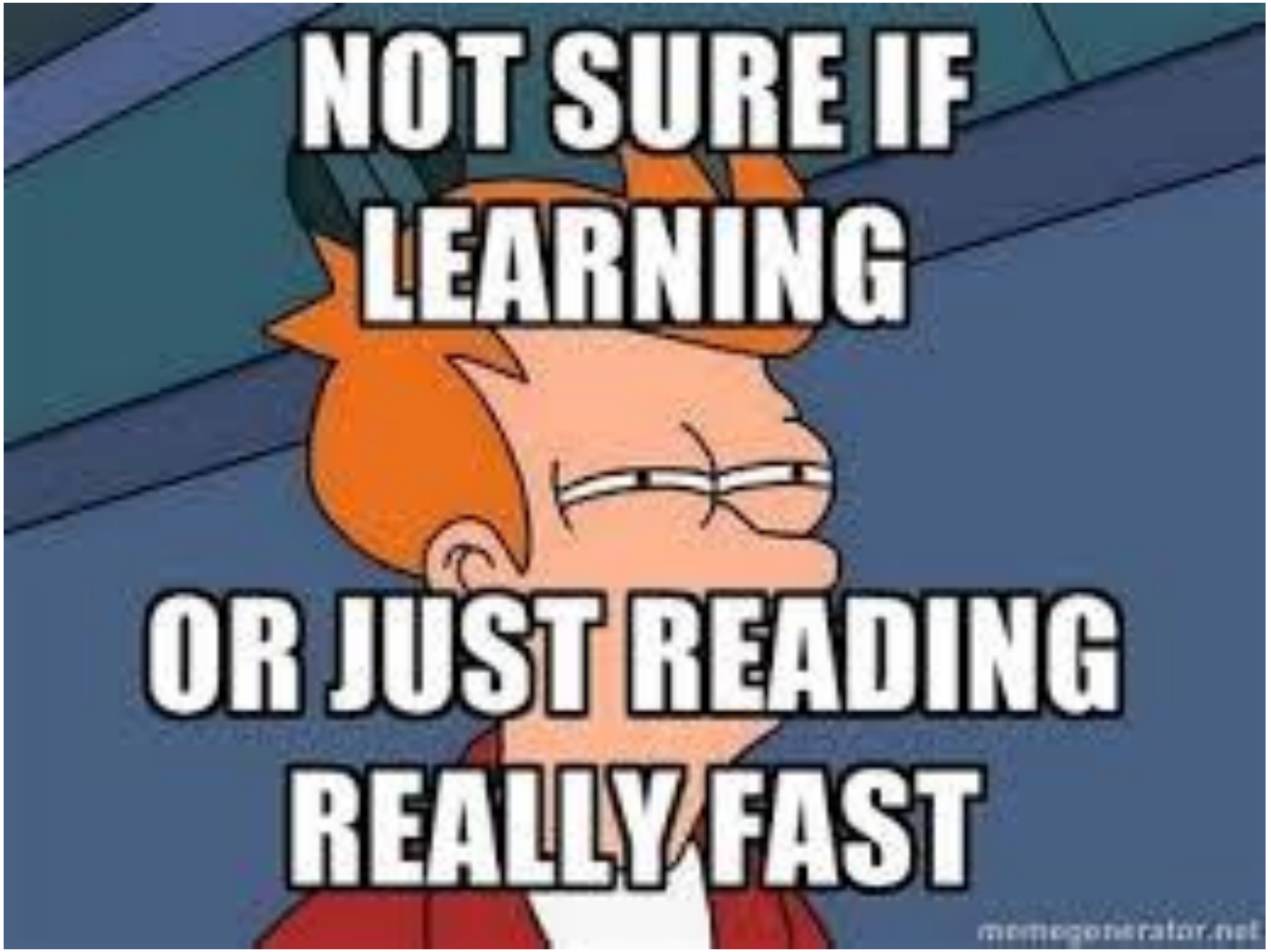
A2 Module 4 Revision

2015



NEURONES, EYES AND MUSCLES...

Describe the structure of a neurone:

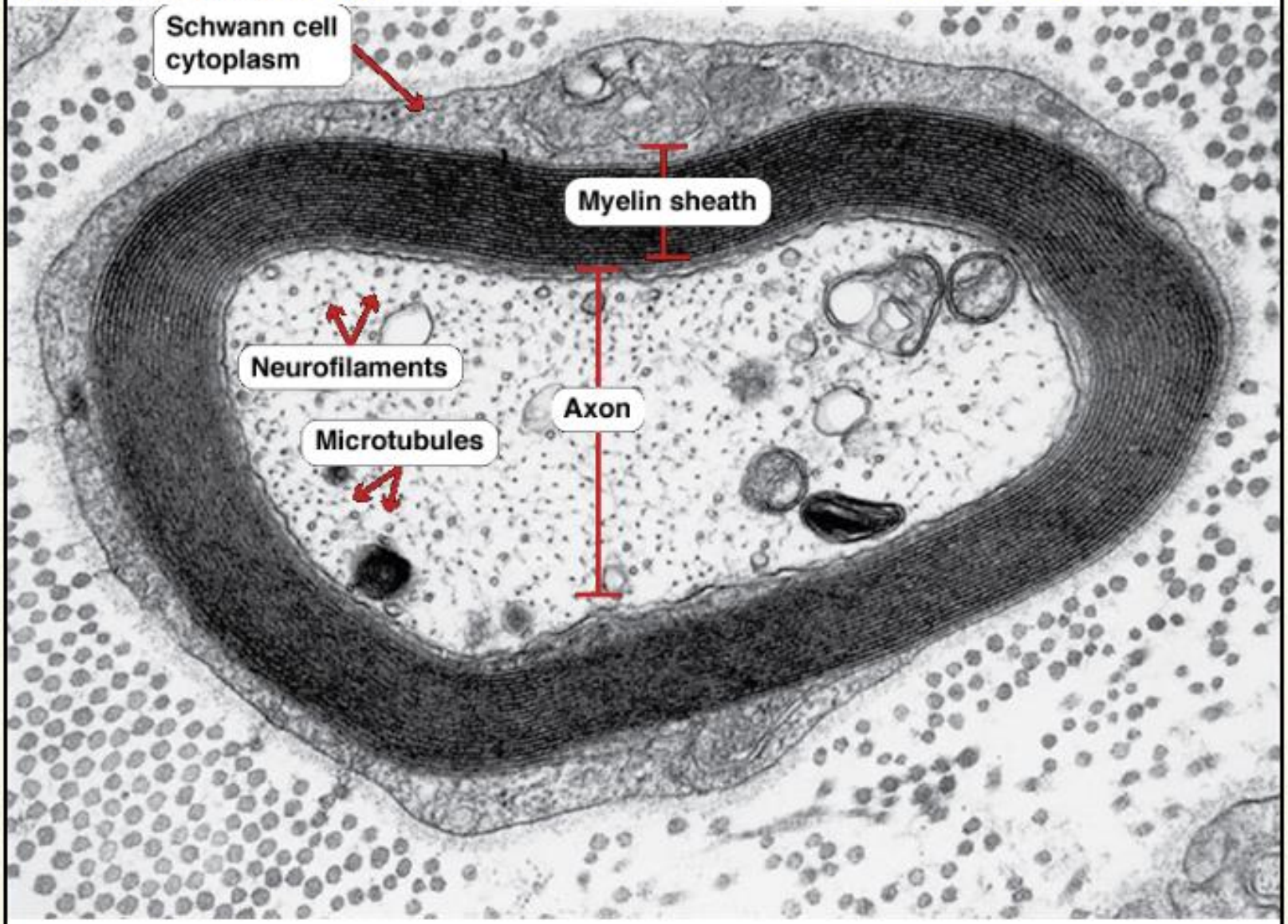
- recognise the following components in LM and TEM photographs and diagrams;
  - dendrons/dendrites
  - cell body
  - axon
  - Schwann cell/myelin sheath
  - node of Ranvier.

4.3.8 Practical Work:

Examine prepared slides/photographs of the mammalian eye:

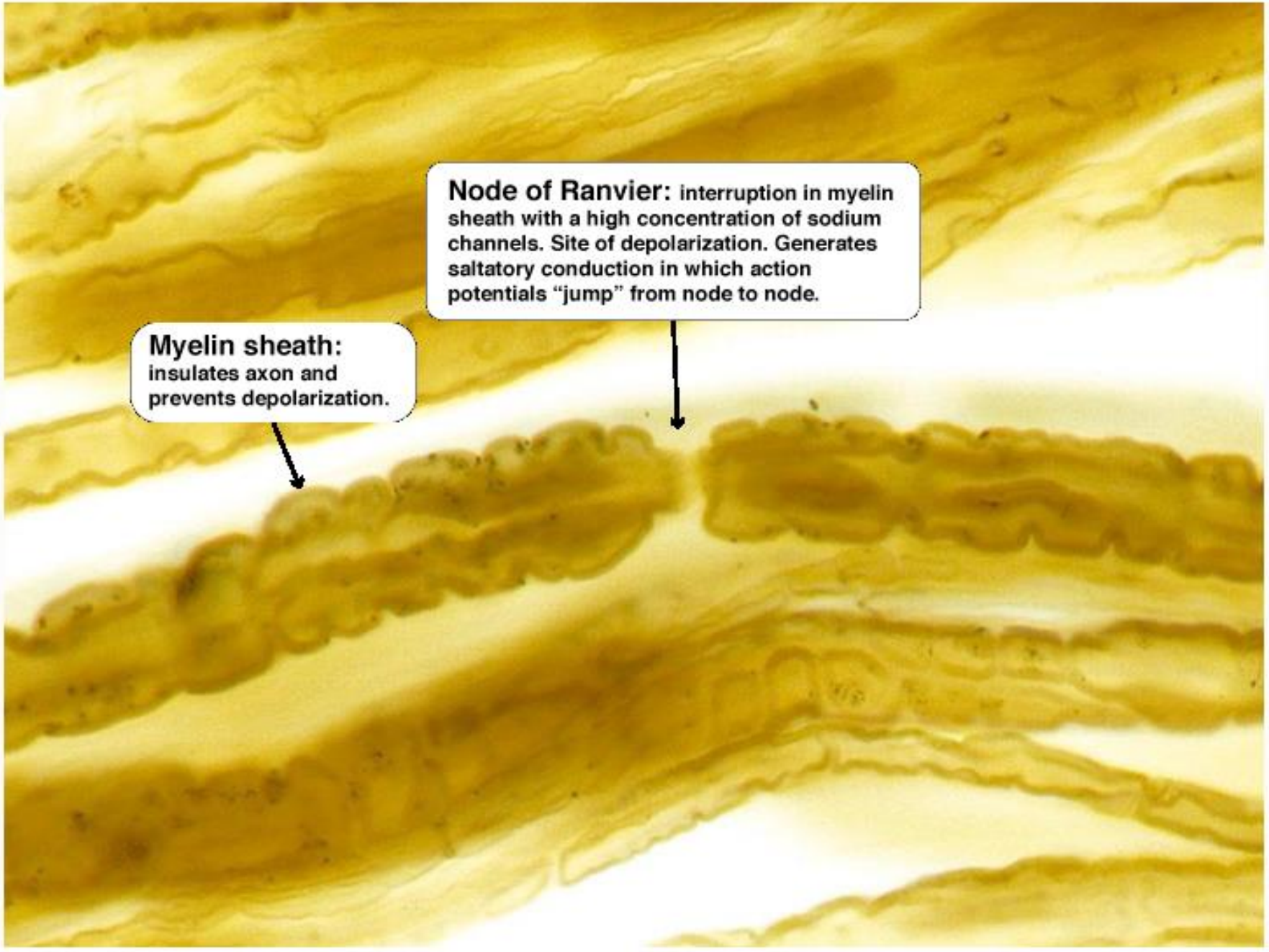
- *recognise the following components;*
- *conjunctiva, cornea, iris, pupil, ciliary body, suspensory ligaments, aqueous and vitreous humours, retina, choroid, sclera, blind spot, optic nerve, rods and cones.*

Myelinated Neuron EM



This electron micrograph shows a cross section of a myelinated nerve. This electron micrograph is considerably more detailed than what you would see when looking at myelinated neurons under the light microscope.

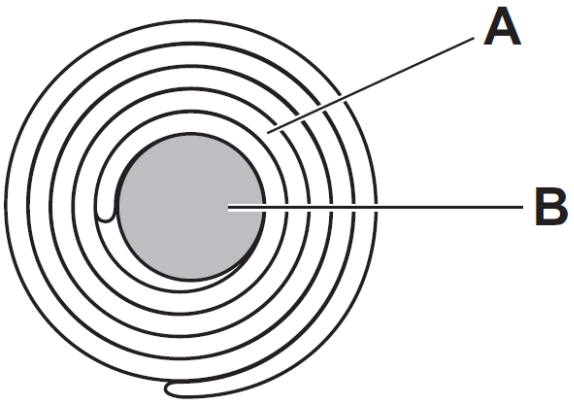
Node Of Ranvier



6 **(a)** Diagram **X** below represents a myelinated neurone in transverse section (T.S.).

Two important features of the neurone are labelled **A** and **B**.

Diagram X



(i) Identify the features labelled **A** and **B**.

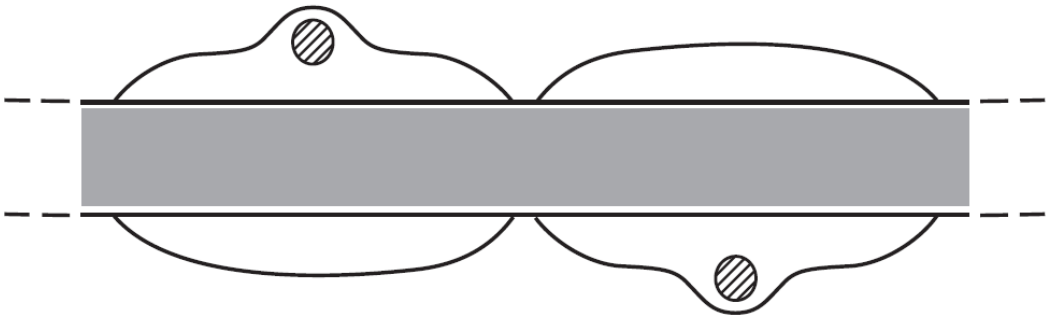
A _____

B _____ [2]

(i) **A** – myelin sheath/Schwann cell;
B – axon;

Diagram **Y** below represents part of the myelinated neurone in longitudinal section (L.S.).

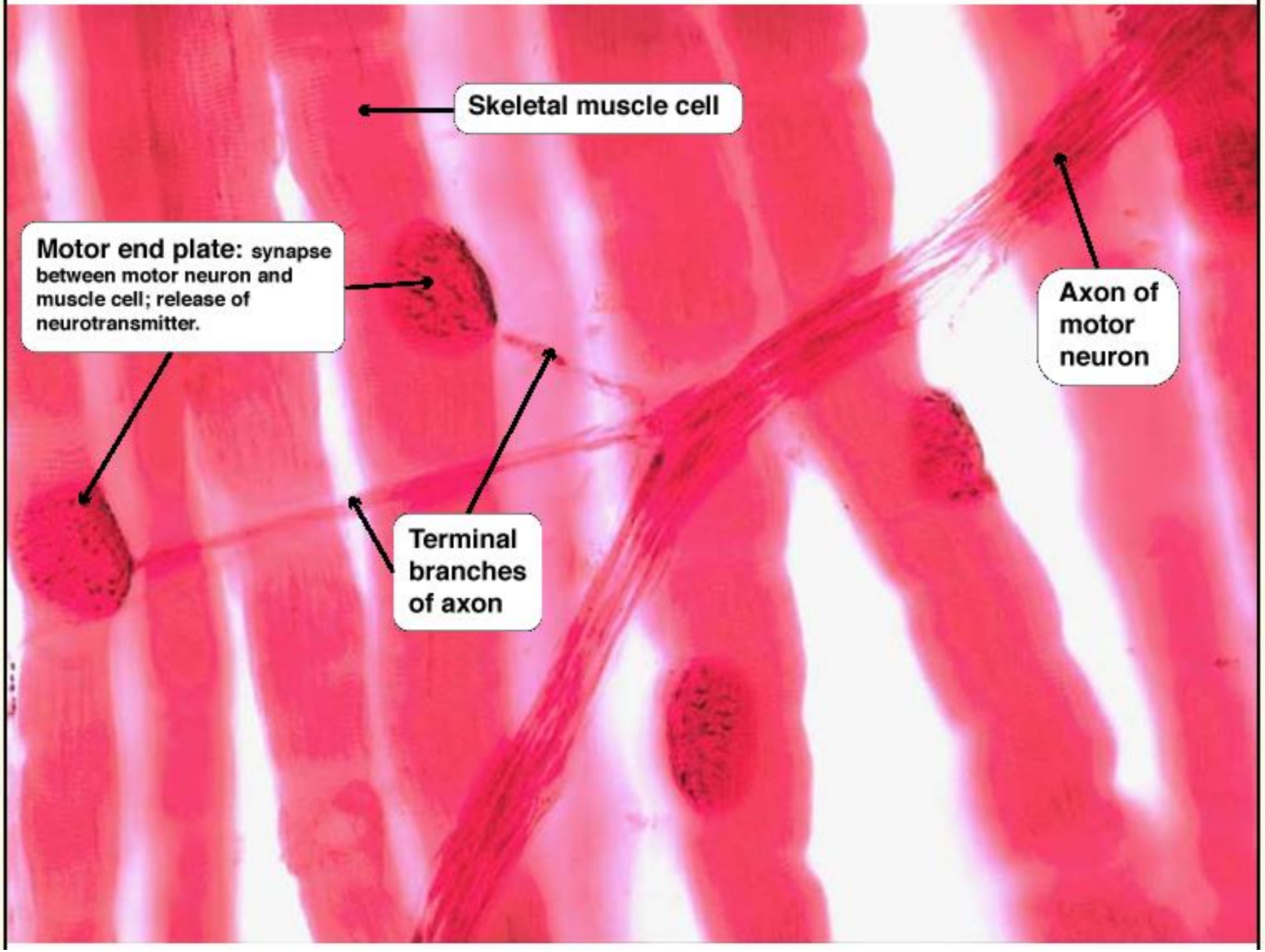
Diagram Y



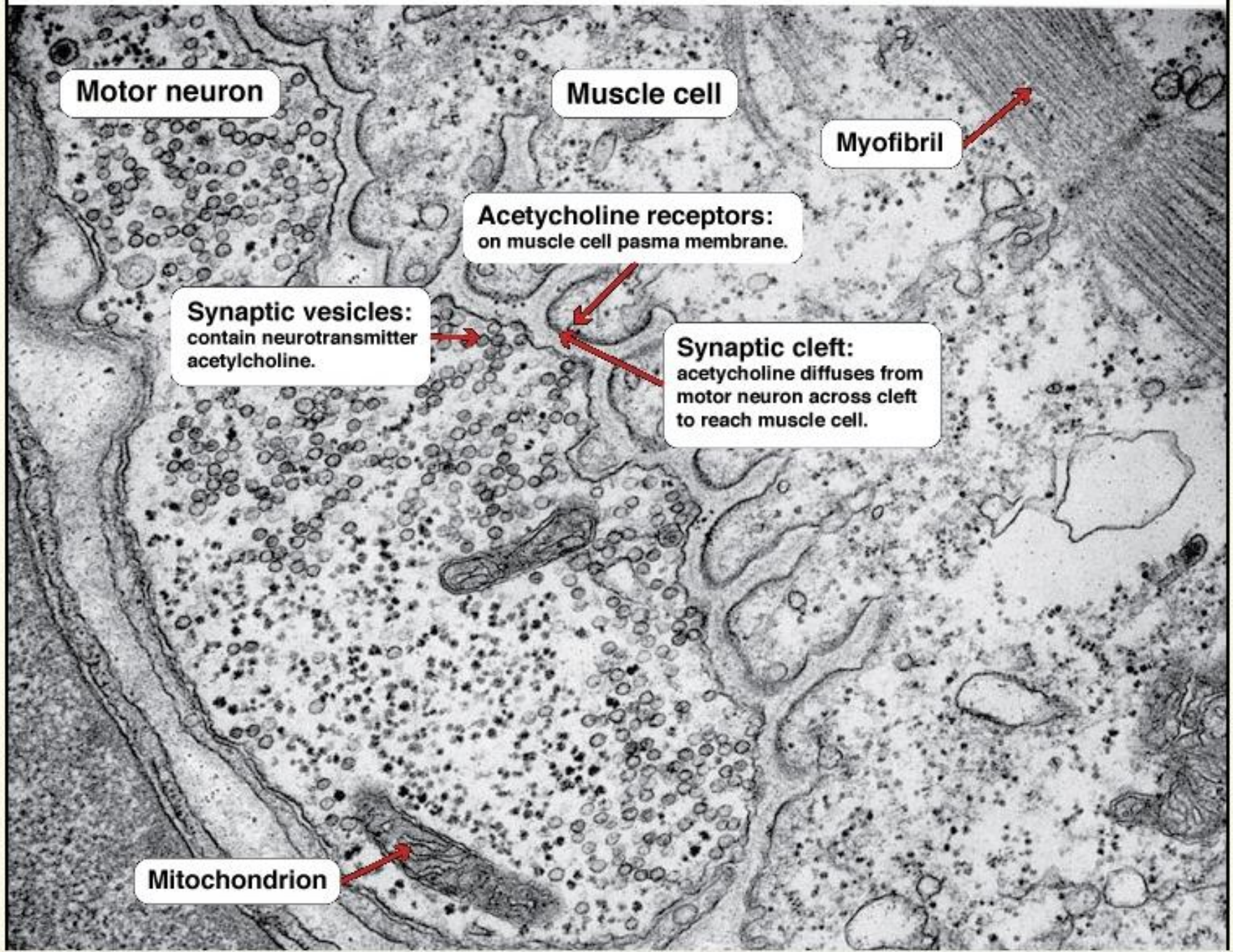
(ii) Draw a line on diagram **Y** to show where the section represented in diagram **X** could have been taken. [1]

