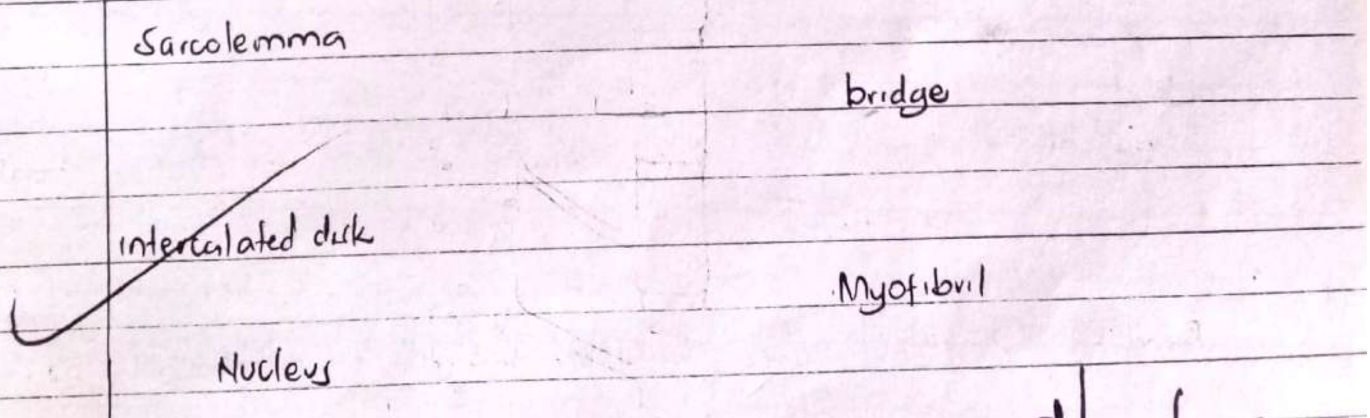
Myogenicity of the heart has been exploited in the heart transplantation surgery because the heart can be removed from the body, put in a saline solution, rich in ATP, minerals and adequate oxygenation and the muscle will continue to contract.

The heart muscle is made up of cylindrical, elongated muscle fibre cells, cemented together by the intercalated disks to form a sheet of muscle fibres.

The muscle fibre cells are branched to give bridges that link one sheet of muscle fibres to another.

The muscle fibres show regular cross striations and hence stripes (light and dark bands) indicating a regular arrangement of the actin and myosin filaments.

Each muscle fibre cell has numerous mitochondria, a system of sarcoplasmic reticulum, many nuclei and abundant sarcoplasm enclosed in a sarcolemma.



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Comparison Between The Three Types Of Muscles.

	Feature	skeletal	Smooth	Cardiac.
				Heart muscle.
1.	other names	striped striated voluntary	Unstriped unstriated involuntary Plain Viceral	
2.	location.	Attached to bone or cartilage	Tubular structures and viceral organs	Heart
3	structure i) Nucleus	Multinucleate	Uninucleate	Multinucleate
	ii) Shape	very long cylindrical cells	Elongated spindle shaped cell	Elongated cylindrical cells.
	iii) Sarcoplasm..	A lot of sarcoplasm	little sarcoplasm around the nucleus	A lot of sarcoplasm.
	Sarcolemma	Has a sarcolemma	No sarcolemma.	Has sarcolemma.
	Mitochondria.	Numerous mitochondria	Few mitochondria	Numerous mitochondria
	striations	Has cross striations	No cross striations	Has cross striations.
	Branching	Not branched	Unbranched cells	Branched cells.
4.	control	Voluntary	involuntary	involuntary
5.	initiation of contraction	Neurogenic	Neurogenic	Myogenic

Explain the features of the skeletal and cardiac muscles that account for their efficient functioning.

Soln. SKELETAL MUSCLE:

- Numerous mitochondria that provide the necessary energy for muscle contraction.
- The myofilaments actin and myosin that slide past each other to bring about shortening of the muscle fibre hence a contraction.
- A system of sarcoplasmic reticulum that releases calcium ions required during muscle contraction.
- Has myoglobin with a higher affinity for oxygen compared to haemoglobin. So it can extract oxygen from haemoglobin storing it in the muscle for aerobic respiration to release energy for muscle contraction.
- ~~Heridetory~~ Regulatory proteins Troponin and tropomyosin that regulate muscle contraction.
- Well supplied with enough nerve fibres that control muscle contraction.
- Elongated cylindrical cells of muscle fibres to spread contractions over long distances
- Richlely supplied with blood vessel that deliver oxygen and glucose required 4 muscle contraction
- The myosin filaments have cross bridges that pull reacting filaments during shortening of the sacomere.

CARDIAC MUSCLE:

- Branched cells to spread contractions all over the heart muscle.
- Coronary blood supply that supply the Heart with oxygen and glucose required during muscle contraction.
- Numerous mitochondria that provide necessary energy for muscle contraction
- long cylindrical cells to spread contractions over long distances.
- Regular arrangement of actin and myosin filaments that slide past each other to bring about a contraction.
- Intercalated disks that spread contractions between muscle fibres

~~ADAPTATION~~

NERVE TISSUE.

Nerve tissue is made up of millions of nerve cells called nerons which are highly specialised and form the nervous syste.

They provide the quickest means of communication within the body and enable the body to respond to some stimuli. A tipical neuron has two distinct regions:

i) cell body

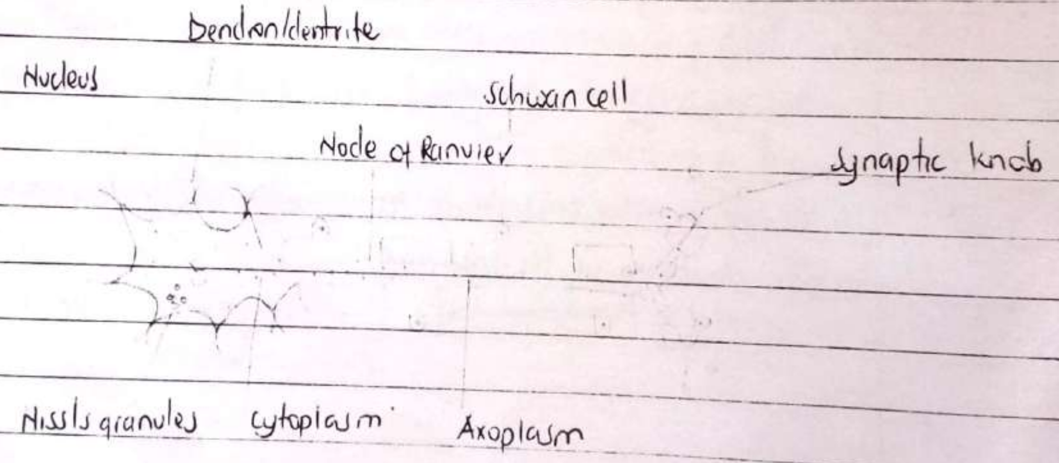
ii) cytoplasmic extensions

The cell body contains the central nucleus and a granular cytoplas In the cytoplasm, there numerous cell organelles present in a tipical cell. The cytoplasm also contains prominent granules called granules reaching RNA and are concerned with protein synthesis.

from the cell body, there are two types of cytoplasmic extensions:

i) Dendrons/dendrites:

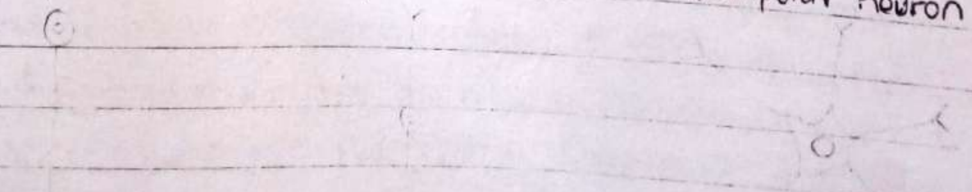
ii) The axon.



Each axon is filled with cytoplasm called axoplasm that is continous with the cytoplasm of the cell body. It contains numerous mitochondria but lacks the granules and the nucleus. Depending upon the number of axons, there are 3 classifications of neurons:

i) Unipolar, bipolar and multipolar.

Unipolar neuron   Bipolar neuron   Multipolar neuron



The unipolar neuron is made up of a single axone eg the sensory neuron.