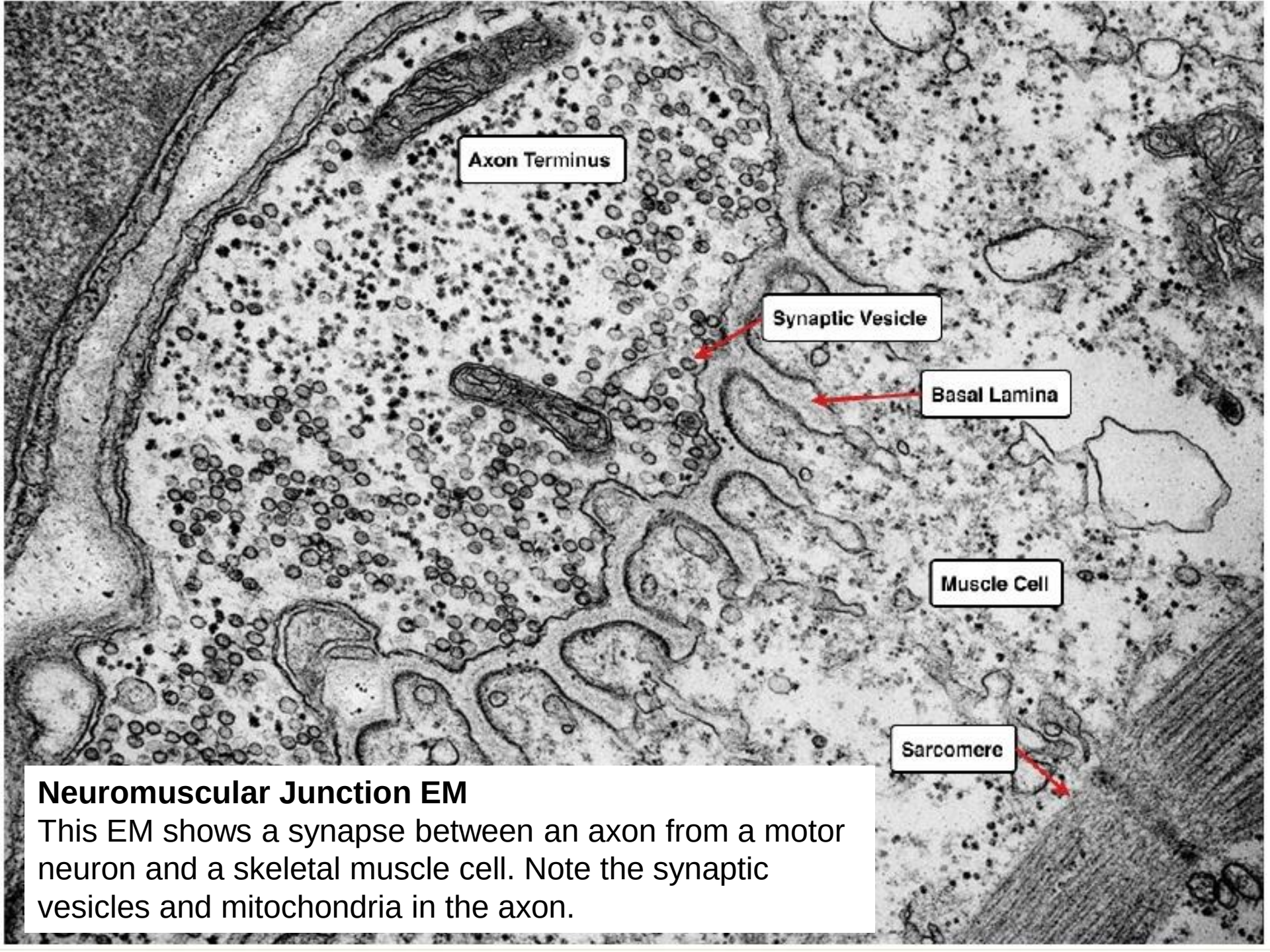
(ii) Vertical line on myelin sheath avoiding nucleus (not across node of Ranvier); [1]

Neuromuscular Junction



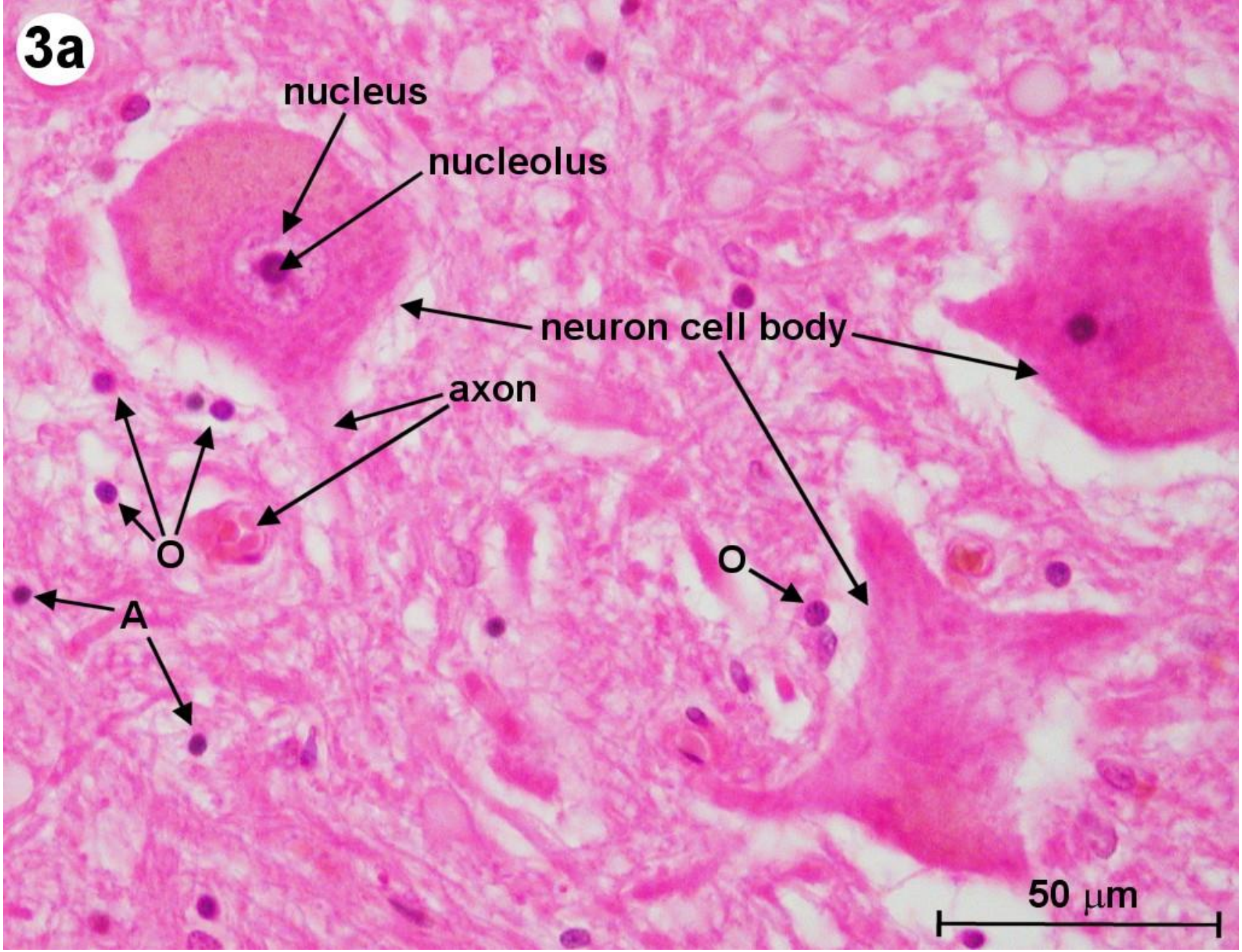
Neuromuscular Junction EM





Neuromuscular Junction EM

This EM shows a synapse between an axon from a motor neuron and a skeletal muscle cell. Note the synaptic vesicles and mitochondria in the axon.



O and A are dendrons/dendrites X40

1 The following statements relate to the structure or function of the eye. Identify the term described by each statement.

- The structures that link the ciliary body and the lens

_____

- The layer that prevents internal reflection of light in the eye

_____

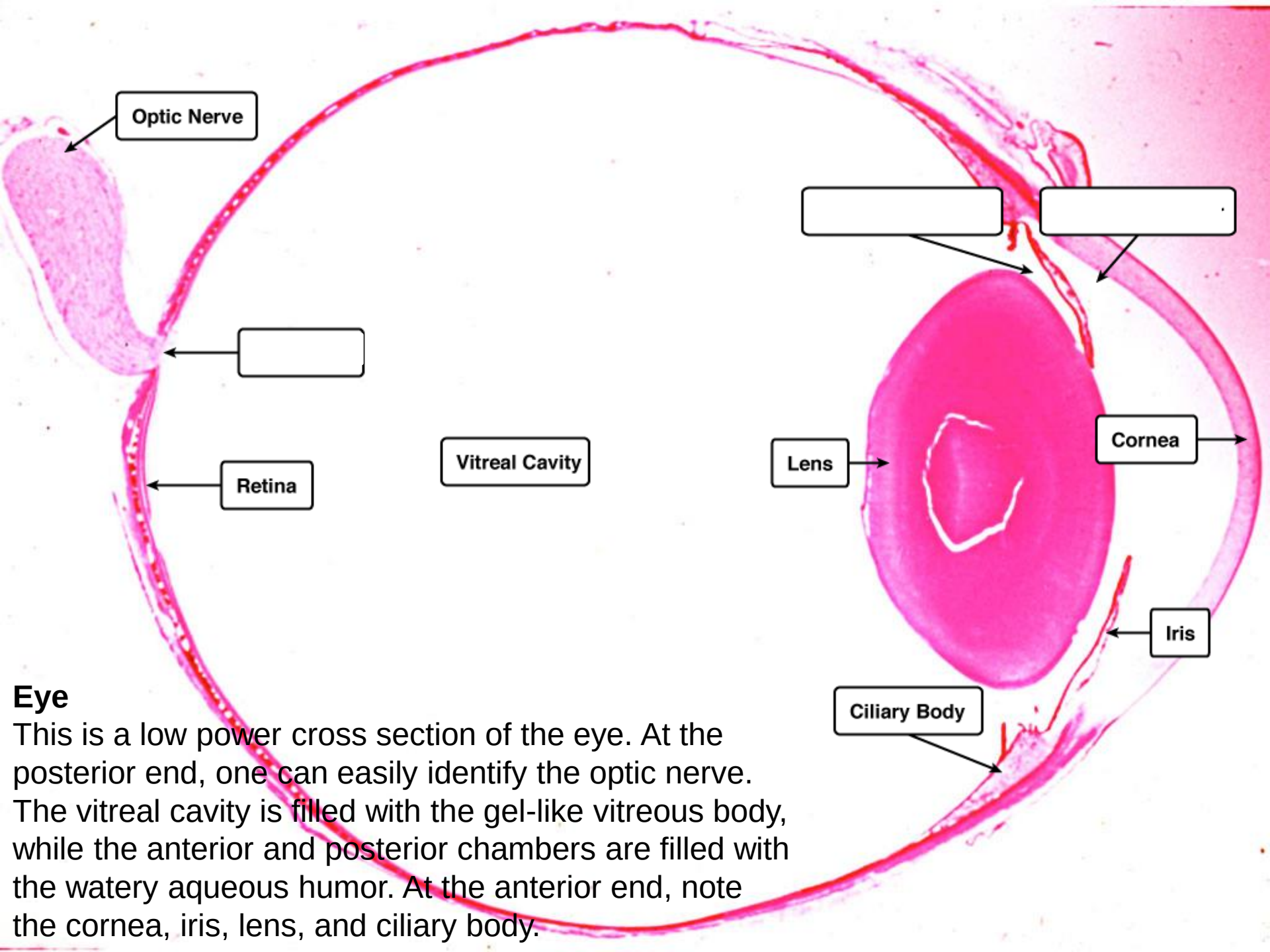
- The neurone arrangement that provides high sensitivity in low light intensities

_____

- The type of vision that makes three dimensional images possible

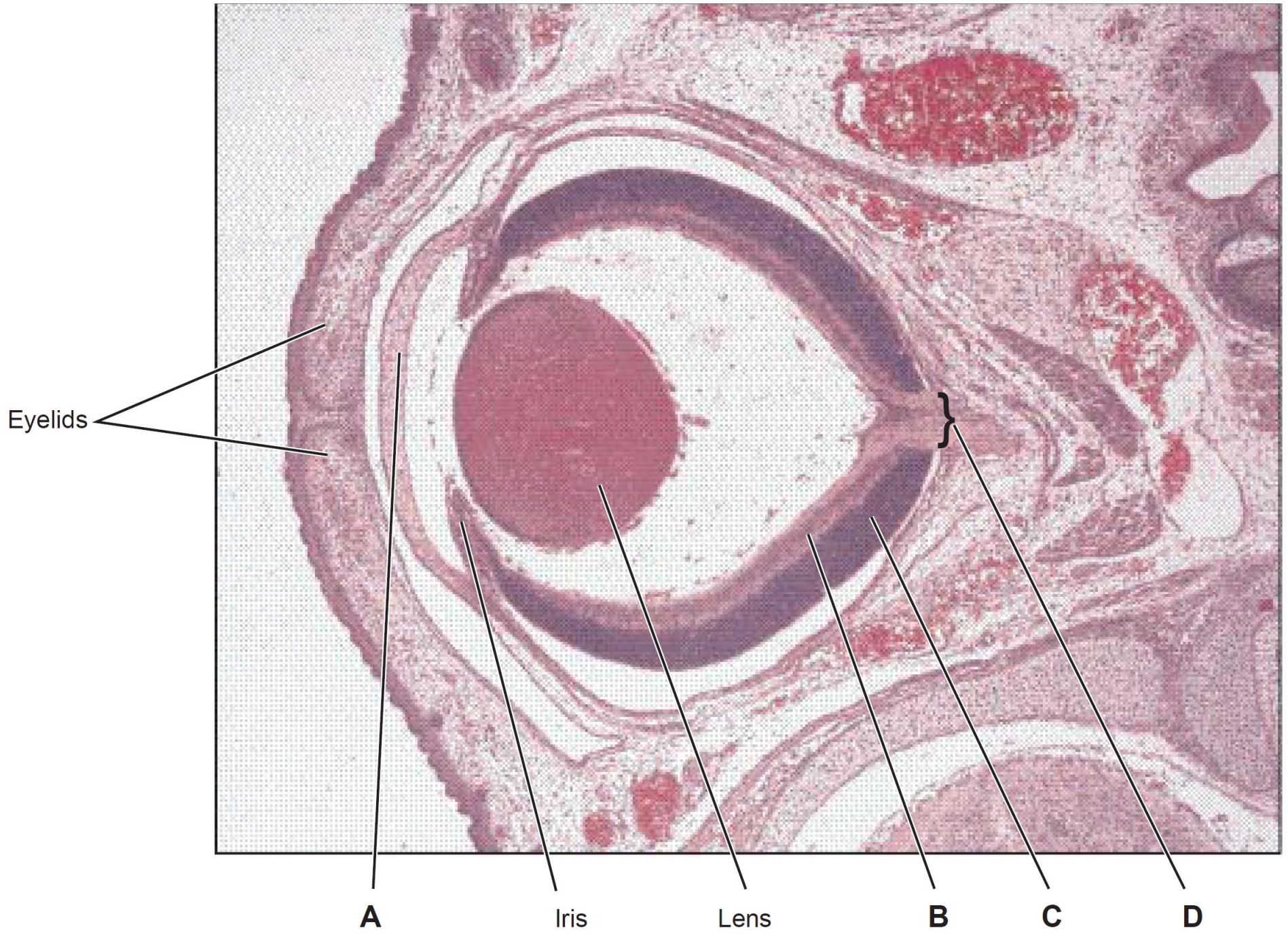
_____ [4]

1 Suspensory ligaments;
choroid;
(retinal) convergence;
stereoscopic;



Eye

This is a low power cross section of the eye. At the posterior end, one can easily identify the optic nerve. The vitreal cavity is filled with the gel-like vitreous body, while the anterior and posterior chambers are filled with the watery aqueous humor. At the anterior end, note the cornea, iris, lens, and ciliary body.


Eyelids
A
Iris
Lens
B
C
D

(a) A: cornea;
B: retina/ganglion cell layer/bipolar cells;
C: choroid;
D: optic nerve; [4]

(b) Describe the operation of the iris in bright sunlight.

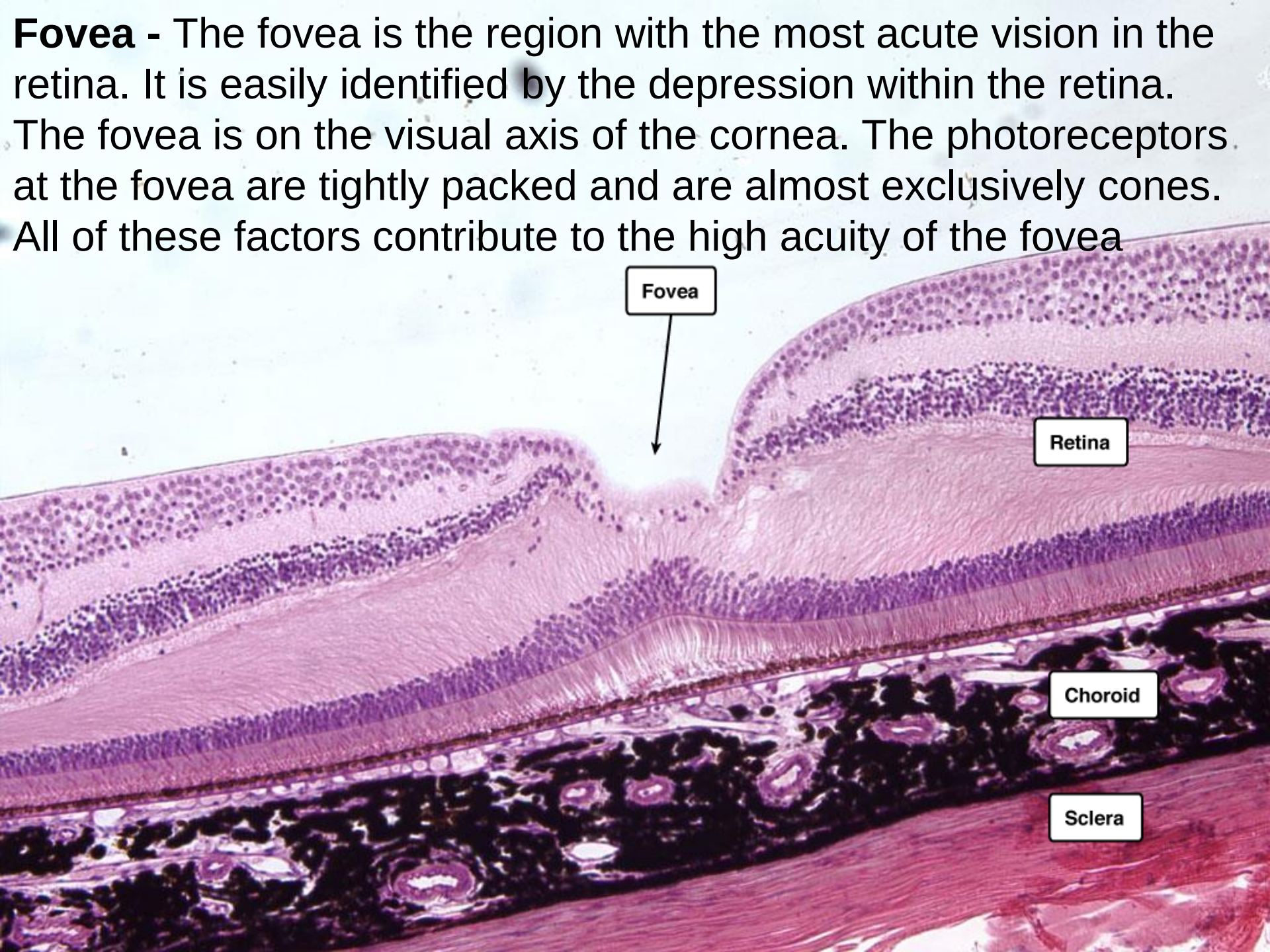
_____

_____

_____ [2]

(b) Circular muscle of the iris contracts (and radial muscle relaxes);
iris expands/pupil constricts; [2]

Fovea - The fovea is the region with the most acute vision in the retina. It is easily identified by the depression within the retina. The fovea is on the visual axis of the cornea. The photoreceptors at the fovea are tightly packed and are almost exclusively cones. All of these factors contribute to the high acuity of the fovea