The bipolar neuron is made up of two axons arising from the cell body eg the intermediate or relay neuron.

A multipolar neuron has several axones and or dendrites arising from the cell body. They are common in the central nervous system especially the brain where they coordinate different information.

The axons of the nerve fibres are elongated to conduct impulses away from the cell body for long distances.

The terminal end of the axons have swollen ends called synaptic knobs. These release chemical substances called Neurotransmitter substances which enable the impulse to travel from one neuron to the next at the synapse.

The nerve fibres may have a fatty sheath over the surface called a myelin sheath. These are called myelinated fibres.

Others lack the sheath. and these are called non-myelinated.

The sheath is secreted by Schwan cells and is interrupted at intervals to form nodes of Ranvier.

The sheath acts as an insulator preventing leakage of an electrolic electrice impulse.

The sheath speeds up therefore the rate speed of the impulse transmission. So insulated axons conduct impulses faster than naked axons and are possessed by vertebrates accounting for the rappid responce in vertebrates

NEUROGLIA CELLS.

In the CNS (central Nervous System), the connective tissue is almost absent and the majority of the intercellular spaces are filled with non nervous system called Neuroglia cells..

Nerve cells when mature and specialised, do not undergo cell division or mitosis. Therefore any damaged nerve tissue is repaired by the Neuroglia cells because they are capable of regeneration.

Some Specialised Neroglia cells are defensive ie they are phagocytic and engulf any pathogen that enters the nerve tissue. These are called microglia

Neuroglia cells also provide nourishment to the sorrounding cells.

Note: Because neuroglia cells are capable of cell division / mitosis, they are the major causes of brain tumours when they divide uncontrollably

BLOOD TISSUE

Blood is a red coloured fluid connective tissue circulating throughout the entire body. It consists of a pale yellow ageous food fluid matrix called plasma inwhich the cells float.
The cells include whiteblood cells (leucocytes), red blood cells (erythrocytes) and the blood fragments called platelets.

Pl

Plasma.

It is pale yellow fluid and forms about 55% of blood by volume. It has a pH of about 7.4 making It slightly alkaline and contains a number of organic and inorganic substances in an ageous state.
Plasma is 90% water, the rest being plasma proteins fibrinogen, albumin, prothrombin, inorganic salts and organic substances.

Inaddition, plasma contains dissolved food substances such as glucose, aminoacids, excretory products like urea, vitamins, hormones, respiratory gases, antibodies, germs and bacteria.

FUNCTIONS OF BLOOD PLASMA.

a) Transport functions

Transports digested food products to different parts of the body.

Transports excretory wastes 4rm tissues to the kidney 4 removal.

Transports oxygen and carbondioxide for exchange of gases at the tissue level.

Carrys hormones from one part of the body to the other.

Transports antibodies providing immunity.

b) Mantanance of pH.

Plasma proteins can neutralise strong acids and bases and hence act as acid base buffers therefore mantain the pH of blood at about 7.4

c) Prevention of blood loss.

Prothrombin, fibrinogen and many other cloating factors are present in plasma. These prevent blood loss at the time of injury of a blood vessel by initiating the process of blood cloating.

d) Regulation of Body temperature.

Plasma distributes the heat from muscles and other organs as a result of increased muscle activity during periods of cold. In this way, the body temperature is regulated at a tem about 30°, in endotherm

Red blood cells.

The number varies from 4.5 - 5M per mm^3. Mature red blood cells lack a nucleus; the cytoplasm has haemoglobin which is a red pigme and they lack the mitochondria

Absence of a nucleus creates enough space for haemoglobin increasing efficiency in oxygen transport and absence of mitochondria safeguard the oxygen which would otherwise be used in respiration before reaching the tissues that need it.

Red blood cells are usually circular or biconcave disks in shape

They are made up of a thin membrane making them pliable so they can alter their shape as they squeeze through the tiny capillaries whose diameter is smaller than the diameter of the red blood cell.

Formation

The process by which they are formed is called erythropoesis in any erythropoetic tissue which depends on the stage of growth and development. In the foetus, red blood cells are made in the liver and spleen because bones are not yet developed.