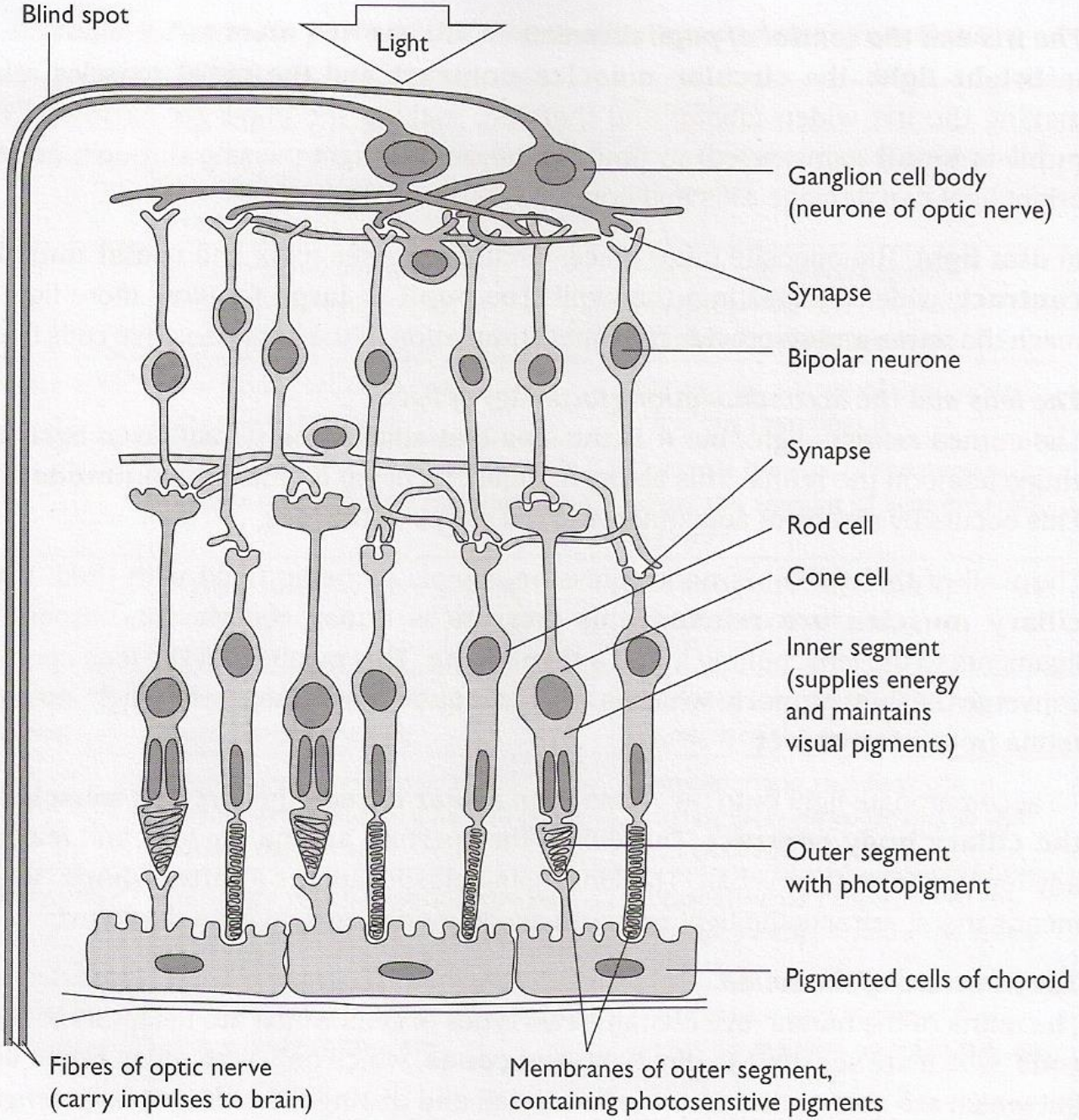
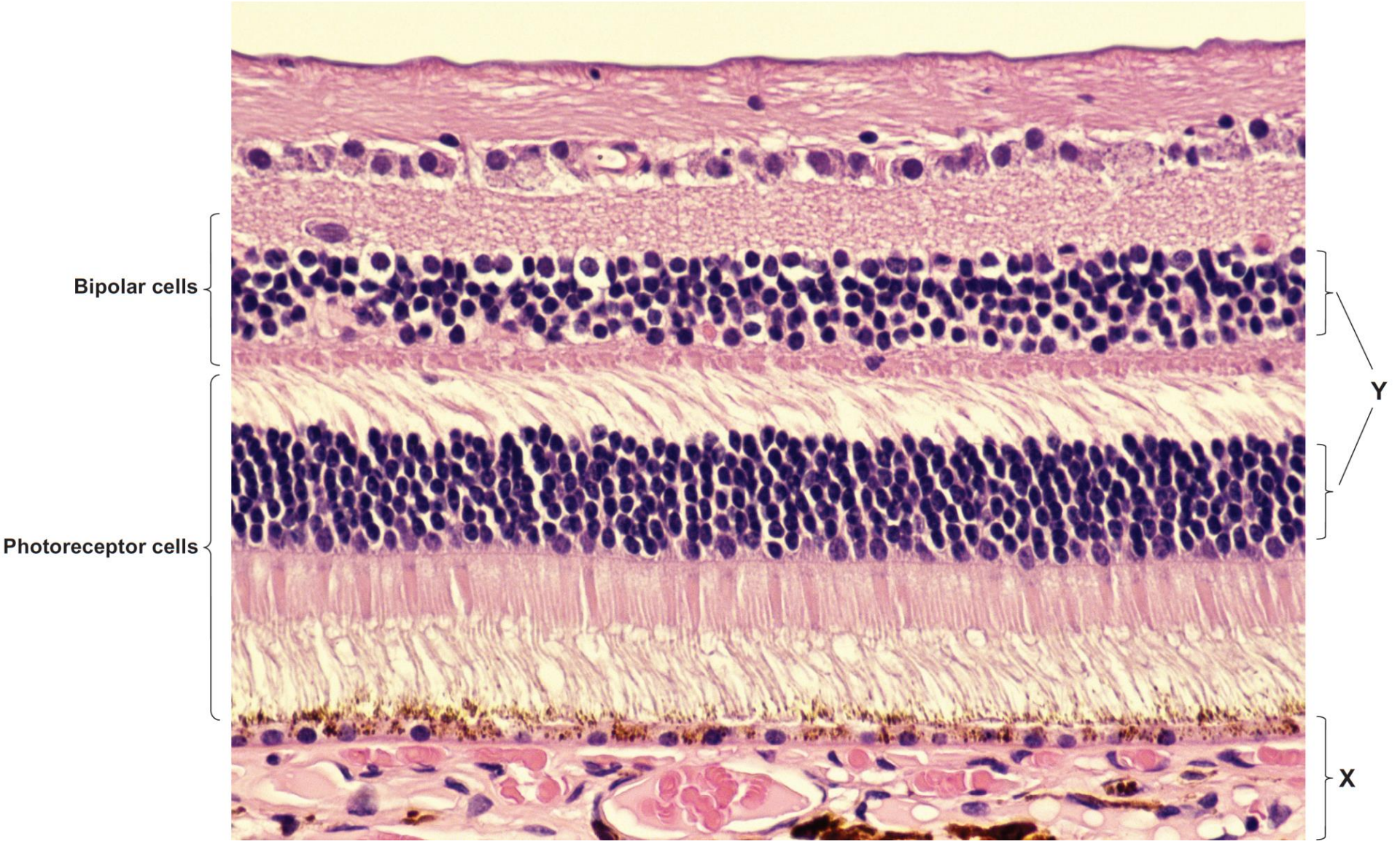


Figure 20 The structure of the retina

January 2013

Photograph 1.4
(for use with Question 4)



(a) **Photograph 1.4** shows a section through part of the wall of a mammalian eye.

(i) Identify layer **X** that lies immediately below the photoreceptor cells.

_____ [1]

(a) (i) Choroid layer; [1]

(ii) Identify the dark circular structures in the layers labelled **Y**.

_____ [1]

(ii) Nuclei; [1]

(iii) The mammalian retina is described as being 'inverted'. Using **photograph 1.4**, suggest why the mammalian retina is described as being inverted and suggest a possible disadvantage of this.

[2]

(iii) To reach photoreceptor cells light has to pass through neurones/photoreceptor cells not at the front of retina where light enters/neurones lie over the photoreceptor cells;
detection of light compromised (e.g. not fully reaching photoreceptors)/ blind spot where neurones leave the eye necessary in this arrangement; [2]

The rods:

- rods contain the photosensitive pigment rhodopsin which is readily broken down (bleached) in low light intensity
- if threshold level is reached an action potential is initiated in the receptor neurone
- in bright light (normal daylight) rods remain bleached (rhodopsin broken down)
- the opsin and retinine only recombine when darker conditions prevail - the time taken for this is known as dark adaptation
- several rods synapse with one bipolar neurone / rods exhibit retinal convergence (and so sensitivity)
- the resultant convergence allows summation of generator potentials / transmitter substance so that in dimmer light a threshold level is reached
- convergence results in a lack of visual acuity / poor resolution

The cones:

- cones contain the pigment iodopsin which is only broken down in high light intensity
- each cone synapses individually with bipolar neurones
- which gives cones greater visual acuity / greater resolution
- there are three types of cone
- each type of cone has a different type of iodopsin sensitive to red, green or blue light
- the variety of colours we perceive depends on the relative amount of stimulation of each of these three types [16]

4.3.10 Practical Work:

Examine prepared slides/ photographs of skeletal muscle, cardiac muscle and smooth muscle:

- *recognise the characteristic features of skeletal muscle and cardiac muscle using LM and TEM photographs and smooth muscle using LM photographs.*

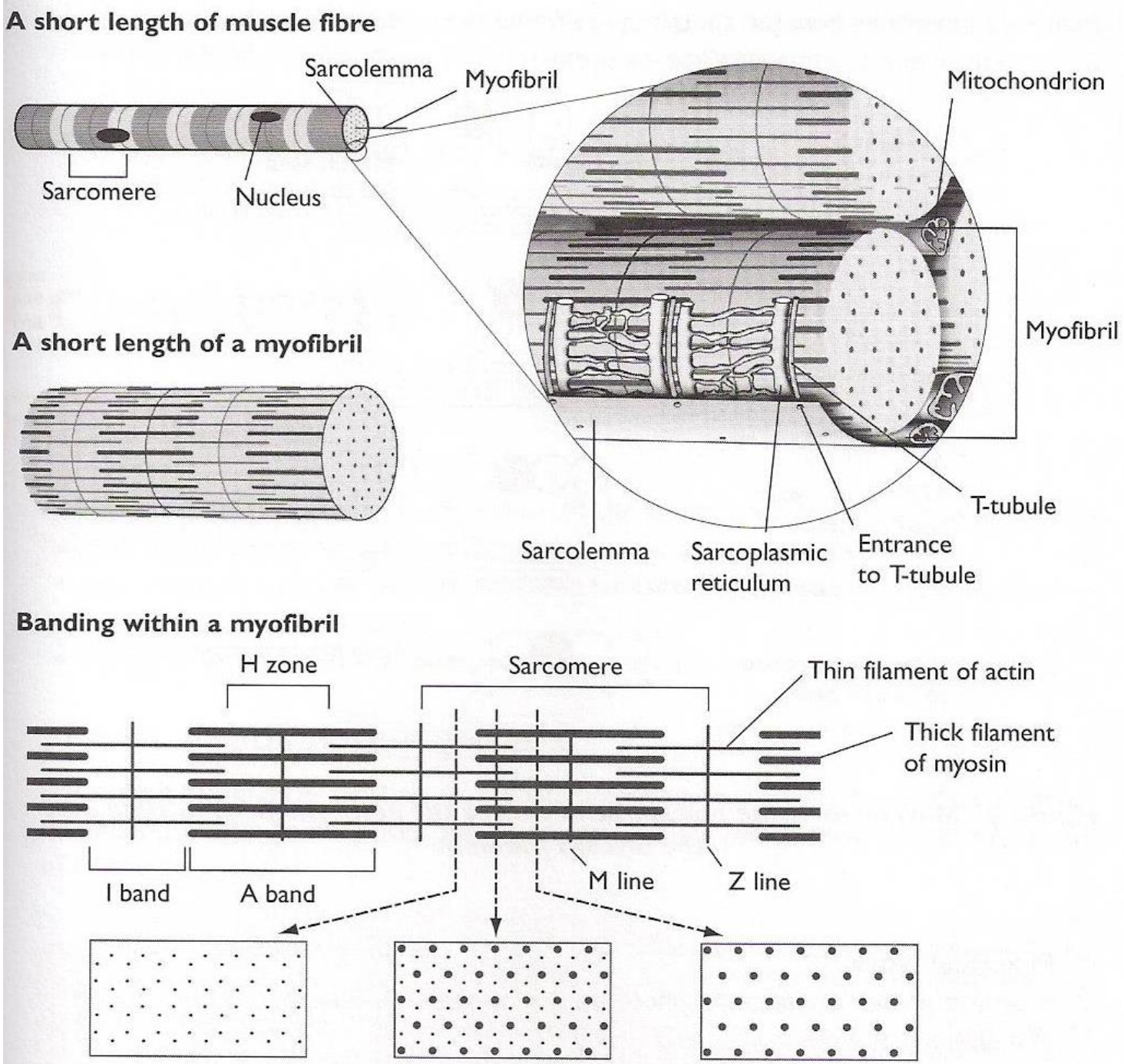
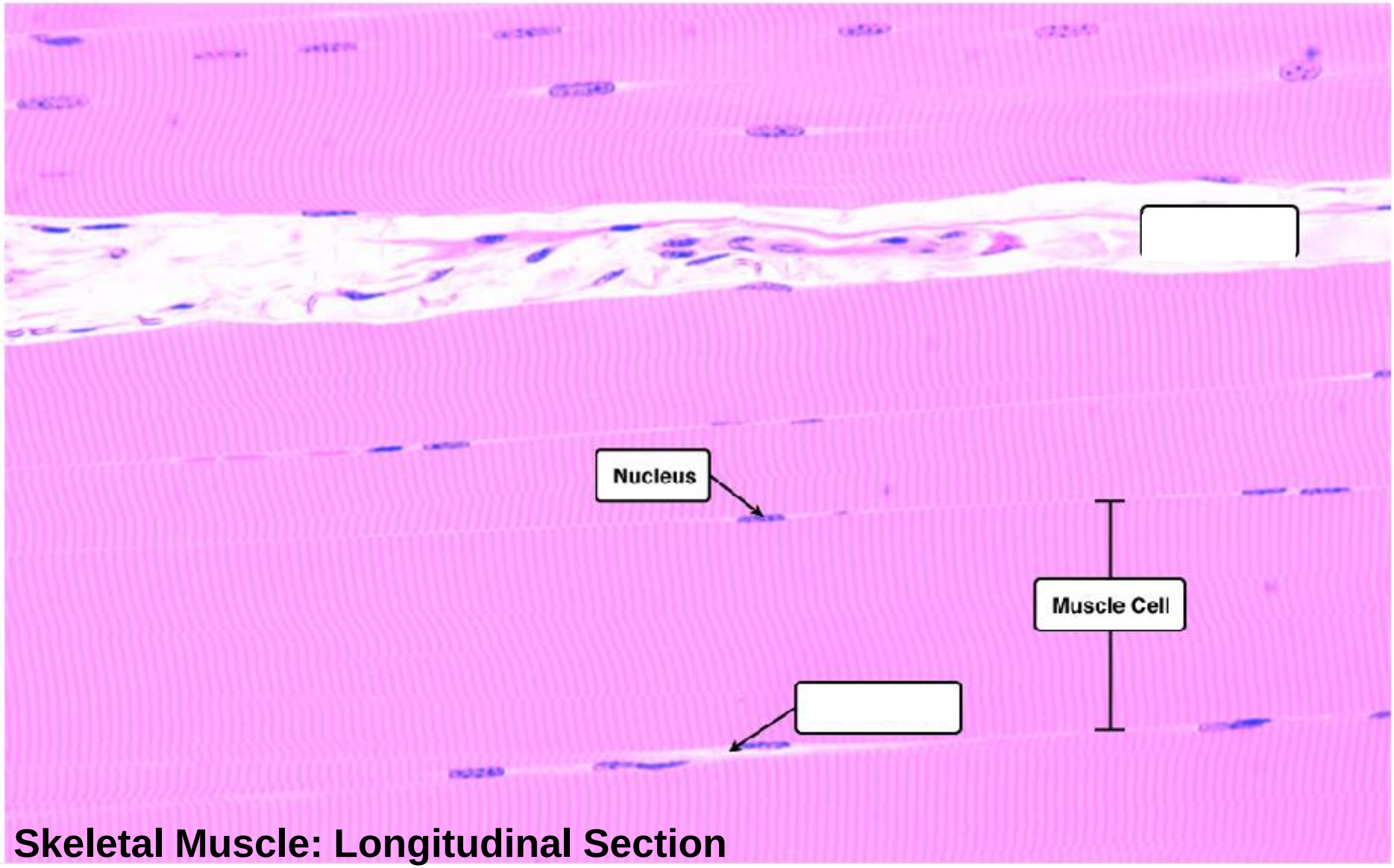

A short length of muscle fibre
Sarcolemma
Myofibril
Mitochondrion
Sarcomere
Nucleus
A short length of a myofibril
Myofibril
T-tubule
Sarcolemma
Sarcoplasmic reticulum
Entrance to T-tubule
Banding within a myofibril
H zone
Sarcomere
Thin filament of actin
Thick filament of myosin
I band
A band
M line
Z line
Transverse views of filaments

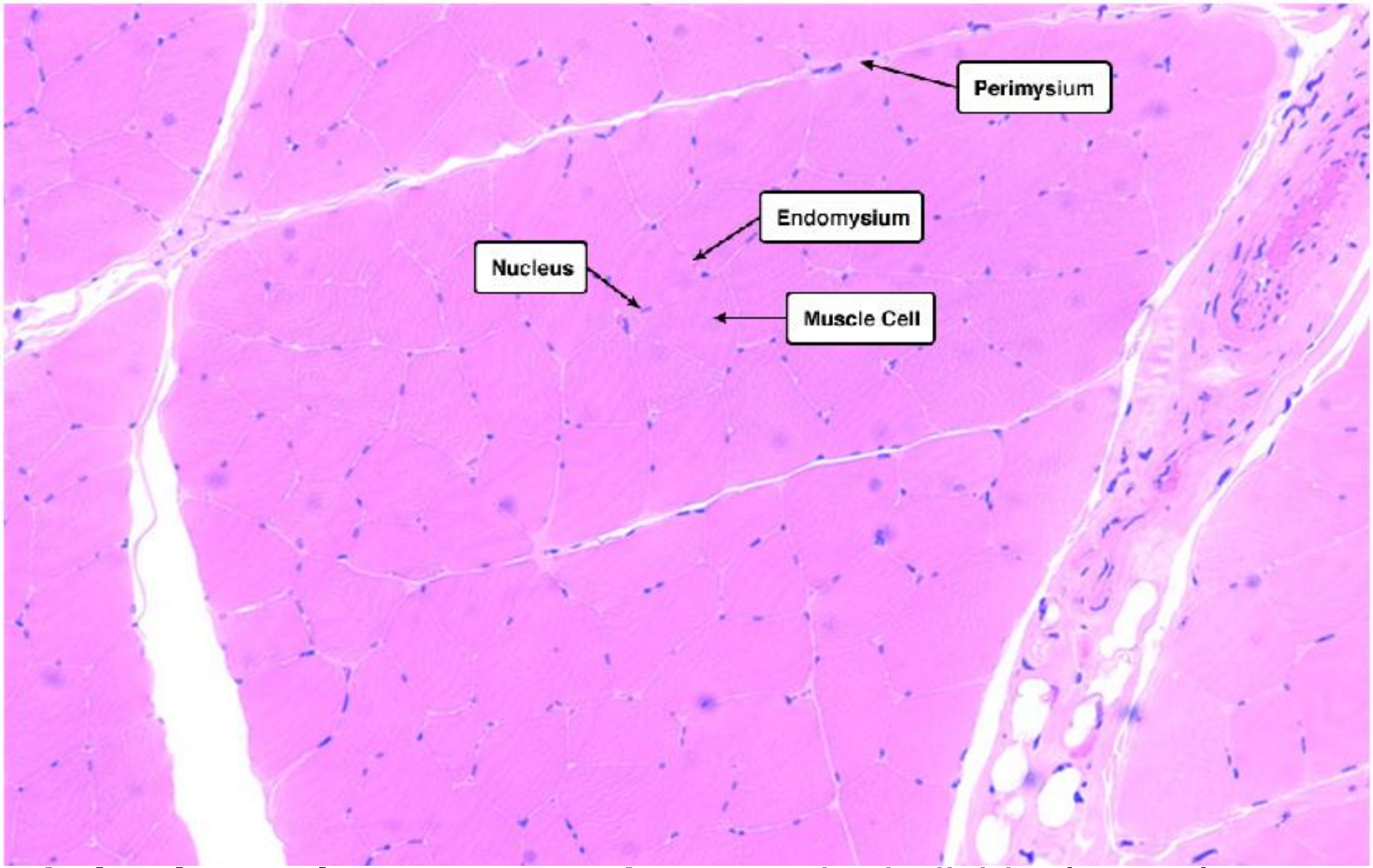
Table 10 A comparison of cardiac, smooth and skeletal muscle

	Skeletal	Cardiac	Smooth
Appearance	Muscle fibres are multinucleate, with distinct striations (bands)	Cells are striated and branched, forming a linked network; intercalated discs between cells	Spindle-shaped cells with a single nucleus and no striations
Distribution	Attached by tendons to bones	Only found in the wall of the heart	Present in the iris and ciliary body of the eye, and in walls of tubular organs, e.g. gut, blood vessels and bladder
Function	Movement of parts of the body and locomotion	Pumping of the heart maintains blood circulation	Movement of materials within the body

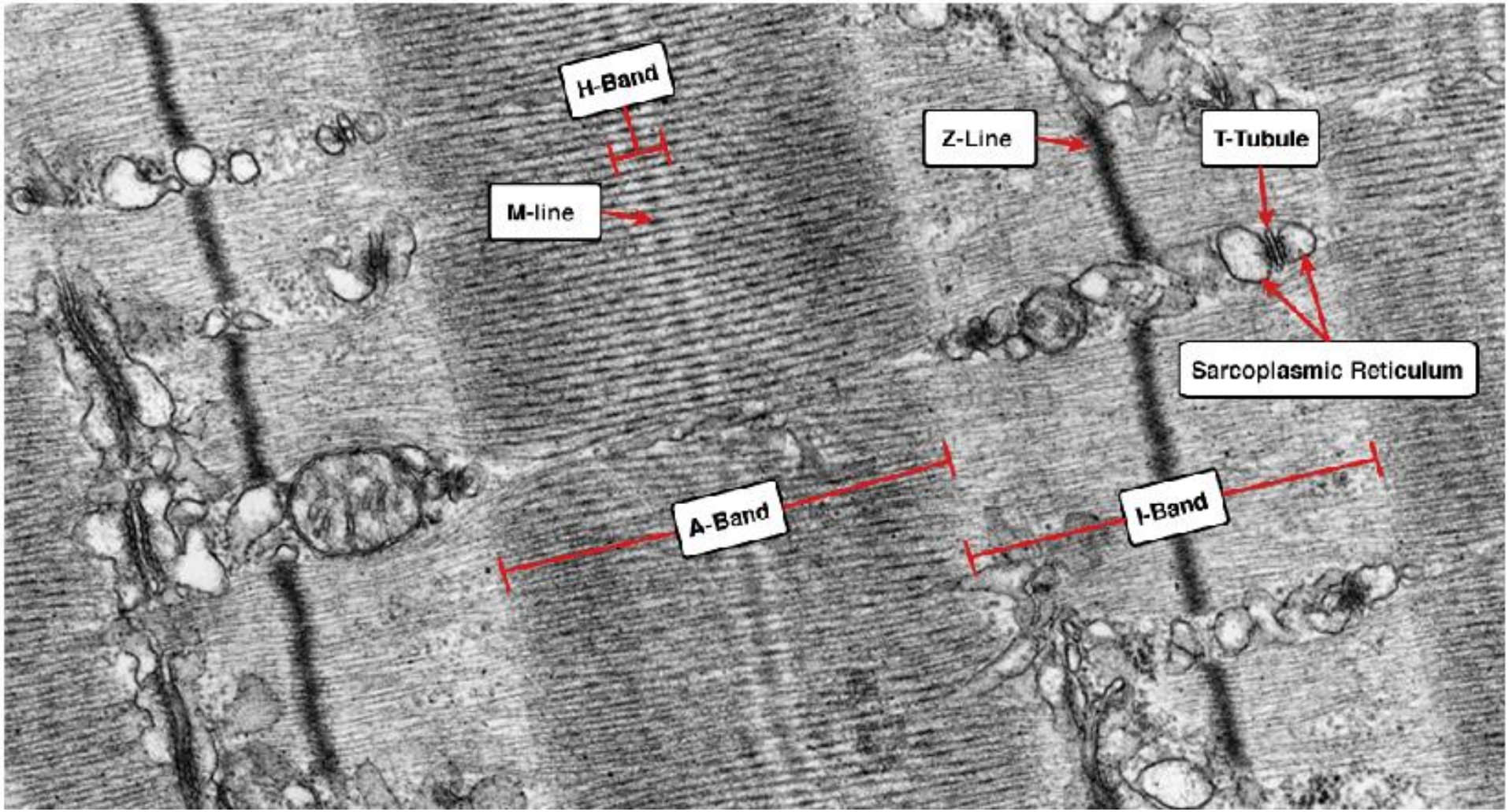


Skeletal Muscle: Longitudinal Section

This is a longitudinal section of skeletal muscle fibres. The skeletal muscle fibres are long and multinucleated. Again, note the peripherally placed nuclei in each cell and capillaries. Observe the striated pattern of skeletal muscle in longitudinal sections: the dark A-bands and the light I-bands