In infants, all bones are erythropoetic but in adults, they are made by the red bone marrow of the bones of the Pelvis, ribs, sternum, vertebrae, Scapular, skull and long bones like the femur.

Destruction.

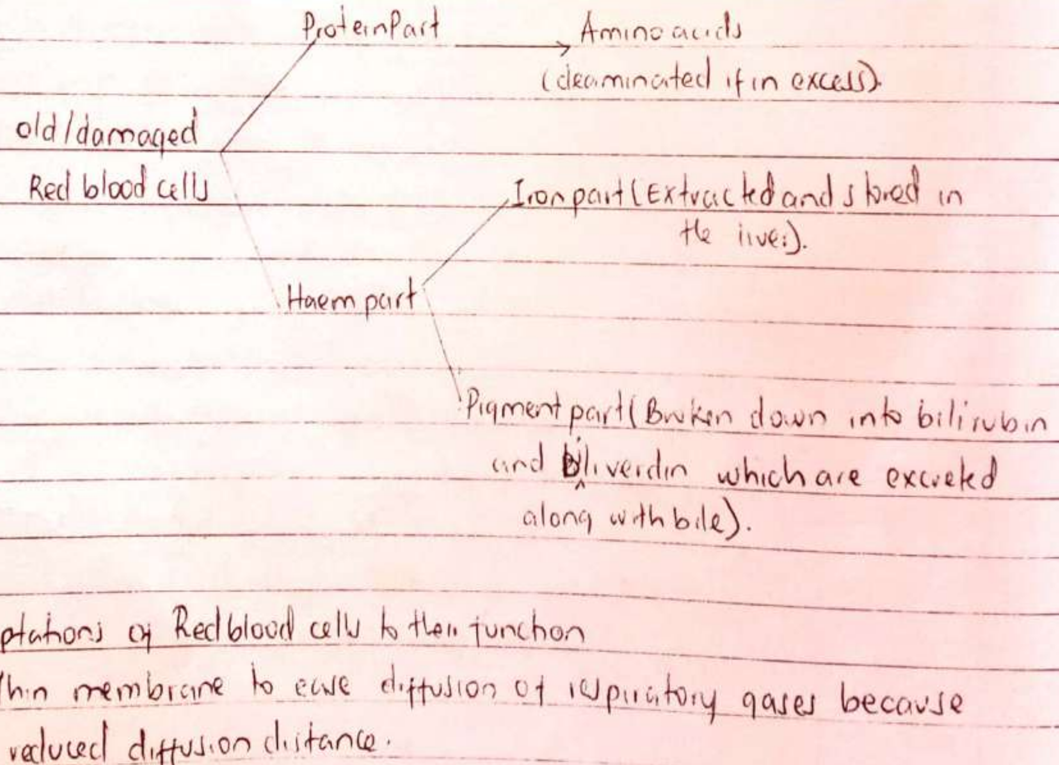
Erythrocytes have an average lifespan of 120 days after which they are destroyed in the liver or the spleen. About 2-10m red blood cells are destroyed per second and replaced in our body.

The rate of destruction and replacement depends on the amount of oxygen available. If the amount of oxygen is high, there is more destruction of red blood cells in the liver than what is made in the bone marrow due to increased rate of respiration

The old and damaged red blood cells are destroyed in the liver by cells called Macrophages and the course of action is complex. The old red blood cells are broken down into the ~~pigment~~ Protein part and ~~iron~~ Haem part. The ~~pigment~~ Protein part is hydrolised into amino acids which are later deamminated in the liver.

The Haem part is broken down into two other parts ie the Iron part and the pigment part. The iron part is extracted and stored in the liver; from where it can be mobilised later for further erythropoesis.

The pigment part is broken down into ~~bilu~~ bilirubin and biliverdin which are yellow pigments. These are excreted along with bile into the gut from where they are lost along with faecal matter and are responsible 4 giving faeces their characteristic colour.



Adaptations of Red blood cells to their function

· Thin membrane to ease diffusion of respiratory gases because of a reduced diffusion distance.

Absence of a nucleus increases surface area to accommodate a lot of haemoglobin increasing efficiency in oxygen transport.

They have haemoglobin with a high affinity 4 oxygen increasing efficiency in oxygen transport.