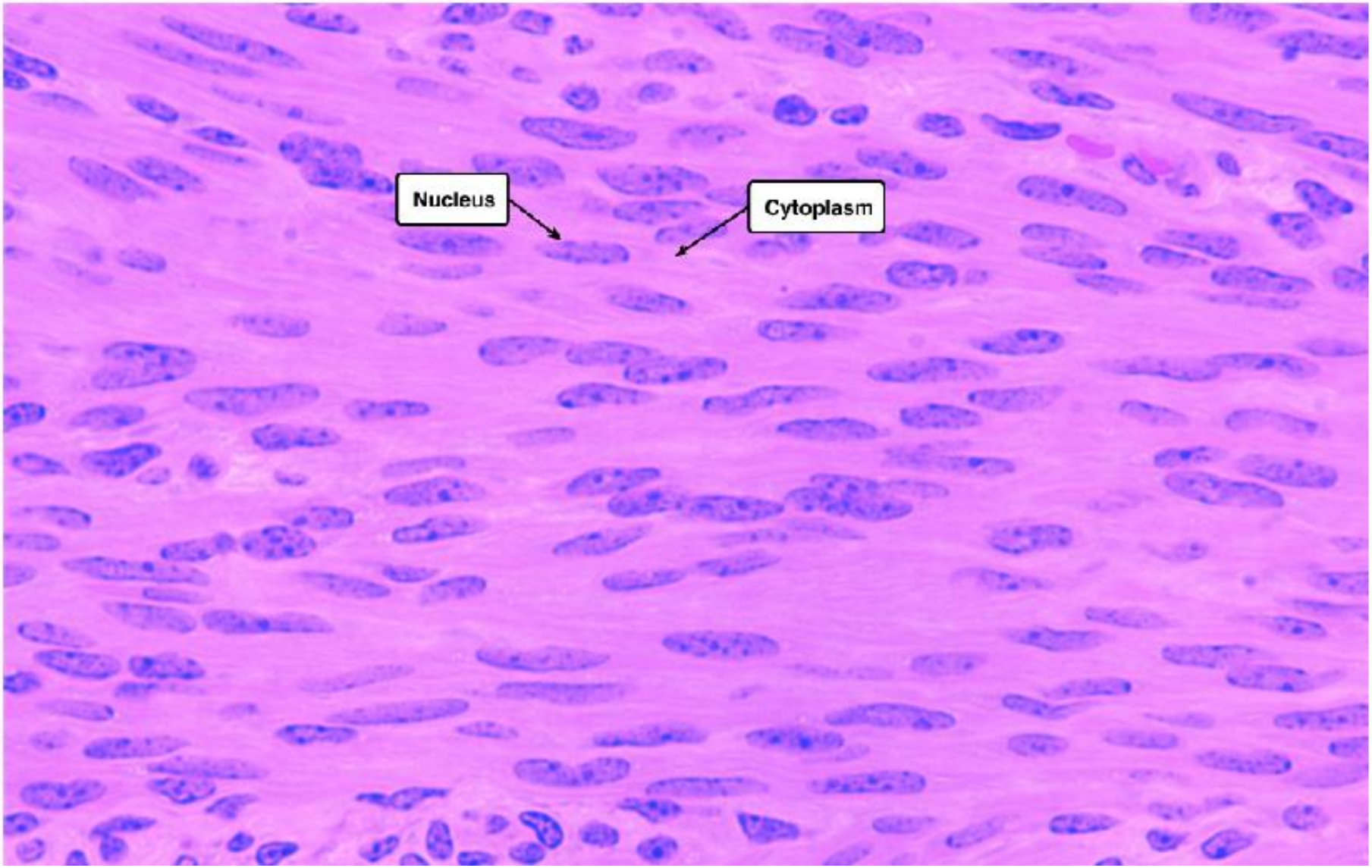


Skeletal Muscle: Cross Section - On the individual muscle fibres, note the peripherally placed nuclei, which are characteristic of skeletal muscle, and the fibrillar texture of the sarcoplasm.



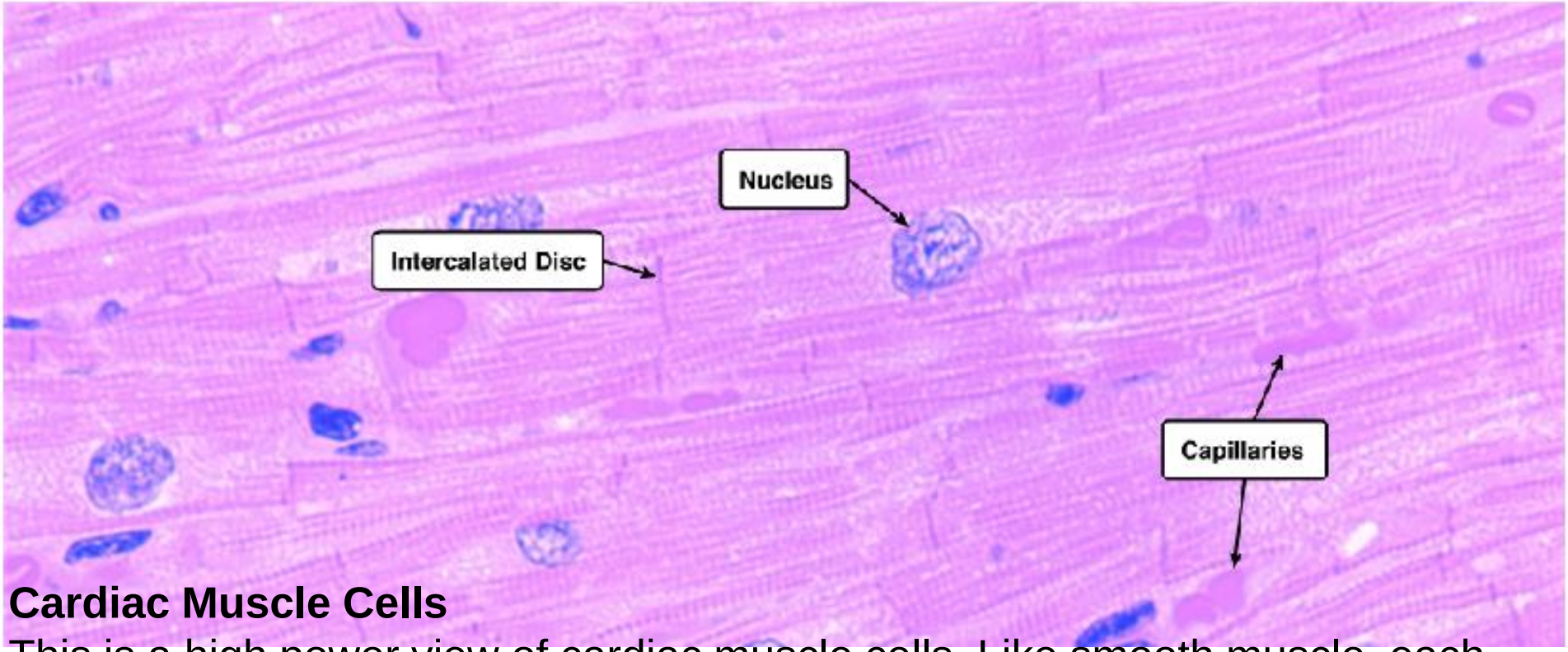
Skeletal Muscle EM

This is an electron micrograph of a longitudinal section of skeletal muscle.



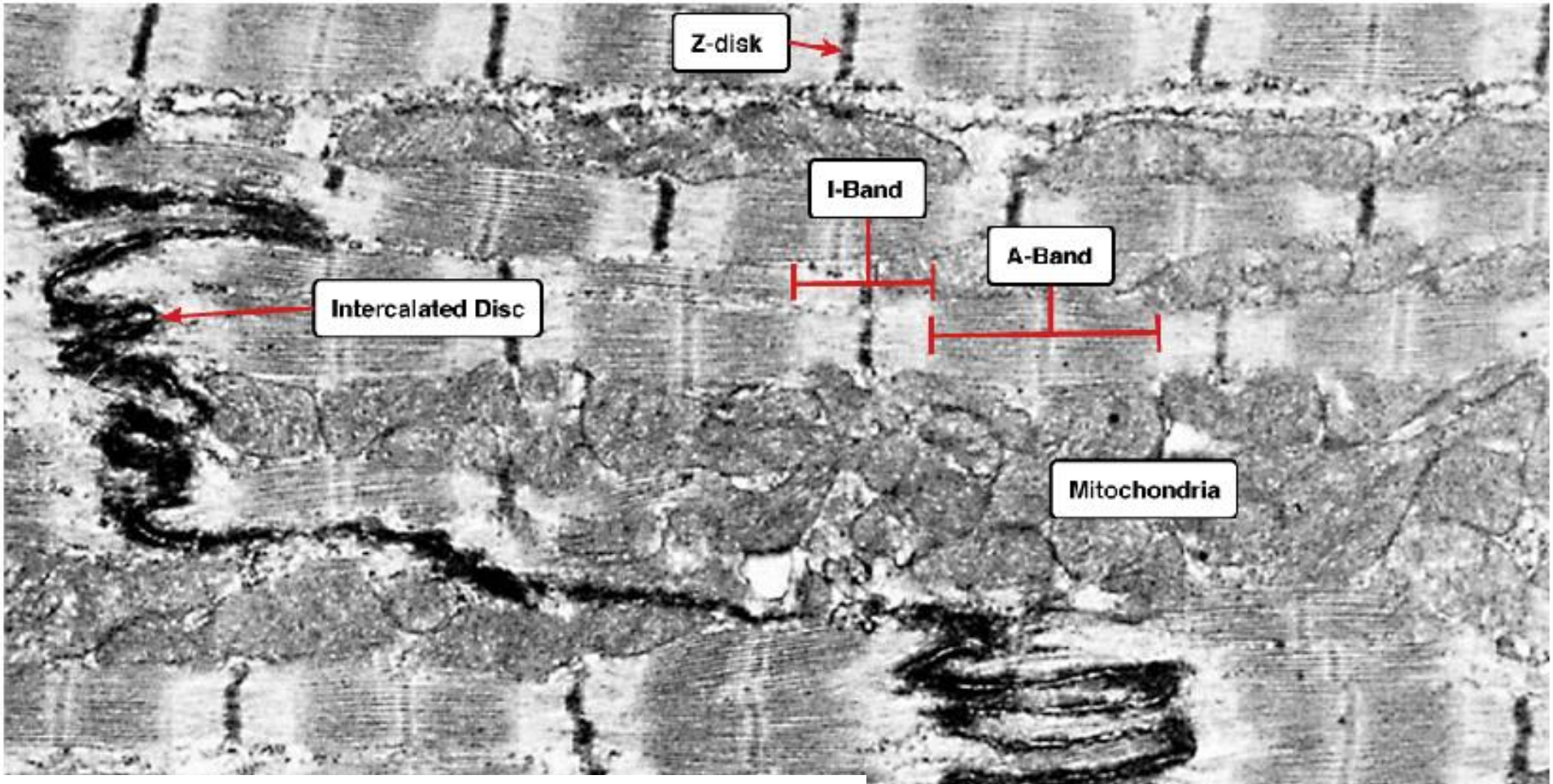
Smooth Muscle Cells

Smooth muscle fibers are long, spindle-shaped (fusiform) cells. Note the single and centrally placed nucleus in each smooth muscle cell. The absence of striation is also characteristic of the smooth muscle cell



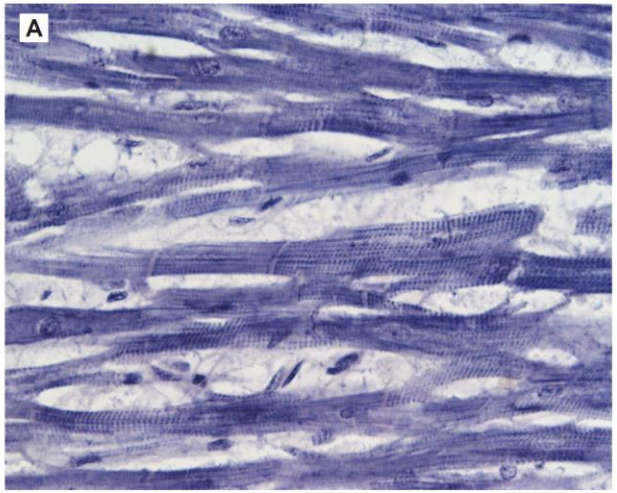
Cardiac Muscle Cells

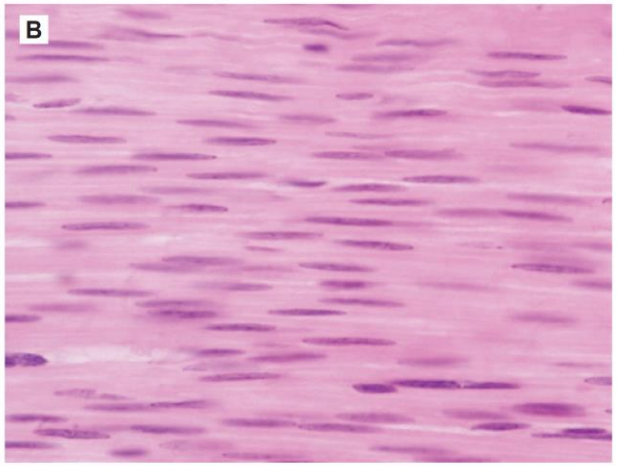
This is a high power view of cardiac muscle cells. Like smooth muscle, each cardiac muscle cell has a single (sometimes two) centrally located nucleus. Like skeletal muscle, cardiac muscle cells are striated due to a similar arrangement of contractile proteins. Unique to the cardiac muscle are a branching morphology and the presence of intercalated discs found between muscle fibres. The intercalated discs stain darkly and are oriented at right angles to the muscle fibres. Often seen as zigzagging bands cutting across the muscle fibres. In the intercellular spaces, note the supporting tissue with an extensive network of capillaries. The abundance of capillaries ensures adequate delivery of oxygen and nutrients to meet the high metabolic demands of cardiac cells

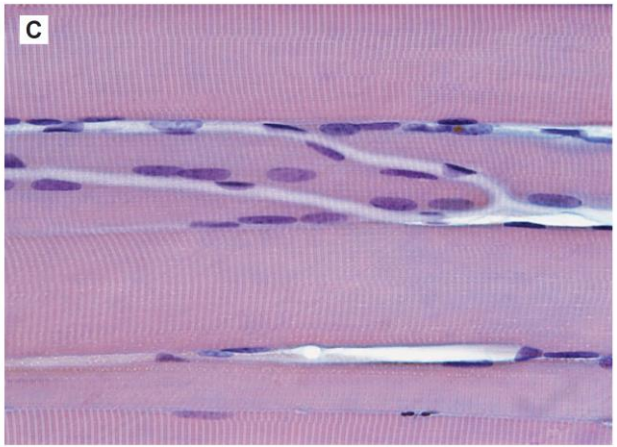


Cardiac Muscle Cell EM

In this EM image of a cardiac muscle cell note the same banding pattern to skeletal muscle cells. In cardiac muscle cells, myosin and actin filaments are organized into sarcomeres as in skeletal muscle cells. The dark-staining line is an intercalated disc that connects adjacent cardiac muscle cells.


A


B

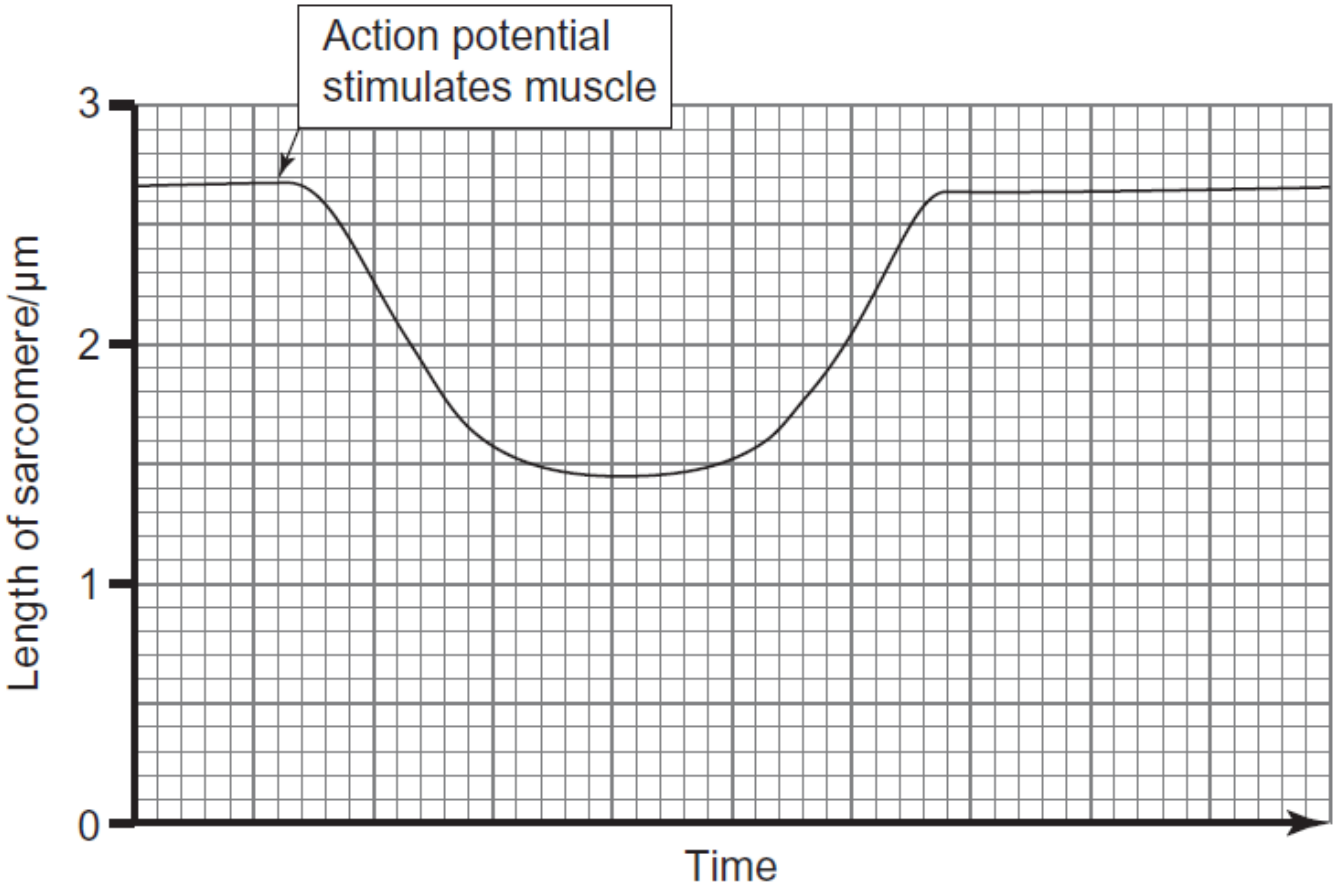

C

A cardiac muscle;
branching/intercalated discs/limited striation; [2]

B smooth muscle;
spindle-shaped cells/single nucleus/no striation; [2]

C skeletal/striated/voluntary muscle;
striation/multiple nuclei; [2]

(b) The graph below shows the length of a sarcomere during muscle contraction.



(i) Explain the role of calcium ions, myosin and actin in bringing about the changes in the length of the sarcomere, as shown in the graph opposite.

[3]

Any three from

- action potential causes calcium ions to (leave the sarcoplasmic reticulum and) enter the sarcoplasm/released
- causes myosin binding sites on actin to be exposed/allowing myosin heads to attach/actinomyosin complexes (cross bridges) form
- myosin heads rotate/rock back pulling actin over myosin
- reduction in calcium ions allows sarcomere to relax/lengthen [3]

(ii) The graph shows that a sarcomere will only shorten by a very small amount (approximately 1.2 μm) when it contracts. Explain how muscle tissue is able to contract many centimetres when stimulated.

[2]

Muscle (fibre) contains many sarcomeres arranged end to end; muscle contraction involves all sarcomeres (in row) contracting simultaneously/contraction is sum total of all sarcomeres; [2]

HOMEOSTASIS...

(b) The kidney and excretion

4.1.2 Understand the role of the mammalian kidney in excretion and osmoregulation:

- removal of toxic waste products of metabolism (urea, creatine);
- maintenance of optimal water potential of body fluids.

4.1.3 Understand the gross structure of the mammalian kidney/excretory system:

- recognise the cortex, medulla, pyramids, pelvis, ureters, bladder, urethra in photographs/diagrams.