The absence of mitochondria keeps oxygen safe until when it reaches the respiring tissues.

Being thin makes them pliable so they can squeeze through the tiny capillaries. altering their shape ie becoming elongated and hence increased surface area 4 exchange of gases.

They have the enzyme carbonic anhydrase that catalises the combination ~~breakdown~~ of carbondioxide and water during carbondioxide transport.

$$CO_2 + H_2O \xrightarrow[\text{anhydrase}]{\text{Carbonic}} H_2CO_3$$

White blood cells / Leucocytes

The number varies from 7000-10,000 per mm^3. They have a nucleus and they are either round or irregular in shape. They are specialised in protecting the body against infection by producing antibodies which fight against infection or directly ~~in~~ engulfing the pathogen.

Two major types are recognised: lymphocytes and phagocytes. Both are made by the stem cells in the bone marrow.

The lymphocytes are involved in production of antibodies which are specific to the pathogens. The common lymphocytes include the T and B lymphocytes.

The phagocytes engulf the pathogens directly and destroy them.

Platelets / Thrombocytes.

These are irregularly shaped bodies without a nucleus and having a life span of about 7 days. Their number is about 250,000 per mm^3. They are involved in blood clotting when a blood vessel is raptured.

PLANT TISSUES

Plant tissues may be simple or compound. They are simple ~~w~~ if they are made up of one type of cells and compound ~~w~~ if they are made up of more than one type of cells.

Simple plant tissues include the Parenchyma, collenchyma, and schlerenchyma.

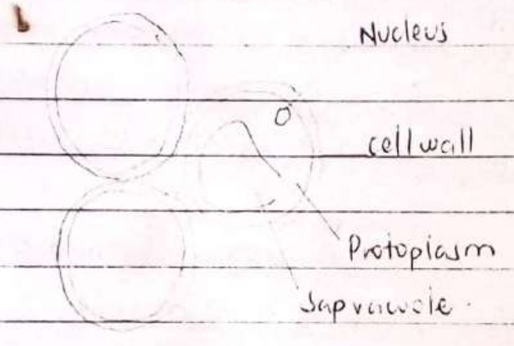
Parenchyma tissue

This is made up of unspecialised cells usually spherical but may be polygonal in shape with a dense cytoplasm and a thin cell wall.

They are meristematic ie capable of cell division and are found in actively growing tissues like fruits, tubers, roots and shoot apices.

They also act as packing tissues by filling spaces between the specialised tissue like the xylem and phloem.

structure



Functions Of Parenchyma tissue.

Parenchyma cells are metabollically active and carry about out vital activities of the

They contain a system of air spaces which act as sites for gaseous exchange.

They act as sites 4 food storage eg in the stem and root tubers which store starch granules.

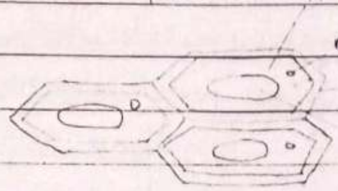
Their walls are important pathways 4 transport of water and mineral salts since they are freely permeable to water.

Some specialised parenchyma cells called chlorenchyma contain chloroplasts and are concerned with photosynthesis.

Parenchyma cells absorb water by osmosis maintaining turgidity stability in cells a mechanism important in giving mechanical support in non woody plants

Modified parenchyma performs particular functions in certain parts of the plant eg (A) epidermal parenchyma

(A) Epidermal Parenchyma



These are tightly fitted cells with a relatively thick cell wall and they form a layer surrounding the plant body.

Epidermal Parenchyma performs the following functions:

It protects the plant dessication and infection by secreting a waxy cuticle. The wax traps the pathogens preventing their entry and It is water repellant preventing excessive water loss.

Some epidermal cells are modified to perform guard cells over the leaf surface. These regulate the size of the stomata controlling both gaseous exchange and transpiration.

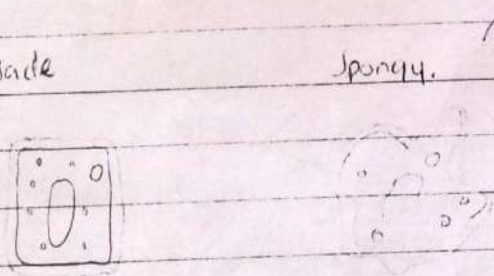
Some epidermal cells have been modified to form root hairs for water absorption from the soil.

Epidermal cells have hairs especially on the leaves and young stems. These hairs trap moisture minimising the excessive water loss.

Some epidermal cells are glandular like in insectivorous plants The glands secrete a sticky substance that traps the insect.

(B) Mesophyl Parenchyma

Mesophyl cells are modified to carry out photosynthesis by having chloroplasts. There are two types: Pallisade and spongy mesophyl cells.

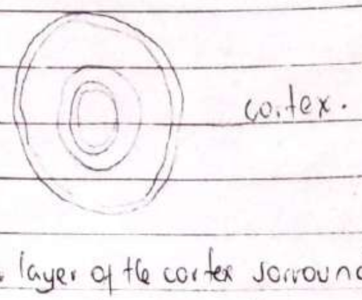


Pallisade mesophyl cells contain numerous chloroplasts, they are elongated and are tightly packed. A lot of photosynthesis occurs in them as compared to spongy mesophyl with fewer chloroplasts.

The spongy mesophyls are irregular in shape scattered in the leaf with large air spaces 4 gaseous exchange.

(c) Cortex / cortical Parenchyma

These are neatly arranged parenchyma cells which are provide support in non woody plants. They are found within the epidermis and endodermis in roots but between epidermis and vascular tissues in the stem. Due to the abscence of the endodermis in the stem.



This is the inner layer of the cortex sorrounding the vascular tissue (Xylemaphloem) It is found in the roots and contains a strip made of soberin called the casparian strip that is important in water transport.

Pith

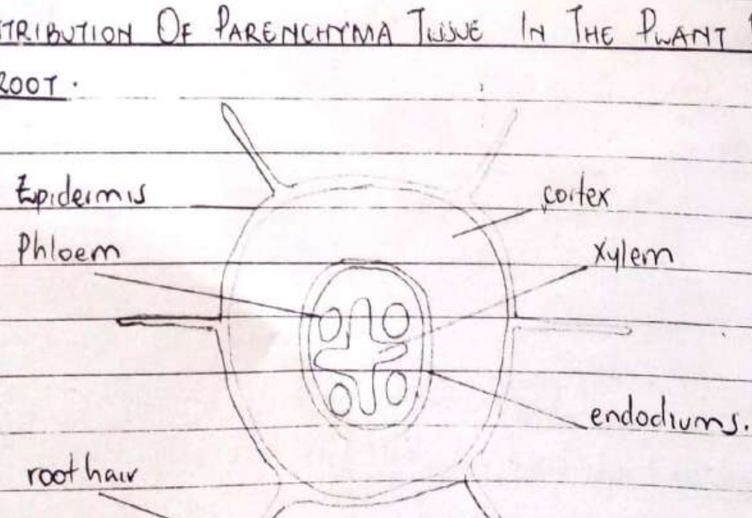
This is a layer of neatly arranged parenchyma cells present in the stem. It is used for providing support to non woody plants.

Note:

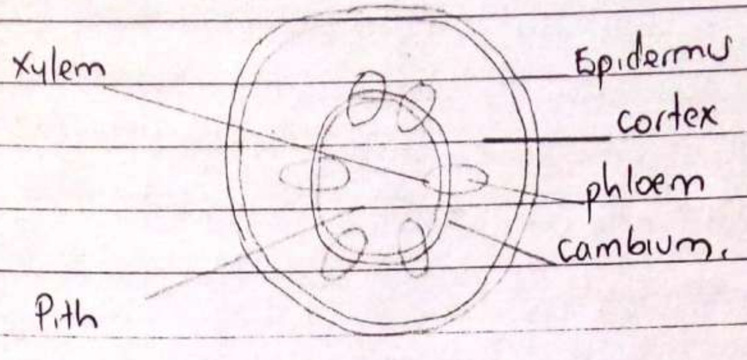
Parenchyma tissue is also found in the vascular tissues forming a Xylem Parenchyma and phloem parenchyma. These may be fill up the spaces within the vascular tissue.

DISTRIBUTION OF PARENCHYMA TISSUE IN THE PLANT BODY.