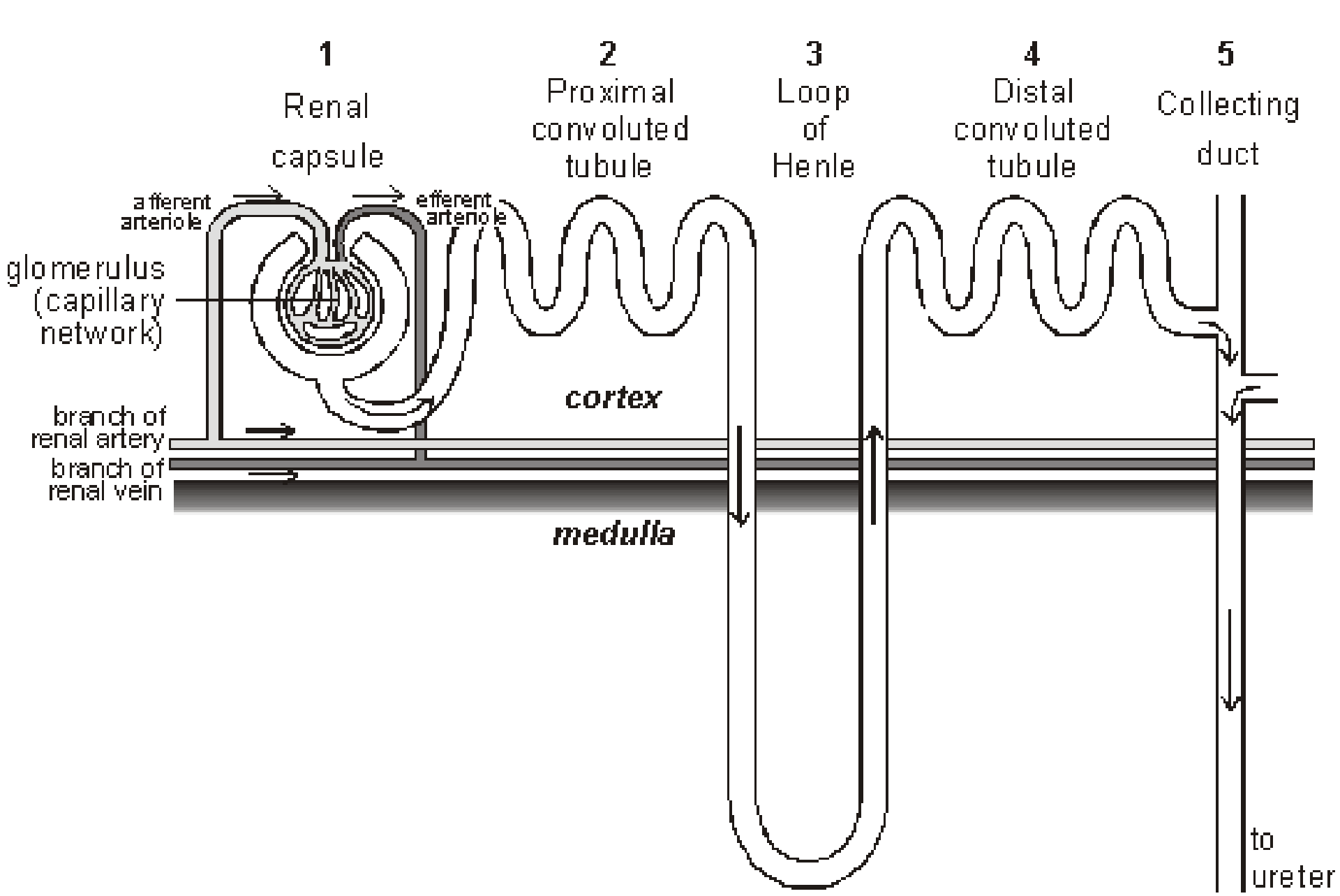
4.1.4 Describe the structure of the nephron:

- Bowman's capsule with podocytes;
- proximal convoluted tubule consisting of a cuboidal epithelium containing numerous mitochondria and with surface microvilli and basal invaginations;
- Loop of Henlé;
  - ascending limb with a cuboidal epithelium containing numerous mitochondria and which is impermeable to water
  - descending limb is permeable to water
- distal convoluted tubule and collecting duct consisting of a cuboidal epithelium.

4.1.5 Describe the structure of the filter:

- squamous endothelium of the blood capillaries in the glomerulus;
- basement membrane as the effective filter;
- podocytes in the wall of the Bowman's capsule.

Toxic substance secreted into the filtrate in the distal convoluted tubule from the blood (vasa recta capillary system)


1
Renal capsule
2
Proximal convoluted tubule
3
Loop of Henle
4
Distal convoluted tubule
5
Collecting duct
afferent arteriole
efferent arteriole
glomerulus (capillary network)
branch of renal artery
branch of renal vein
cortex
medulla
to ureter

4.1.6 Describe the mechanism of ultrafiltration:

- afferent arterioles are wider in diameter than efferent arterioles;
- high blood pressure within glomerular capillaries as the main driving force for filtration;
- osmotic gradient from the filtrate in the nephron into the glomerular capillaries opposes the blood pressure;
- resistance to further filtration due to back pressure of the filtrate in the nephron;
- appreciate which components of blood are commonly filtered and which are not and the reasons why.

4.1.7 Describe the mechanism of selective reabsorption:

- in the proximal convoluted tubule there is active transport of salt, glucose and amino acids from the filtrate into the cuboidal epithelium and then into the capillaries of the vasa recta system;
- lowering of the solute potential in the cuboidal epithelium and blood capillaries;
- resultant osmotic gradient responsible for the bulk of water reabsorbed;
- in the distal convoluted tubule/collecting ducts there is facultative reabsorption of water dependent on the permeability of the epithelial lining which, in turn, is dependent on the level of ADH in the blood.

Tip You should refresh your understanding of water potential, i.e. that it has the components solute potential and pressure potential ($\Psi = \Psi_s + \Psi_p$), that Ψ_s has a maximum value of zero, generally being negative, and that fluid moves from a region of high Ψ to a region of low Ψ.

Overall, the water potential of the glomerular plasma exceeds the water potential of the filtrate in the capsule. This is due to the large pressure potential (high hydrostatic pressure) within the glomerulus. This is, in part, opposed by a more negative solute potential within the plasma (in which the retained proteins act as solutes) than in the filtrate, while there is some resistance to further filtration due to back pressure of the filtrate in the nephron.

The net filtration force is the difference in water potential either side of the filter, i.e. water potential of glomerular plasma minus water potential of filtrate in the capsule. Net filtration force is calculated as follows:

Ψ_{plasma} = Ψ_s (due to proteins) + Ψ_p (hydrostatic pressure)
= (– 3.3 kPa) + 6 kPa
= 2.7 kPa

$\Psi_{filtrate}$ = Ψ_s (no proteins present) + Ψ_p (hydrostatic pressure)
= 0 – 1.3 kPa
= 1.3 kPa

Therefore the net filtration force = $\Psi_{plasma} - \Psi_{filtrate}$ = 1.4 kPa

Renal Corpuscle

This is an H&E-stained image of the glomerulus. Identify the squamous epithelial cells of the parietal layer. Note that the parietal layer is continuous with the cells of the proximal convoluted tubule and the epithelium changes from squamous to cuboidal. The cells of the proximal convoluted tubule also have fine brush border on their apical surfac

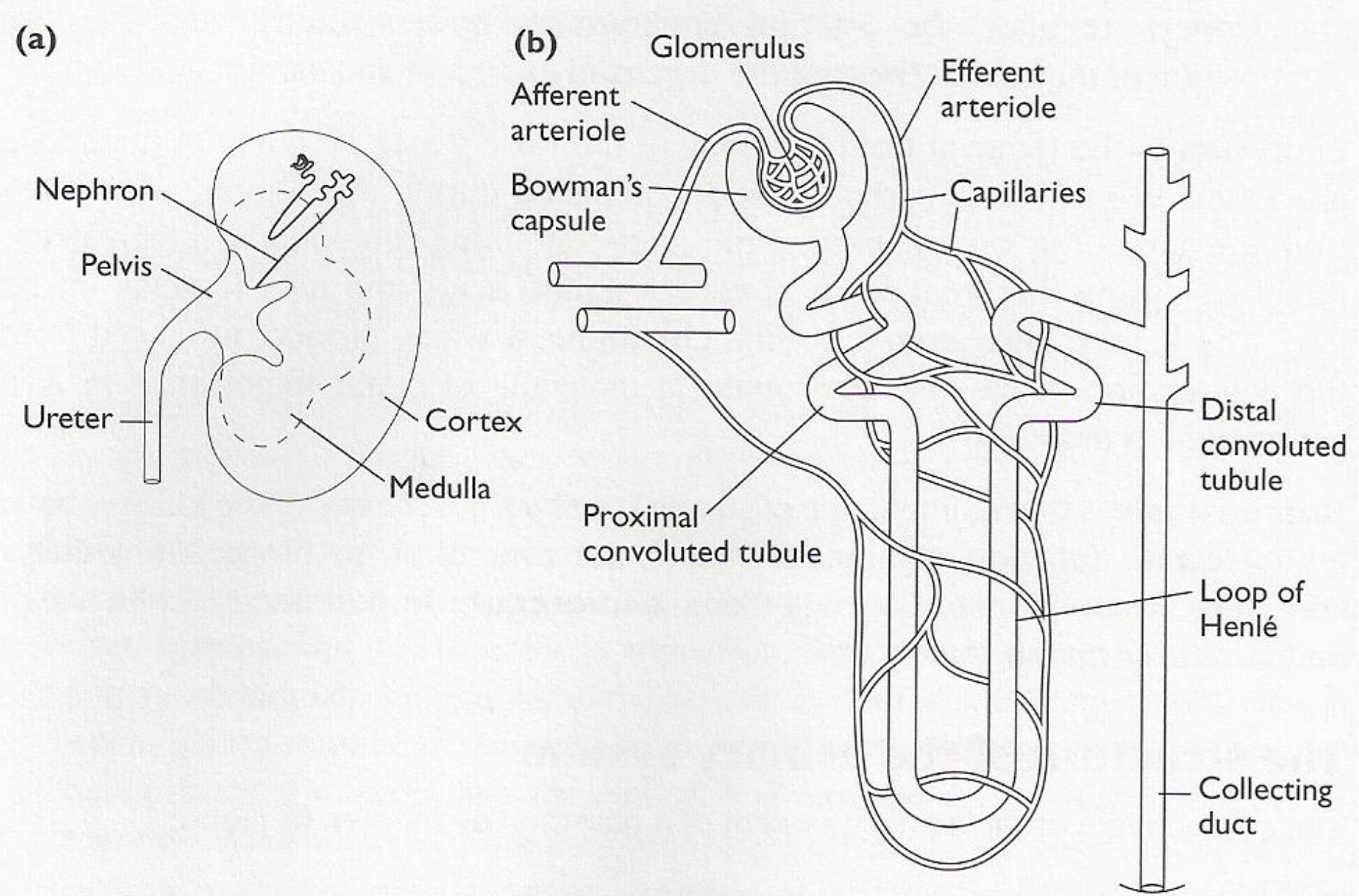
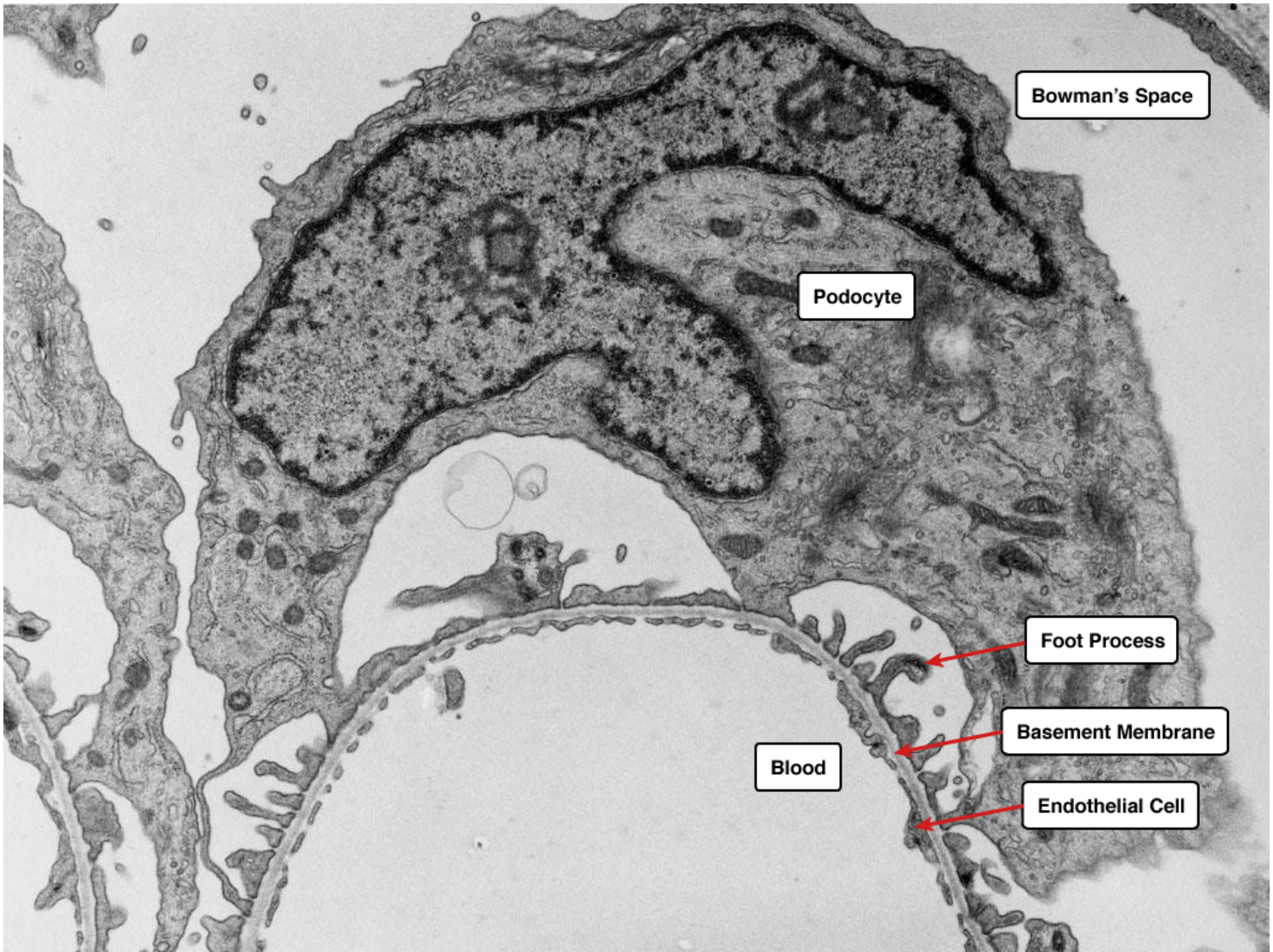
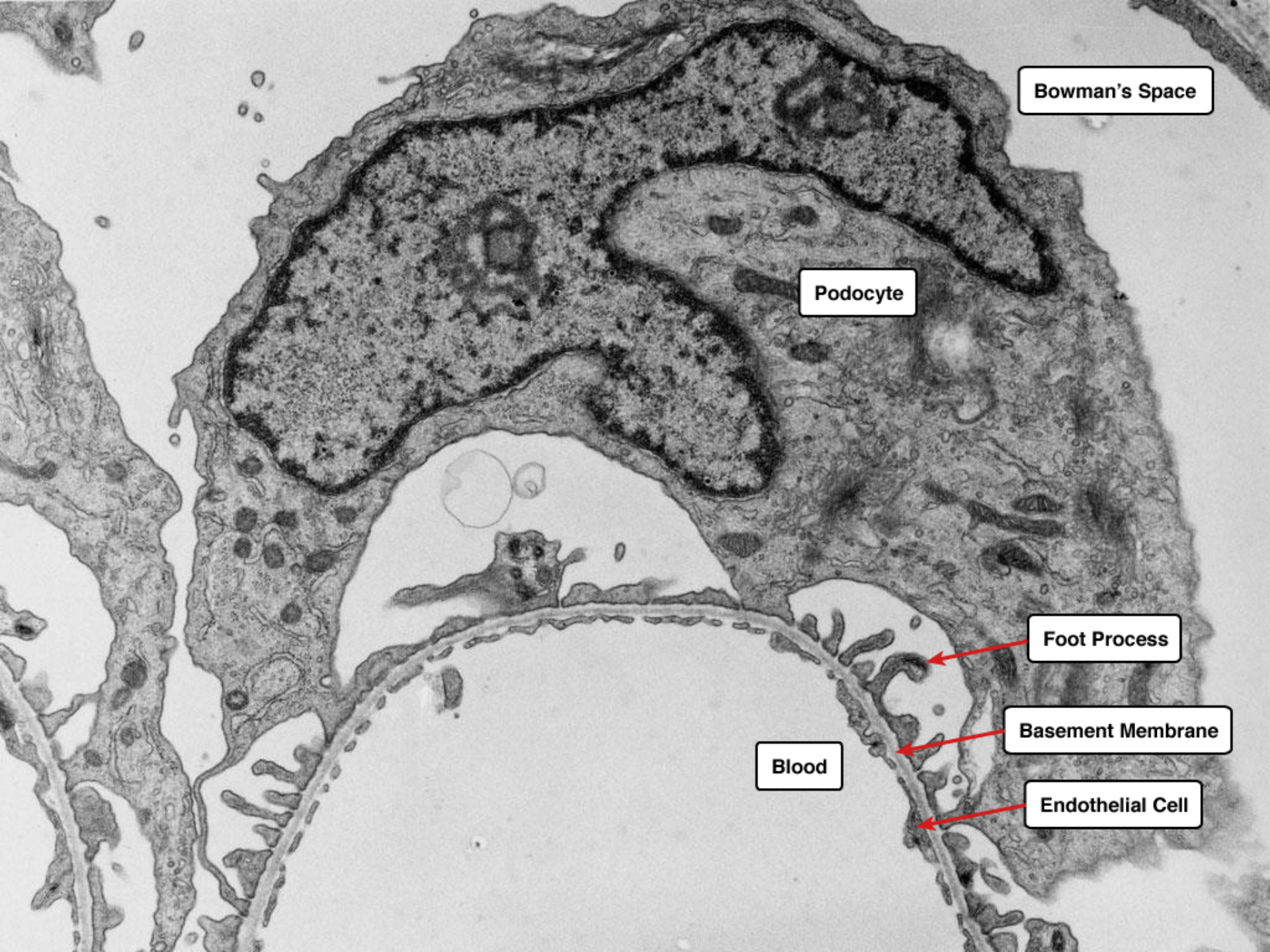


Figure 2 (a) Main regions of a kidney; (b) the nephron and its blood supply

Podocyte EM

Podocytes are specialized eptithelial cells that separate the network of capillaries in the glomerulus from Bowman's space. Podocytes extend processes that surround the capillaries. These processes form secondary processes called foot processes. The foot processes associate with the basement membrane opposite from the endothelial cells of the capillaries




Bowman's Space
Podocyte
Foot Process
Basement Membrane
Blood
Endothelial Cell

- Podocytes form a **large surface area** for the abosrption of the filtrate into the tubule of Bowman's capsule. Plasma goes through them and or through the slit pores

- Remember it is **the basement membrane which is the effective filter** i.e. prevents the loss of most proteins from the blood capillaries

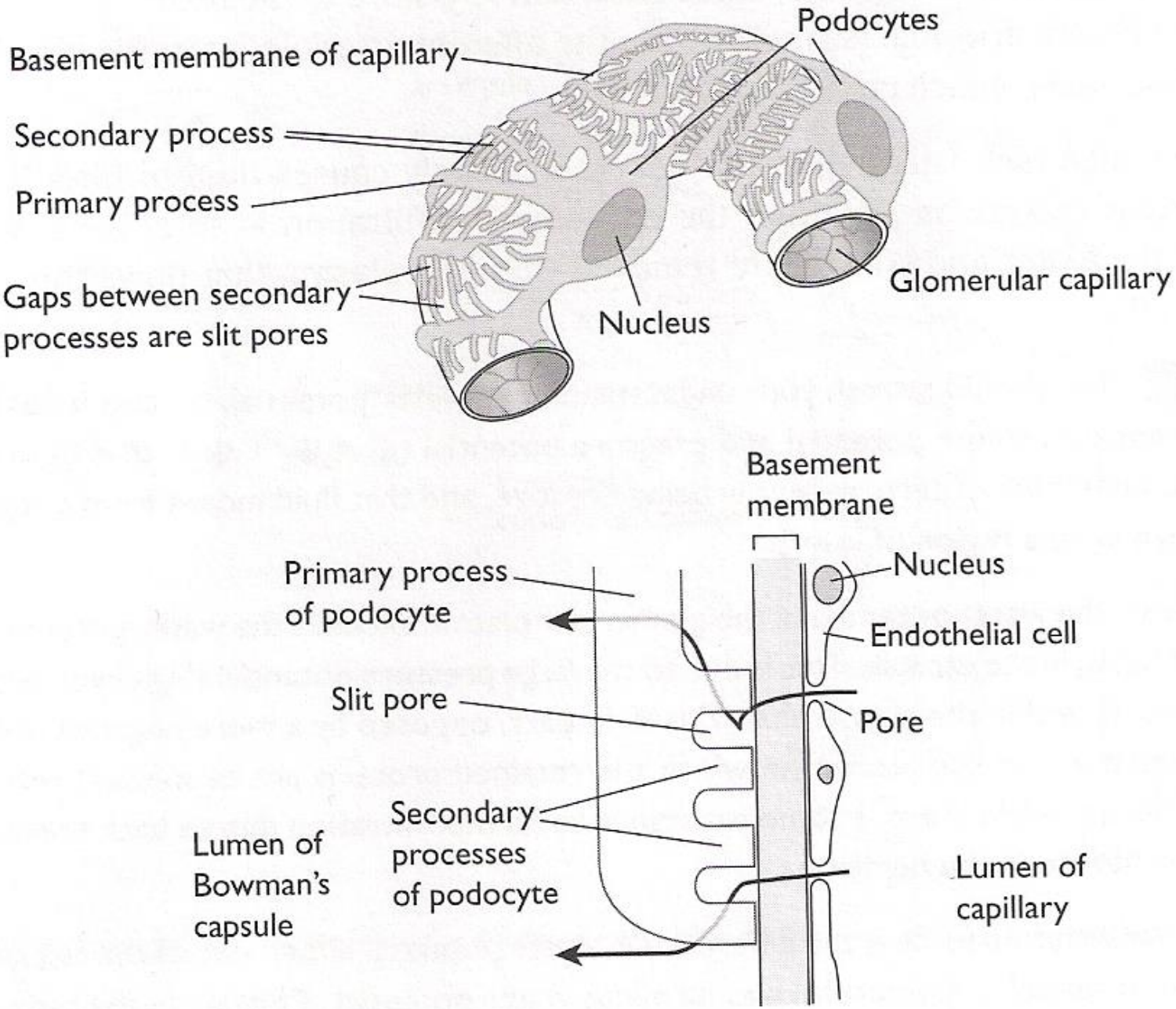
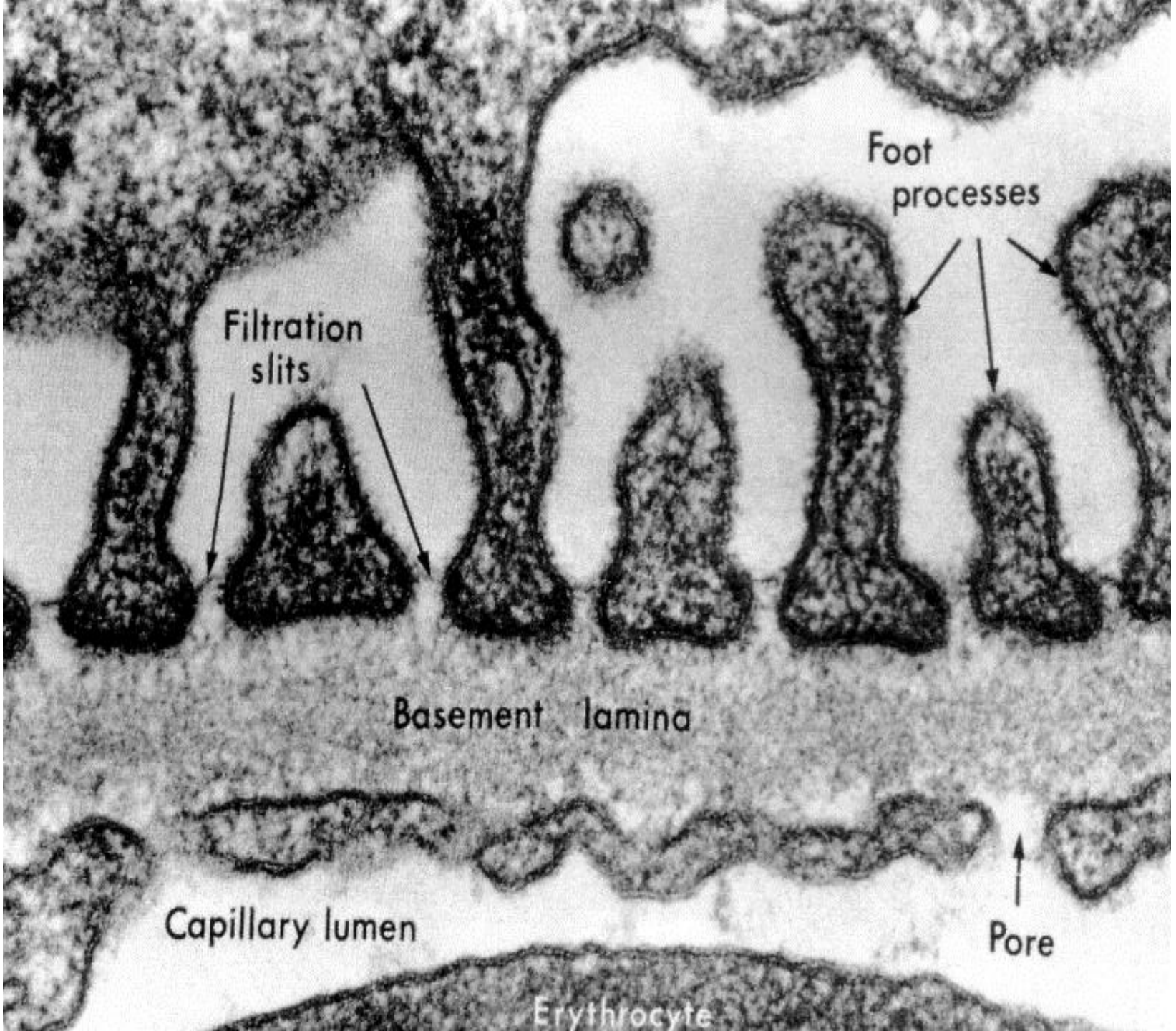
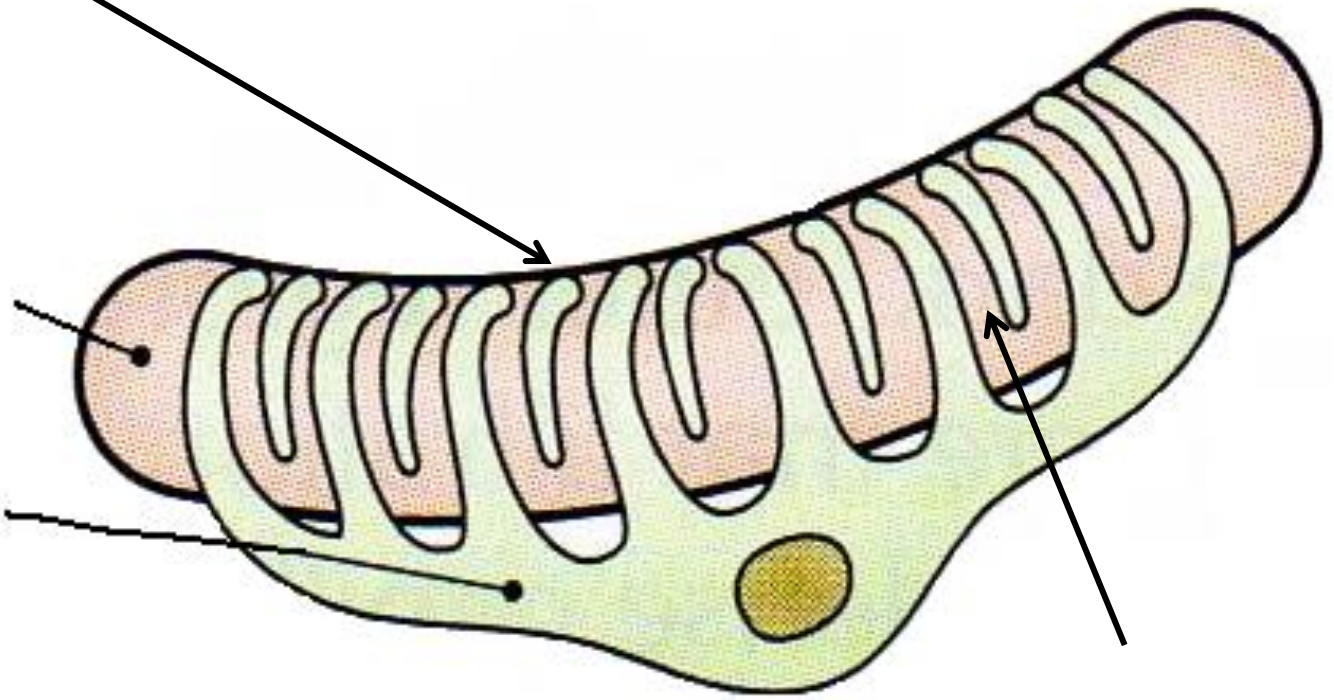