A ROOT.



B STEM.



a) Describe the distribution of Parenchyma tissue in the plant body
b) How is the distribution related to function epidermis.

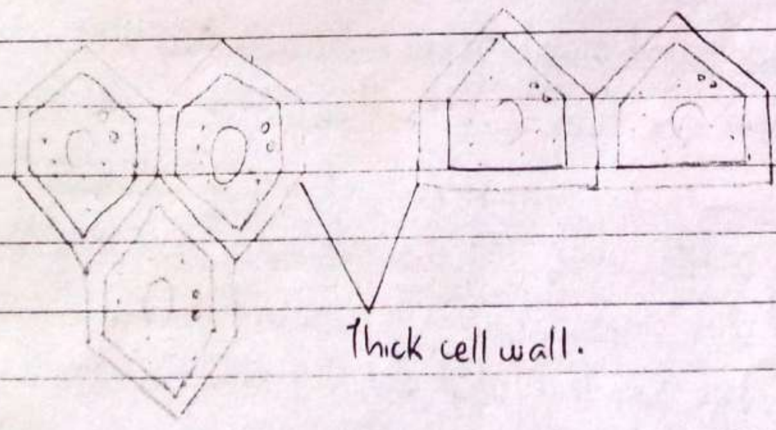
COLLENCHYMA TISSUE:

Consists of living cells modified to give support to the plant body. The cellwalls of the cells are deposited with cellulose which provide extra support. They have little cytoplasm because of the presence of a fixed cell wall.

The cells appear elongated polygonal which may be hexagonal or pentagonal.

They provide support in young plants, non-woody plants and the leaves to supplement the effect of the parenchyma cells. which give support when turgid.

They are found in the midrib of the leaves and the region outside the cortex, young stems and non woody plants.



SCLERENCHYMA

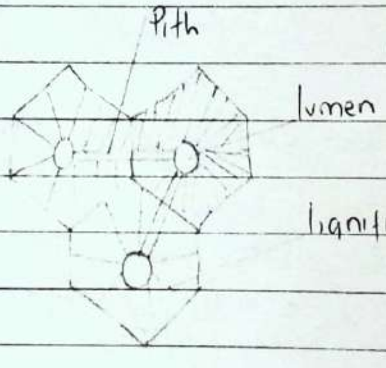
Consists of dead cells that provide extra support and strength to the plant body. Upon death, the walls become deposited with lignin which is a strengthening material with high tensile strength.

They are found in the outer region of the cortex, in the stems of trees and the xylem as well as the phloem where they provide extra strength for the suppotive tissue.

They may be fibres or sclereids. Fibres are elongated cylindrical cells which make up fibre crops like cotton and sissle as well as the fruit walls like the fibrous wall of the coconut.

Sclereids are found scattered in the cortex, xylem and phloem, where they supplement the support offered by the supportive tissue.

Mature sclerenchyma cells have lost the cytoplasm which is replaced by lignin except at particular points where lignin fails to deposit forming paths that link one cell to the next.



VASCULAR

These are compound plant tissues because they are made of more than ~~one~~ one type of cells. They · ~~the~~ ~~and~~ · are the conducting

The xylem conduct water and mineral salts while phloem conduct sugars and other organic products of photosynthesis.

The xylem also provide support and they are the major supportive tissues in the plant body. Being dead, the plant doesn't spend energy in mantaining why some trees are huge and long.

XYLEM TISSUE.

Consists of 4 types of cells:

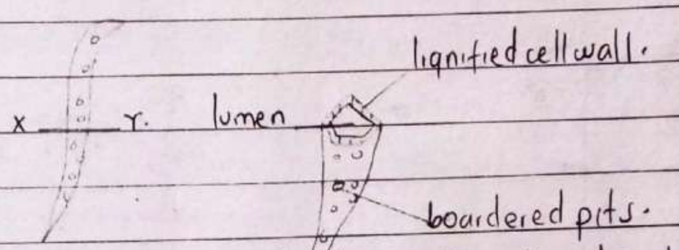
vessels

tracheids

/chlorenchyma Parenchyma

fibres.

The tracheids consists of cells that are elongated and lignified with bothends tapering/pointed.