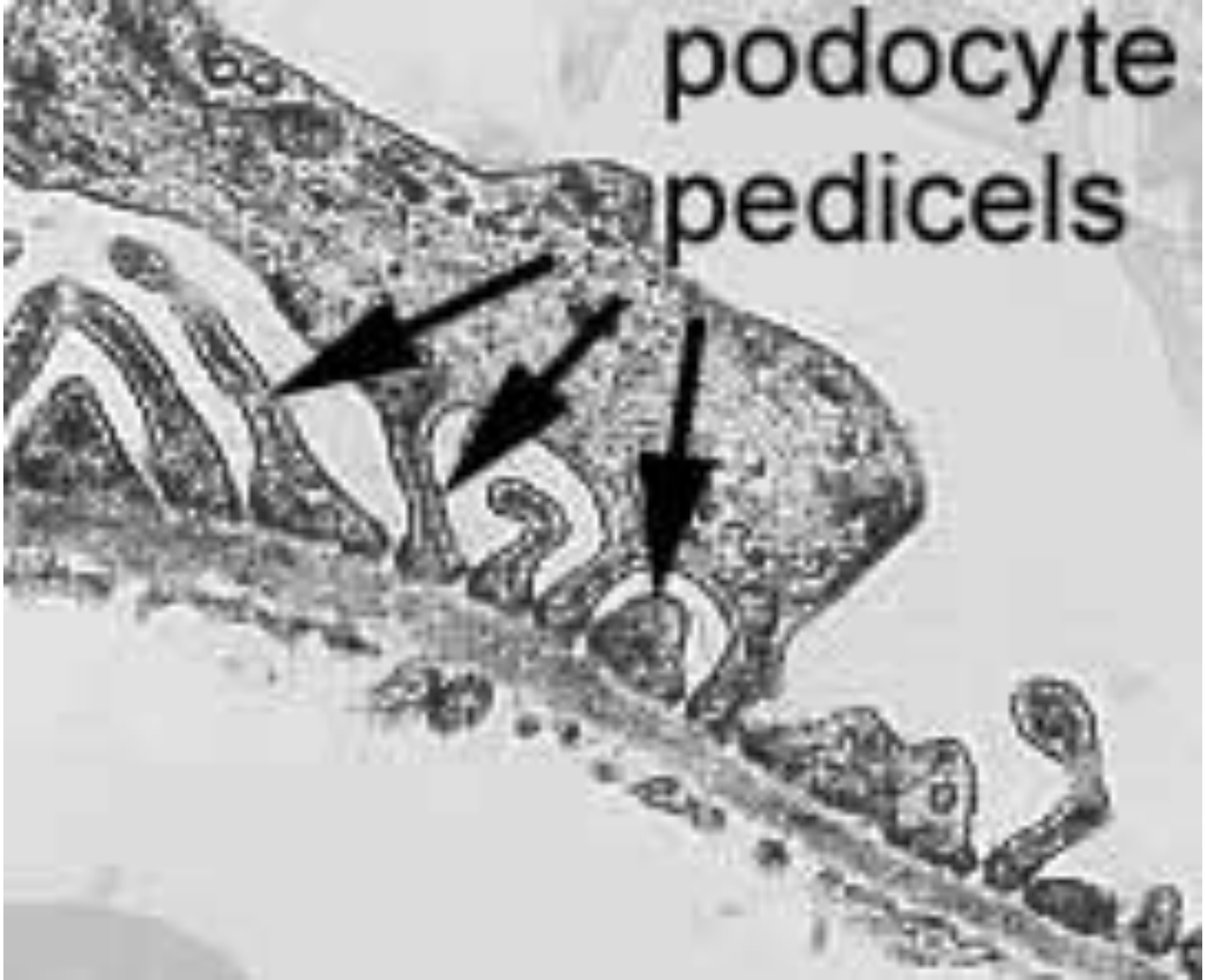
Figure 3 The structure of the filter

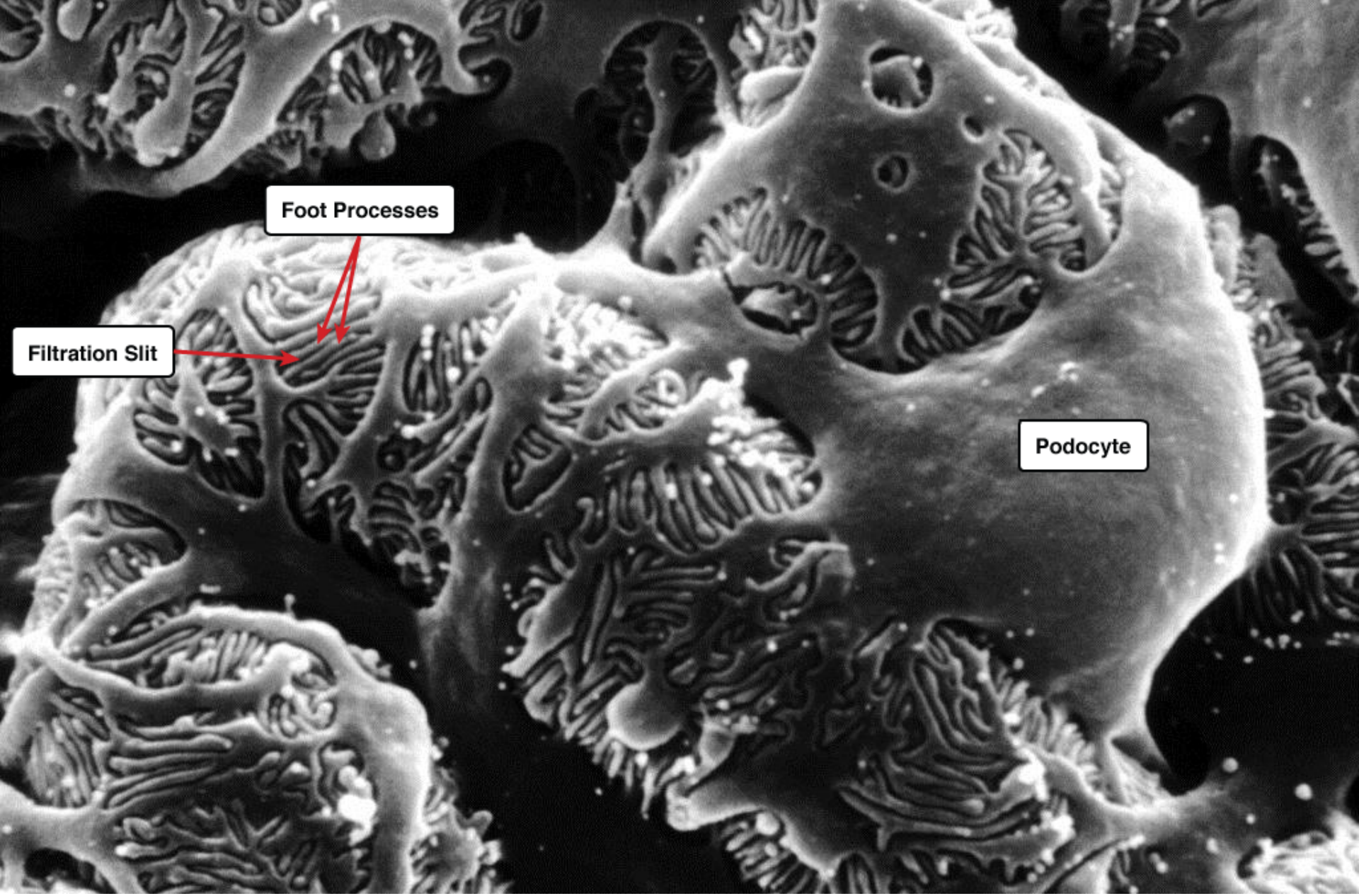

Foot
processes
Filtration
slits
Basement lamina
Capillary lumen
Pore
Erythrocyte

Podocyte foot processes increase the surface area for absorption



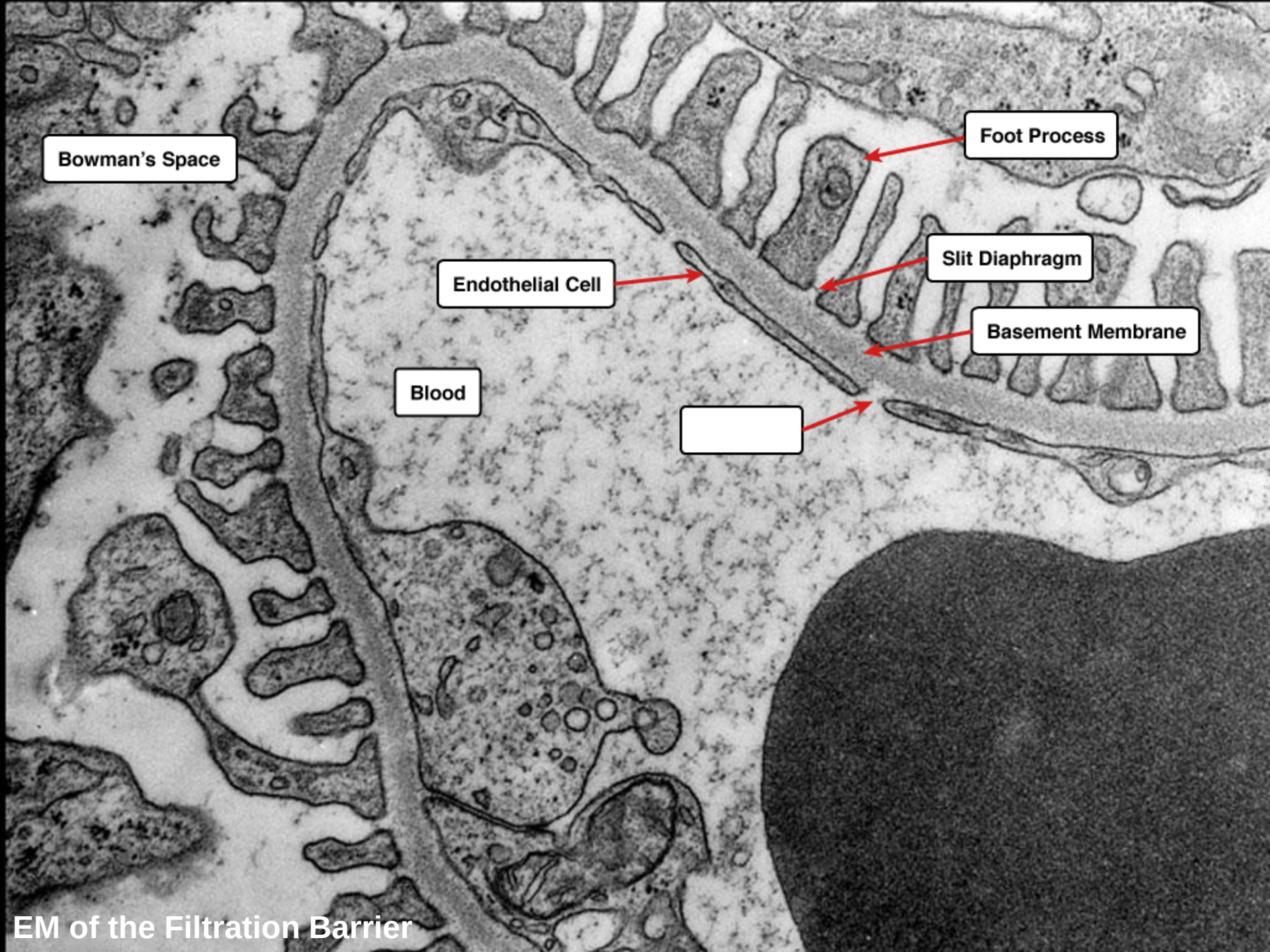
Use hair clasp to demo


podocyte
pedicels



Podocyte Scanning EM

The scanning EM demonstrates the branched structure of podocytes and how foot processes of adjacent podocytes interface to form filtration slits around a capillary



EM of the Filtration Barrier

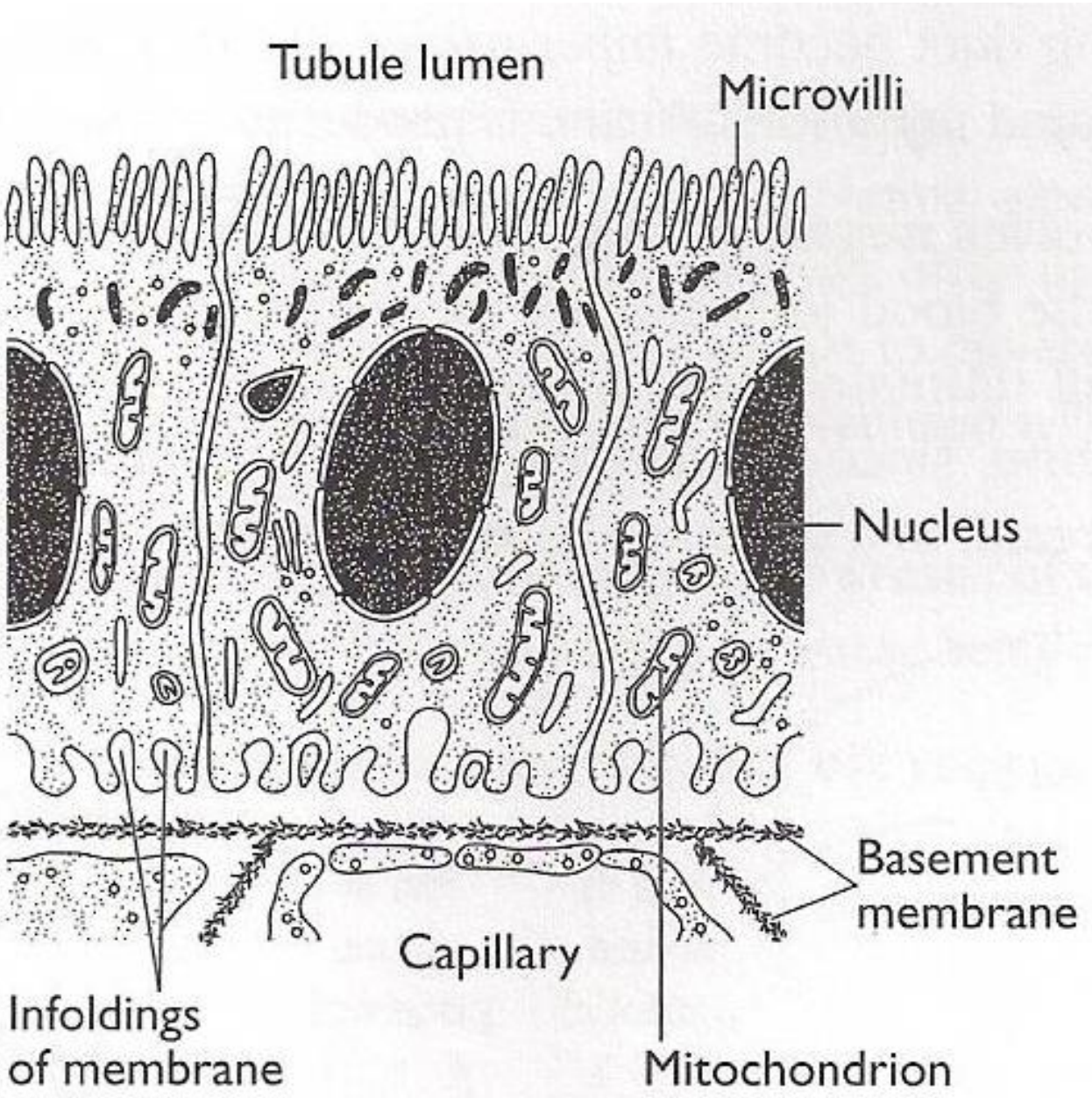
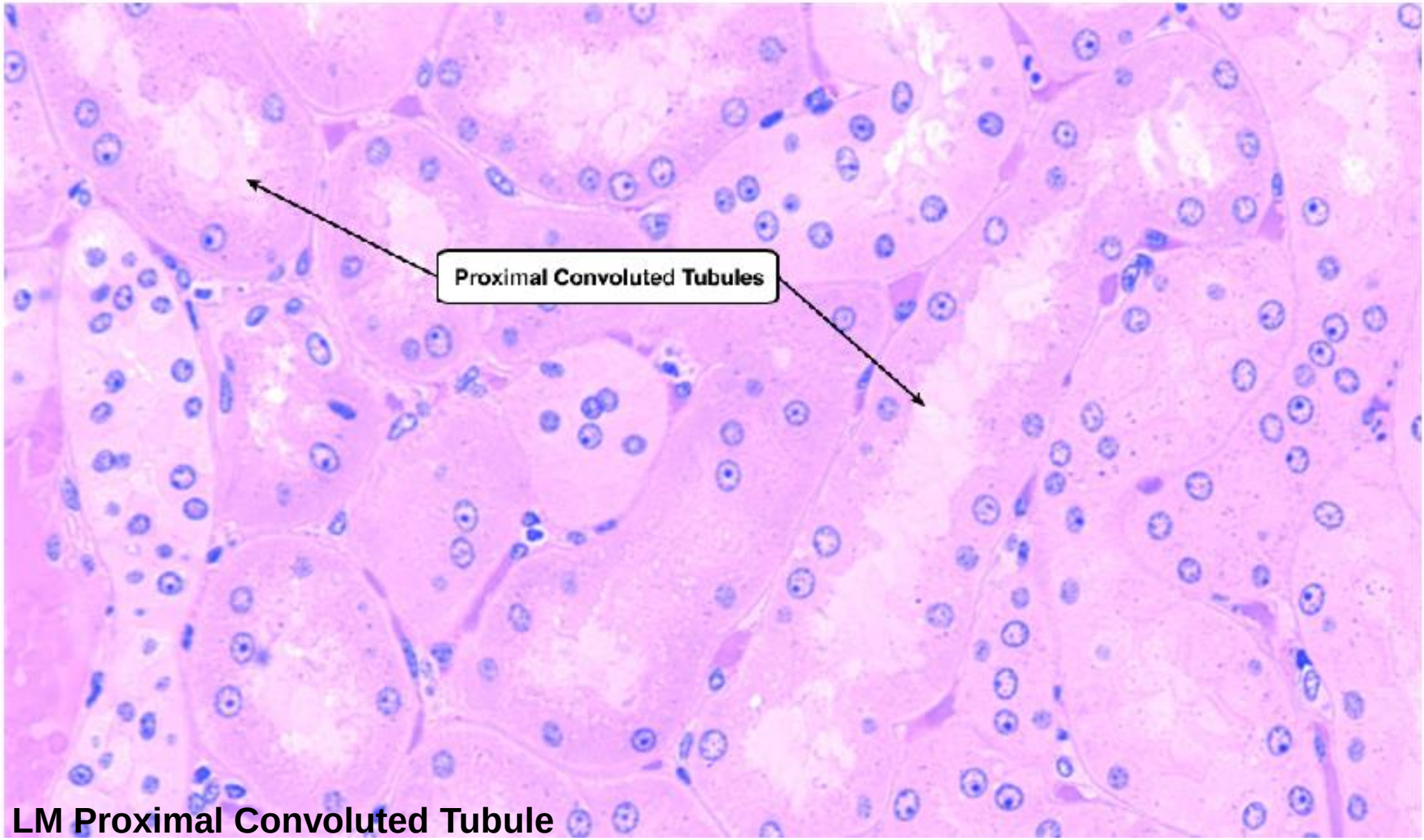


Figure 4 A proximal tubule cell



LM Proximal Convoluted Tubule

The proximal convoluted tubule is the site where majority (65%) of ions and water in the urinary space is reabsorbed back into the body. The cells are large so that in cross section not every nucleus will be visible, making it appear that the proximal convoluted tubule has fewer nuclei than other tubules. The cells also have an apical brush border to increase their surface area

Osmoregulation involves **negative feedback**: it is *feedback*, since a change in the water potential of the blood (detected by the osmoreceptors and determining the release of ADH) will ultimately lead to another change in the water potential of the blood; it is *negative*, since an increase in water potential (e.g. blood diluted by drinking) will later result in a decrease in water potential (see Figure 5).

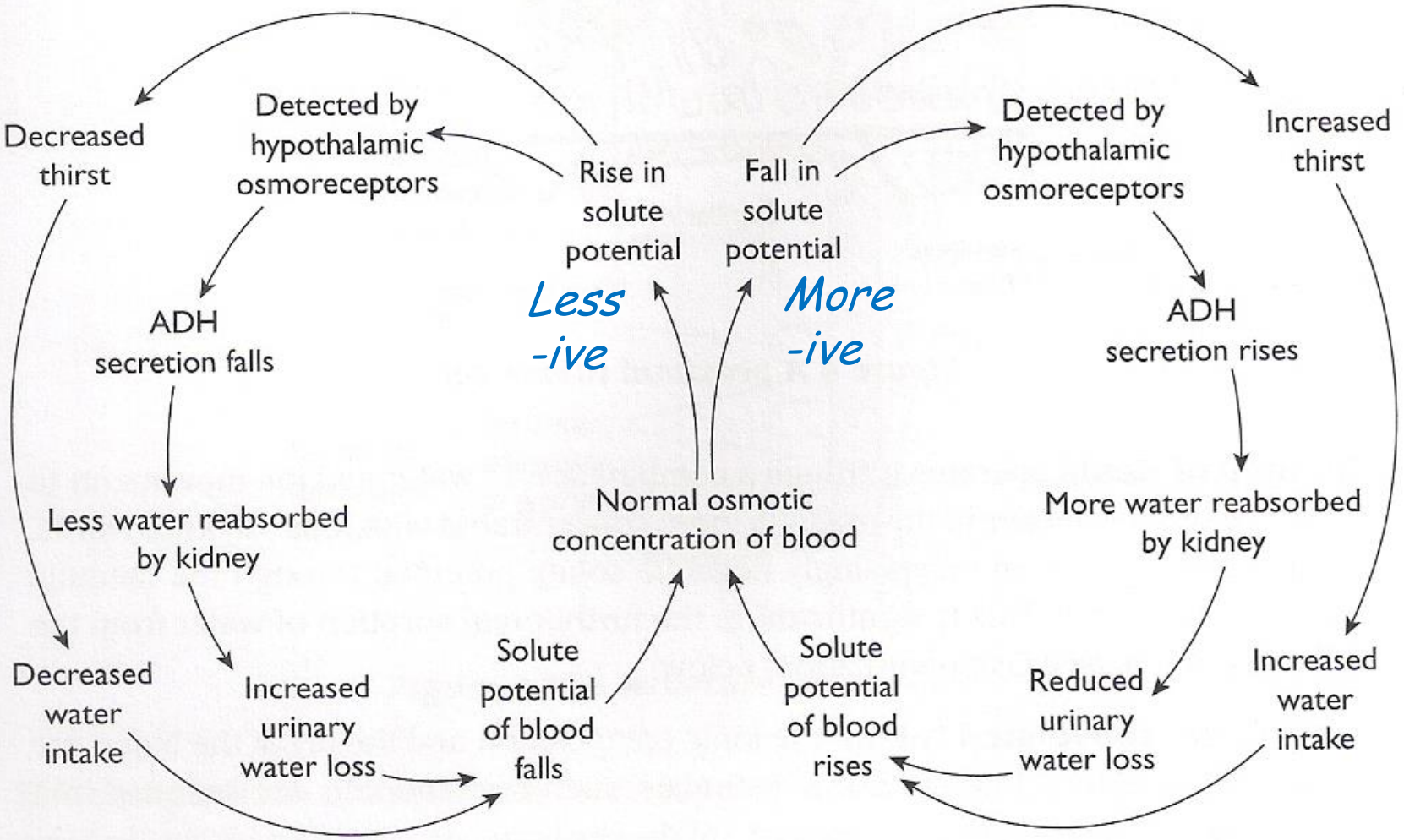
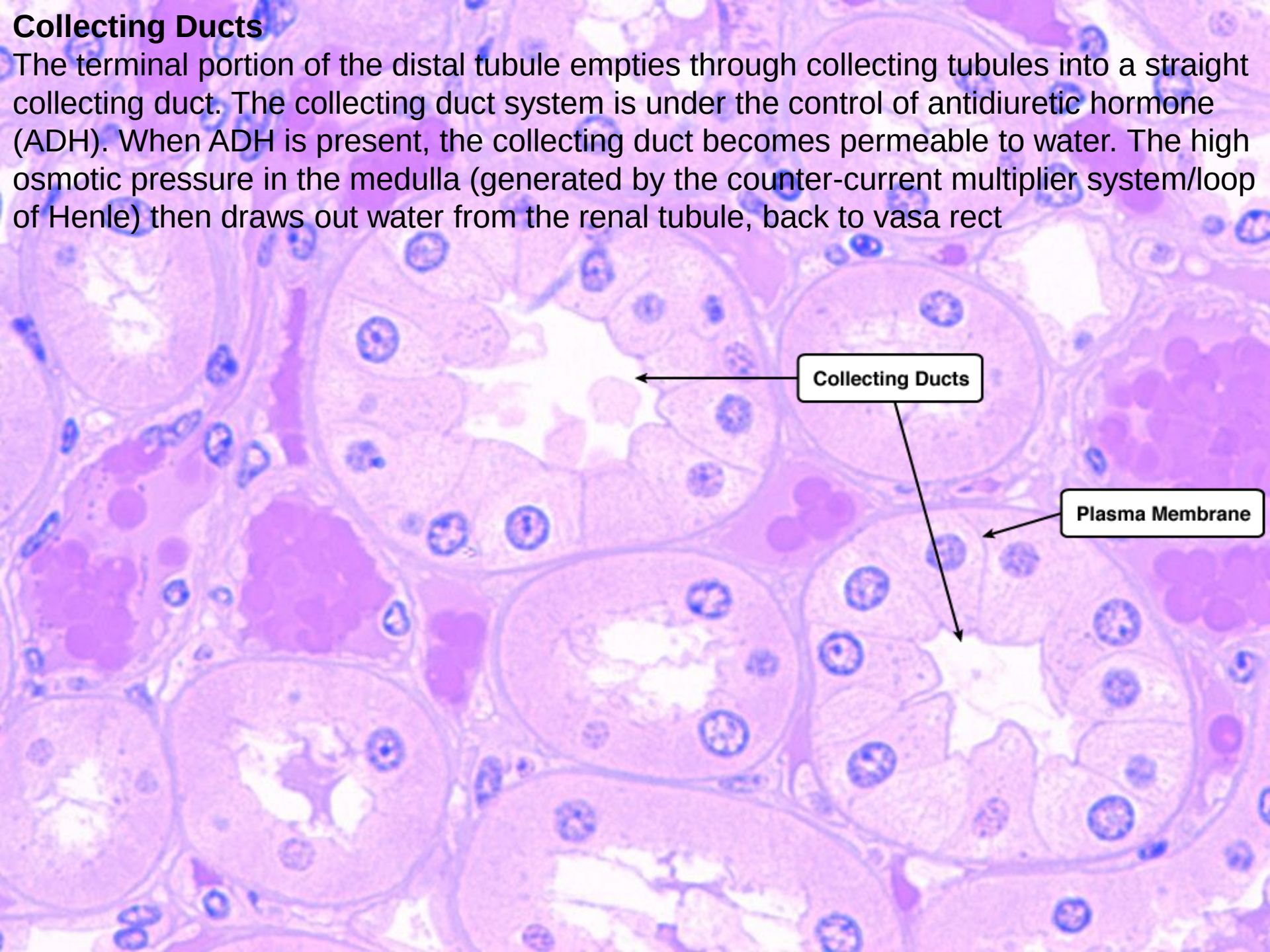


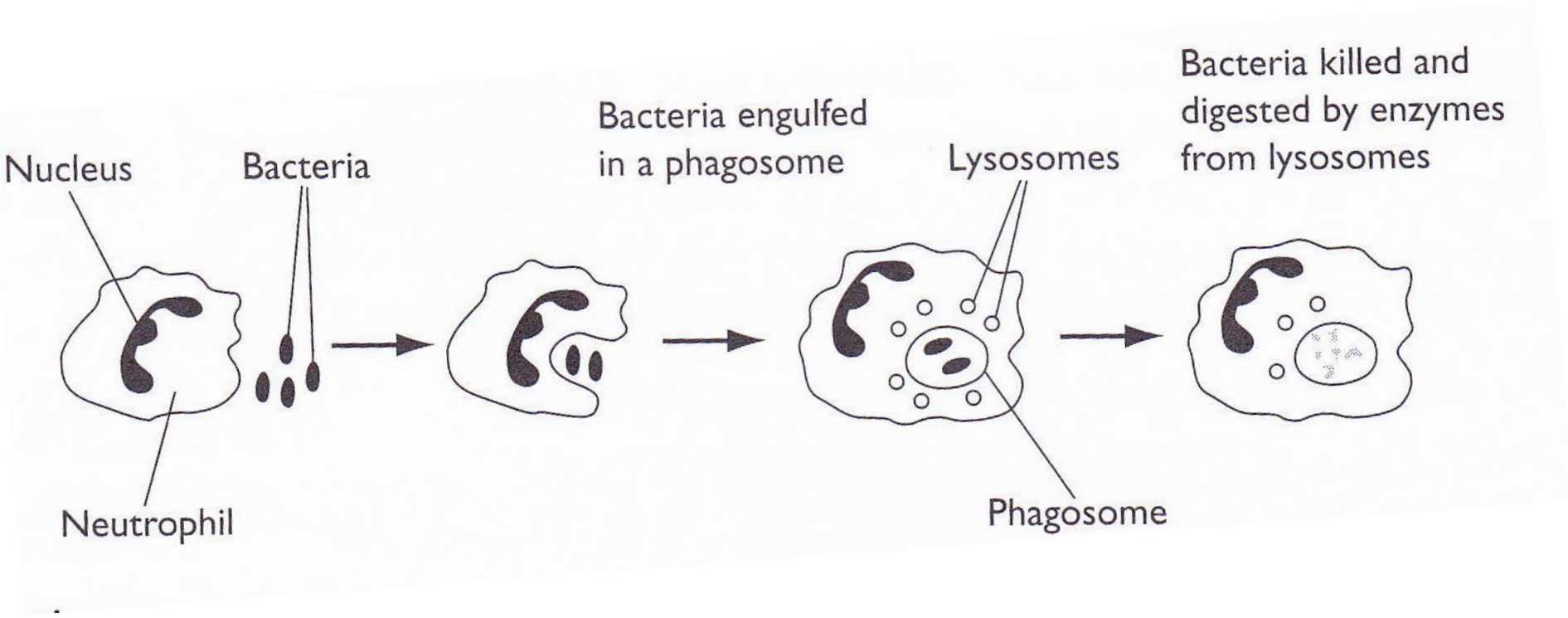
Figure 5 Osmoregulation as a negative feedback process

Collecting Ducts

The terminal portion of the distal tubule empties through collecting tubules into a straight collecting duct. The collecting duct system is under the control of antidiuretic hormone (ADH). When ADH is present, the collecting duct becomes permeable to water. The high osmotic pressure in the medulla (generated by the counter-current multiplier system/loop of Henle) then draws out water from the renal tubule, back to vasa rect

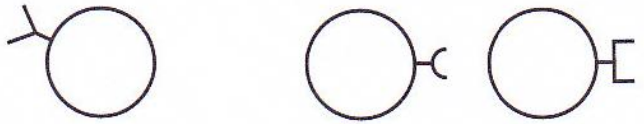


IMMUNITY...


Nucleus
Bacteria
Bacteria engulfed in a phagosome
Lysosomes
Bacteria killed and digested by enzymes from lysosomes
Neutrophil
Phagosome

1 Bacteria invade body — antigens on bacterial surface

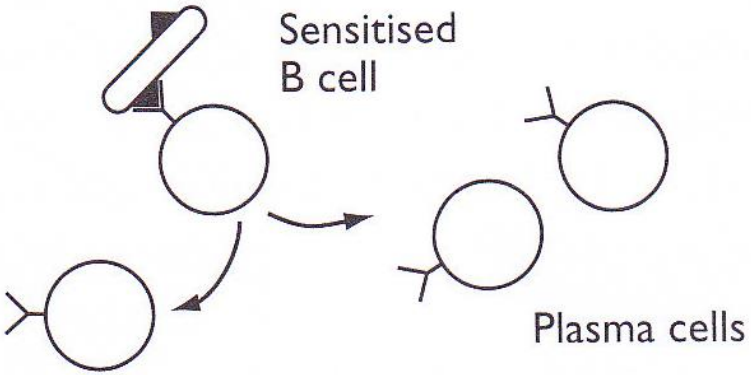
2 Bacterial antigen recognised by the correct B cell with the complementary receptor



Correct B cell

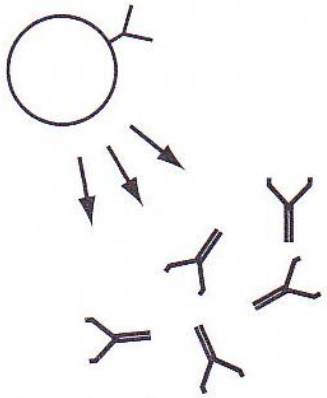
other B cells with different receptor sites

3 The sensitised B cell divides by mitosis to produce plasma cells and memory cells

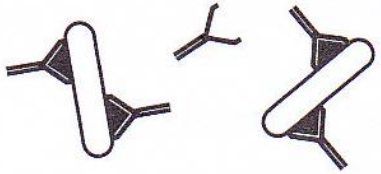


Memory B cell — remains in the body for a long time, providing immunity

4 Plasma cells produce antibodies, which destroy bacteria



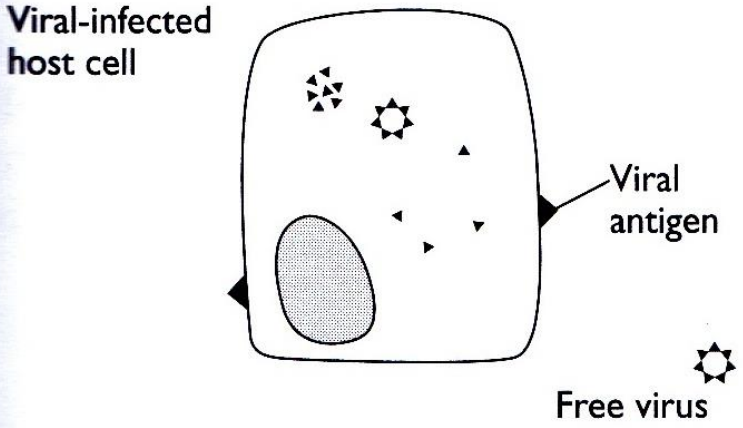
Antibodies



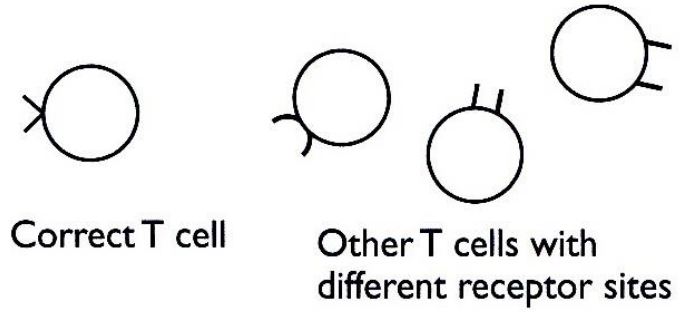
Antibodies destroy bacteria (e.g. causing cells to clump)

Figure 7 Antibody-mediated immunity

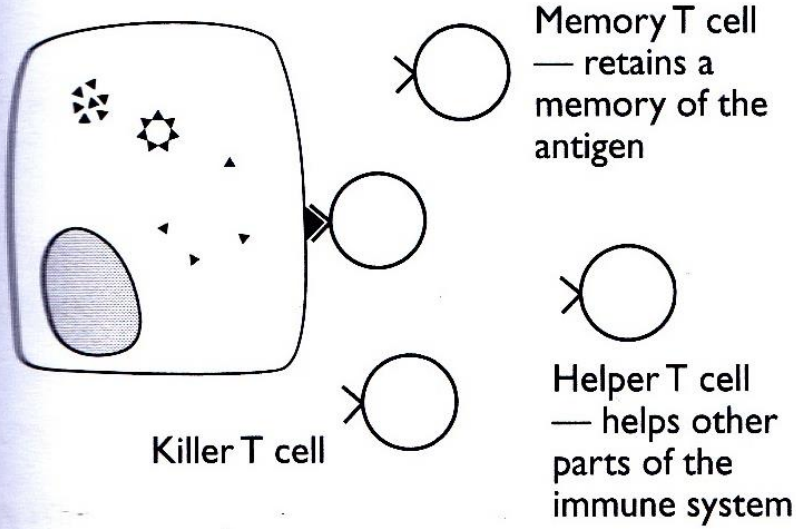
1 Host cell infected with viruses presents viral antigens on its surface membrane



2 The viral antigen is recognised by the correct T cell with the complementary receptor



3 The sensitised T cell divides by mitosis to produce different types of T cell



4 Killer T cells recognise infected cells and destroy them before viruses reproduce

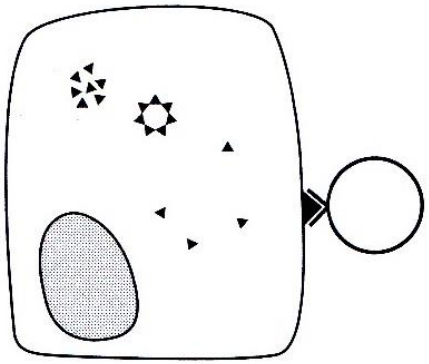


Figure 8 Cell-mediated immunity

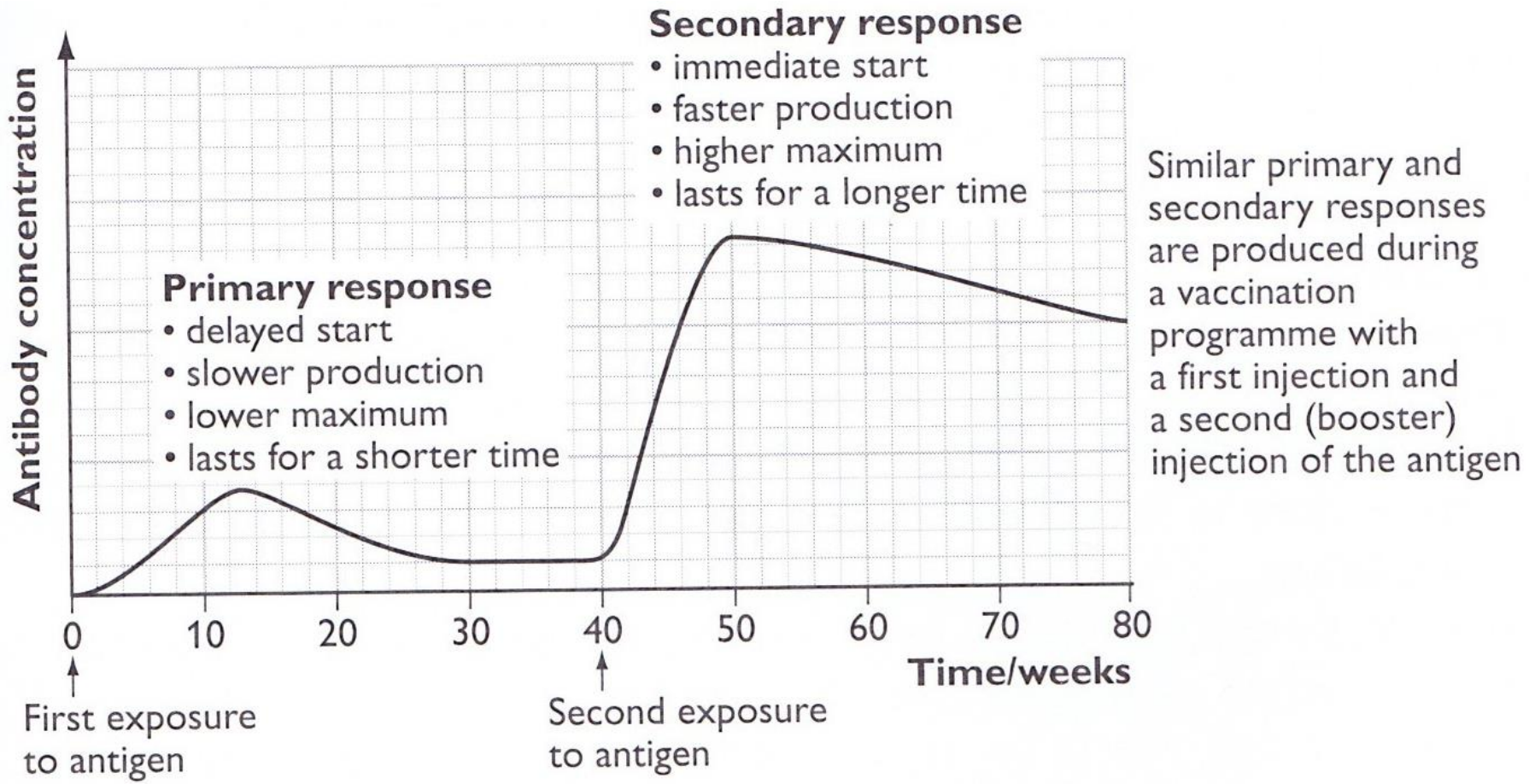


Figure 10 Changes in the concentration of antibodies within the primary and secondary responses during active immunity

Antibodies necessary for medical treatment of humans can be obtained from horses that have been given the appropriate vaccination. Serum (plasma minus the clotting factors) containing the required antibodies is subsequently extracted from the horse.