The tracheids are elongated cells and when mature, they die, leaving an empty lumen which acts as a pathway for water transport. The walls of the tracheids are deposited with lignin. A material with high adhension for water molecules increasing its water conducting capacity. In areas where the lignin fails to deposit, pits develop which allow for lateral exchange of water between adjacent tracheids. Tracheids are common in gymosperms or non-flowering plants like conifers, ferns, Pinus but are rare in Angiosperms. In conifers, boardored pits are the plug called torus which regulate the passage of water.

torus.

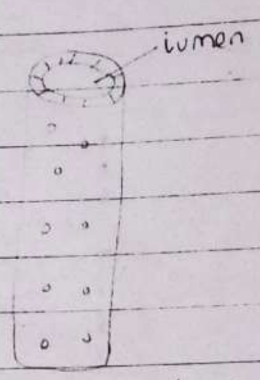
Scanned with CamScanner

VESSELS

These are the distinguishing features of angiosperms and they are the major conducting tissues in Angiosperms.

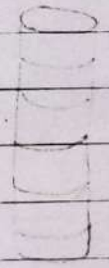
They are made of elongated cylindrical cells joined end to end but when mature, the end walls breaks to give a continous lumen that allows water transport with minimum resistance.

The walls of the xylem vessels are deposited with lignin, a material important 4 water transport and where lignin trys to deposit their boarderd pits which allow for lateral exchange of water



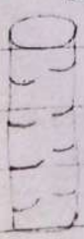
The walls are strengthened by thickening as a result of deposition of lignin. There are several forms of ~~strengthening~~ thickening including:

i) Annular ~~strengthening~~ thickening



ii) Spiral thickening

iii) Retriculate thickening.



Xylem fibres.

These are similar to sclerenchyma fibres- They do not conduct water but they are scattered within the xylem to supplement on the strength provided by the vessels and

Parenchyma cells.

These are scattered within the xylem and act as packing cells by filling the spaces between other cells.

Adaptation of Xylem tissue to function.

Endwalls have been broken forming a continous lumen for continuity of flow.

Walls are made up of lignin with high adhesion 4 water molecules facilitating water transport.

lignified walls increases strength of the vessels preventing them 4rm collapsing under the influence of the transpiration pull.

It is made up of dead cells without the cytoplasm which would resist the floor of water.

The vessels have a narrow lumen so they can take up water by capillarity force.

The boarderd pits allow for lateral exchange of water between adjacent vessels. when required.

The fibres within the xylem tissue provide for extrastrength within the xylem tissue providing support even in tall trees.

PHLOEM TISSUE.

Consists of cells modified to carry food substances and have three types of cells: sieve tube cells, companion cells, phloem parenchyma.

Sieve tubes are long tube like structures joined end to end with endwalls perforated to form sieve pores within the sieve plates to allow for continuity of floor.

The inside of the sieve tube cells contains cytoplasmic strands which run through the pores. The cytoplasm of the sieve tube cells is highly and is pushed to the peripheral leaving enough space for the passage of sugars with minimum resistance.

The companion cells are connected to the sieve tube cells by plasmodesmata. This connection allows for exchange of materials between the two cells such as ATP required 4 active transport of sugars.

The companion cells has all the organelles such as the ER, mitochondria, Golgi, vacuole, but has characteristically large number of mitochondria which provide the necessary energy for the active transport of sugars.

Adaptation of the phloem to function.

The large lumen ~~with~~ within the sieve tube element allows 4 transportation of materials in bulk.

The companion cell contain numerous mitochondria which provide energy for active transport of sugars.

The sieve plate is perforated forming sieve spores for continuity of floor.

The plasmodesmata allow movement of ATP 4rm the companion cell to the sieve tube element 4 active transport.

The thin living cytoplasmic material in the sieve tube element allows for cytoplasmic streaming, a mechanism used in transport of sugars.

The strands allow for transport of sugars by peristaltic waves; an alternative mechanism that has been suggested 4 the transport of sugars.

Other cells present in the phloem tissue are the phloem parenchyma which act as packing cells filling up the spaces in the phloem tissue but they have also been suggested as loading cells, that pump sugars from the leaves into the sieve tube elements.