This method of providing passive immunity was used for many years but it had its limitations. It was difficult to produce enough antibodies to meet medical demand. Additionally, the horse serum contained many different types of antibodies rather than just the specific type required.

(b) Suggest **two** reasons why the horse serum contained many different types of antibody.

1. _____

_____

_____

2. _____

_____

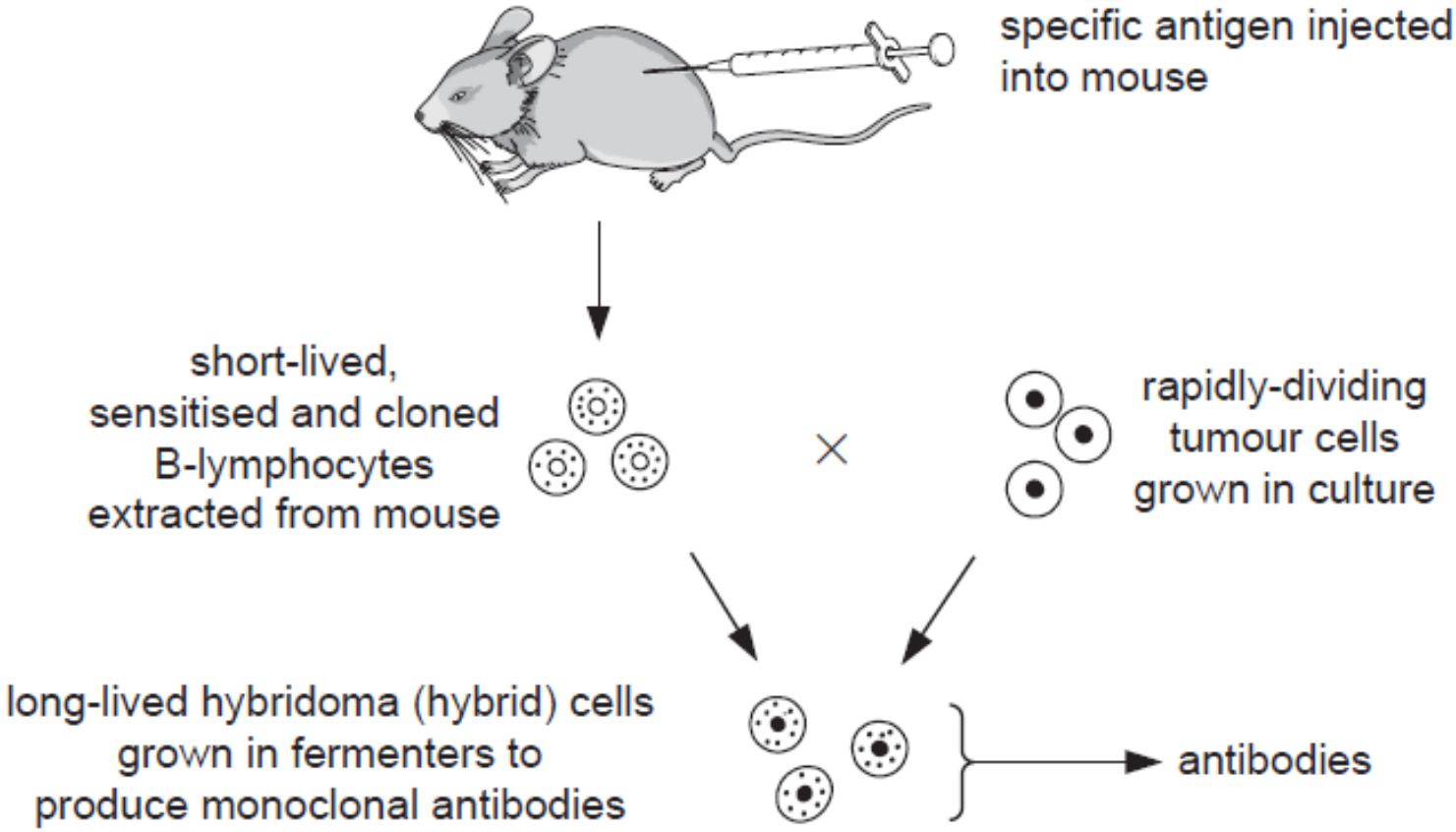
_____ [2]

(b) Any two from

- previous infection
- a microbe may possess different antigens
- different vaccines used previously
- other appropriate response

Monoclonal antibodies all bind to the same antigen and have come from identical parent cells – polyclonal antibodies have been produced by different b-cells and bind to the same antigen in different ways

(c) In 1975, Kohler and Milstein made a breakthrough in the production of antibodies for human use. They used B-lymphocytes from mice to produce a single type of antibody (a monoclonal antibody). The technique they used is outlined in the following diagram.



(i) Using the information provided, explain why only one type of antibody was produced.

(i) One type of antigen used in immunisation/sensitised (cloned) B-lymphocytes specific to antigen;

(ii) Suggest why Kohler and Milstein fused tumour cells with the B-lymphocytes.

(ii) Give long life qualities/rapid division to hybridoma cells;

(iii) Two advantages of this method are that animals such as the horse do not have to be used, while the antibodies produced are of a single type. Suggest **one** other advantage in producing antibodies by this method.

_____

_____ [1]

(iii) Antibodies produced in large quantities/faster production/meet medical needs/less risk of infection from animals/other appropriate suggestion; [1]

susceptible to infection.

4.2.8 Understand human blood antigens and the basis of blood group polymorphism:

- blood group specified by the antigen type present on the surface membrane of erythrocytes;
- four blood groups recognised in the ABO system (A, B, AB, O);
- individuals possessing a particular type of antigen cannot possess complementary antibody in their plasma;
- rhesus antigen (antigen D) may also occur on the surface membrane of erythrocytes;
- anti-rhesus antibodies do not naturally occur in any individual;
- production of anti-rhesus antibodies;
  - Transfusion error where a rhesus negative individual is given rhesus positive blood and the consequence thereof
  - a rhesus negative mother is exposed to the rhesus antigens of her rhesus positive baby and the consequences for that child and future children.

No one has the anti-D antibody naturally – although it can be made by Rh–ive people if they get Rh+ive blood

Other ways of grouping or classifying blood exist. The **Rhesus system** has two types, positive (Rh+ve) or negative (Rh-ve), according to whether or not a marker protein is present. People who are Rh+ve will, of course, not produce the Rh antibody (anti-D). However, people who are Rh-ve, whose blood has been contaminated by red blood cells with the Rh antigen, either during a blood transfusion or during labour, will produce anti-D. With respect to transfusions, a Rh-ve person can only safely receive Rh-ve blood, while a Rh+ve person can receive both types. However, there are *potential complications if a pregnant woman is Rh-ve and the baby is Rh+ve* (fetal blood cells may be forced across the placenta as a result of severe uterine contractions during delivery). Generally, the first Rh+ve baby is born before the Rh+ve mother produces the anti-D. However, any subsequent Rh+ve baby may receive anti-D from the mother, with the result that the baby's blood agglutinates. One possible way to eliminate the problem is to give the fetus several blood transfusions as it develops in the uterus. An alternative solution is to inject a Rh-ve mother with anti-D immediately after she has given birth to a Rh+ve baby; this injected anti-D will destroy fetal blood cells in the mother's body before the latter is sensitised to make its own antibodies.

4.2.10 Appreciate the consequences of transfusion incompatibility:

- formation of antigen/antibody complexes resulting in agglutination of erythrocytes;
- potential for blockage of the blood/O_2 supply to a tissue and the consequence thereof.

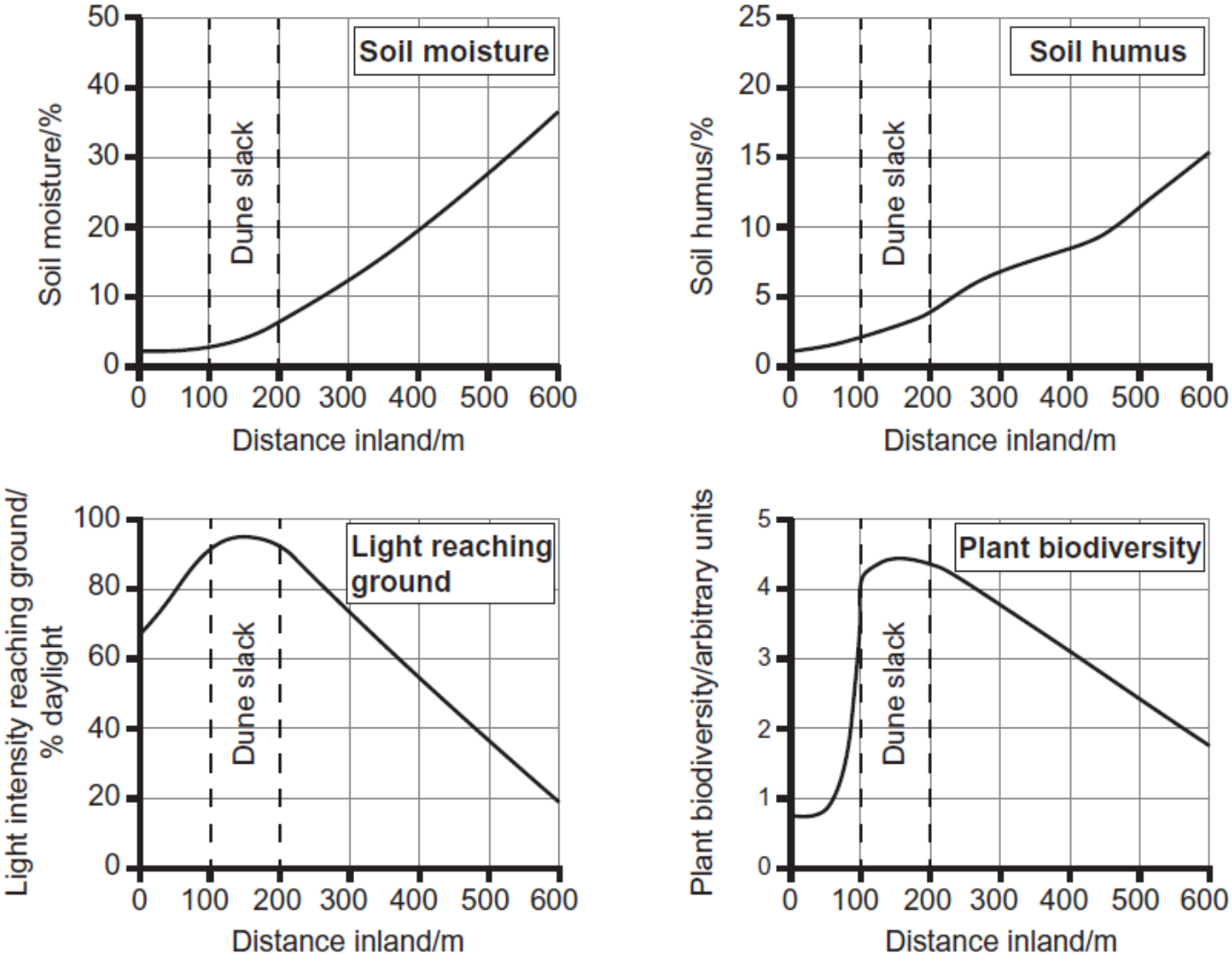
ECOLOGY - To include:

Succession

Nutrient cycling

Human effects on the environment

(b) In an ecological investigation of a sand dune system the following data was obtained.



(i) Using the information provided, describe and explain the change in plant biodiversity across the sand dune system. [5]

(i) Low biodiversity in young dunes/near sea, increases to maximum in dune slack and falls further inland;

Any four from

- in young dunes soil moisture/humus levels too low to support most plants (will only support specialist plants, e.g. marram)
- in dune slack high light levels and rising soil moisture/humus levels will support greater variety on plant species
- in dune slacks little marram grass to provide shade/most plants are ground-hugging
- some plants may be nitrogen-fixing (in nutrient-poor soil)
- the older more stable dunes allows the establishment of shrubs (plants with longer life cycles/K-strategists)
- (due to) high humus/high moisture levels
- the shrubs/species in older dunes (heather, bracken, gorse) reduce light levels reaching the ground
- reducing biodiversity in ground layer/only allowing mosses to grow in ground layer
- other appropriate response [5]

(ii) When carrying out this investigation, it was important that the data was gathered within a reasonably short time frame (i.e. a few hours). Suggest **two** reasons for this.

1. _____

_____

2. _____

_____ [2]

(ii) Any two from

- angle of sun will change (affecting amount of light reaching ground layer)/light levels change during the day
- rain may increase soil moisture levels/sun may reduce soil moisture
- other appropriate response, e.g. grazing effects [2]

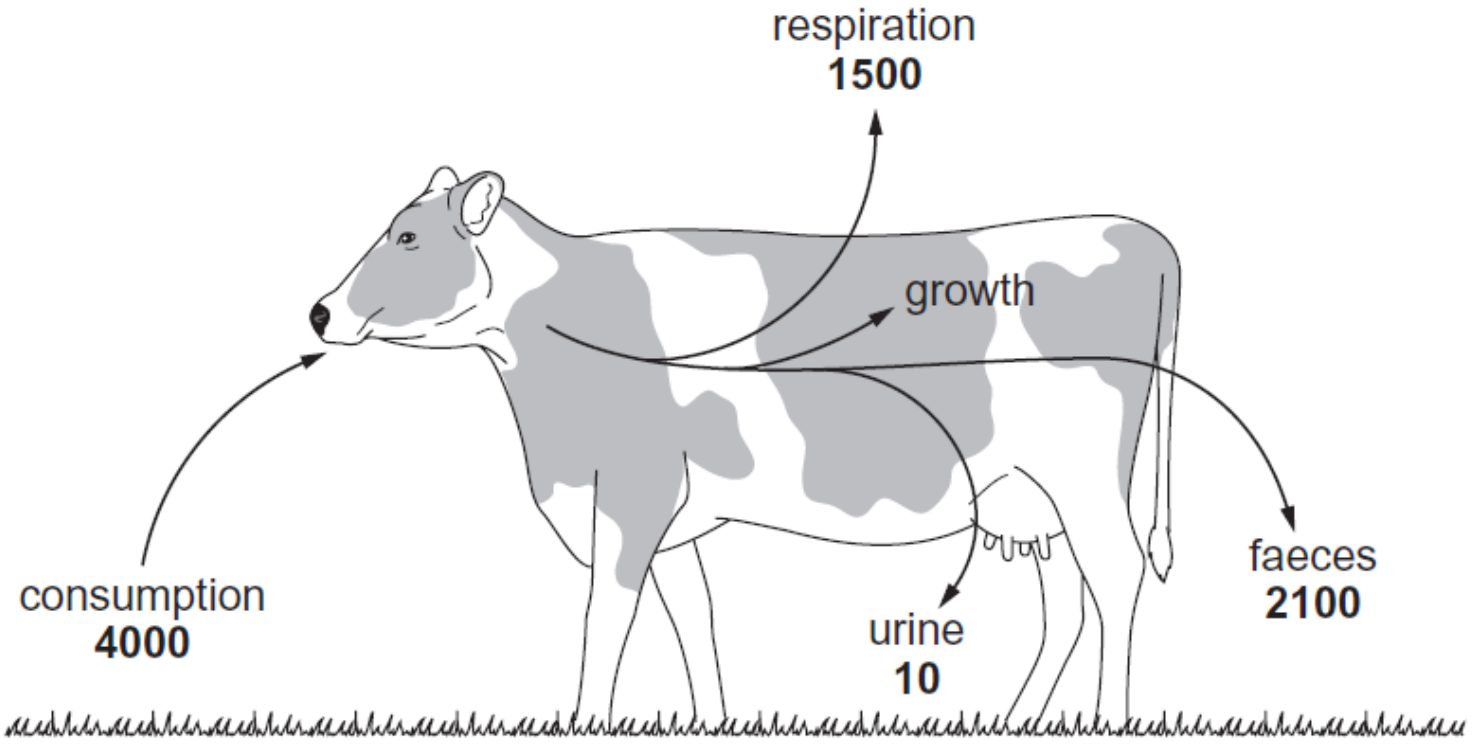
(d) (i) Explain why both a sand dune and a quarry succession can be regarded as a primary succession.

_____

_____ [1]

(i) Both develop on bare rock/land that has not been colonised before; [1]

2 **(a)** The diagram below shows part of the energy budget of a cow grazing in a field. Figures are in $kJ\,m^{-2}\,year^{-1}$.



(i) Calculate the percentage of energy consumed that is available for the growth of the cow.
(Show your working.)

(a) (i) 390 kJ m^{-2} $year^{-1}$;

9.75%; **[consequential to figure above]**

(ii) In terms of energy loss, explain the reason for the high values shown for respiration and faeces in the cow.

Respiration _____

_____

_____

Faeces _____

_____

_____ [2]

(ii) Respiration – cows/mammals are endotherms/high levels of respiration needed to maintain body temperature above surroundings;
Faeces – cellulose in grass difficult to digest; [2]

(b) One method of increasing the efficiency of energy transfer in livestock is to confine the animals in small enclosed areas.

(i) State **two** ways that confining livestock in small enclosed areas can increase the efficiency of energy transfer.

1. _____

_____

_____

2. _____

_____

_____ [2]

(ii) Apart from ethical considerations, give **one** argument against the practice of confining animals in small enclosed areas in intensive farming.

_____ [1]

(b) (i) Any two from

- respiratory/energy losses reduced as less used in movement
- large number of animals in close proximity increase ambient temperature thus reducing heat loss/warmer temperature indoors than outdoors
- more efficient grazing of confined area/allows grass in other areas to recover (become more nutritious) [2]

(ii) Disease spread more readily/animals more likely to develop bone or joint injury/grass too heavily grazed causing damage/other appropriate response (e.g. crowding causes stress so reducing meat quality); [1]

(c) Ecological energetics	4.4.10 Understand food chains and food webs: • the role of producers and consumers (herbivores and carnivores) in grazing food chains and, additionally, the role of detritivores and decomposers in detritus food chains. 4.4.11 Understand trophic levels: • primary producers as the first trophic level; • net primary production as the gross primary production less respiration; • other trophic levels to include primary, secondary and tertiary consumers, and detritivores and decomposers.

REMEMBER:

- A grazing food chain starts with living plants fed on by herbivores then carnivores
- A detritus food chain starts with dead organic matter fed on by detrivores and decomposers

An ecological niche is the functional position of an organism in its environment (e.g. how and when it obtains its resources)

Remember the principle that no two species can share the same ecological niche

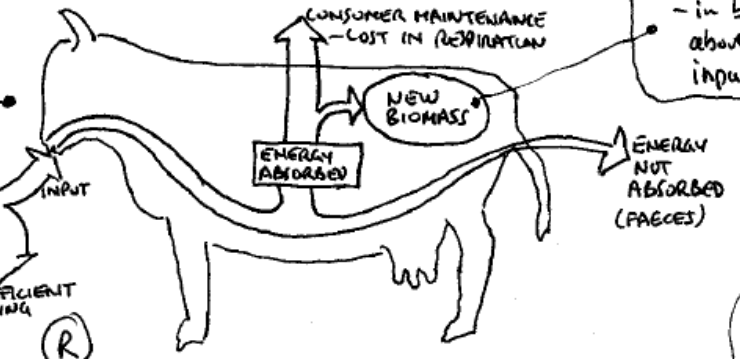
(c)	**Ecological energetics (cont.)**	4.4.12 Understand the quantitative relationship between trophic levels: • pyramid relationships and their relative usefulness; - pyramids of numbers - pyramids of biomass - pyramids of energy (productivity) • calculation of the efficiency of energy transfer through trophic levels; • reasons for the low percentage of solar radiation absorbed by plants in photosynthesis; • reasons for the reduction in energy at progressive trophic levels; - losses to the decomposer food chain - losses through egestion and excretion - the difficulty of digesting plant material (eg cellulose) and the relatively high losses via egestion in primary consumers (herbivores) - losses through respiration (with energy dissipated as heat) - the relatively high losses via respiration in endotherms (mammals and birds). 4.4.13 appreciate the implications for agriculture: • extra energy cost of producing animal products; • aspects of intensive farming methods to include; - the use of fertilisers to increase primary productivity - confinement to improve respiration/production ratio - the use of high energy foods such as silage and high protein foods.

REVISION SHEET 1.6

ENERGY FLOW IN ECOSYSTEMS

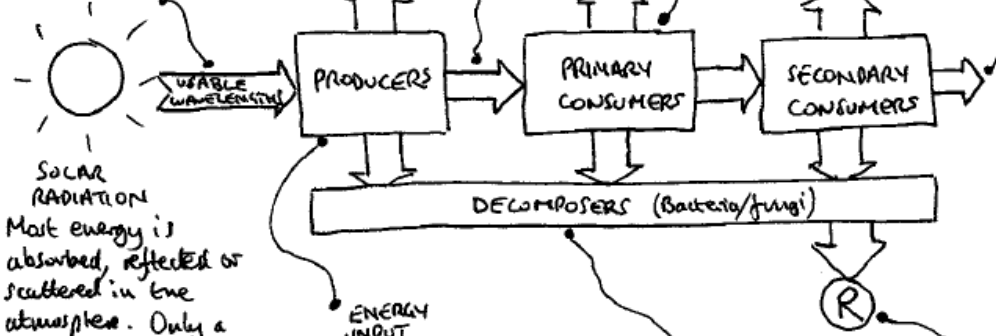
ENERGY TRANSFER BETWEEN LEVELS:
Typically 5-10% of NPP actually is used by the primary consumer -
- much of plant biomass is indigestible + passes thru animal
- not all of a plant is eaten
(but all of biomass eventually decomposed unless PEAT is formed).

ENERGY BUDGET OF A 1° CONSUMER:



This is SECONDARY PRODUCTION - in beef cattle it is above 5% of energy input.

Amount of energy entering the system is major factor determining productivity.



SOLAR RADIATION

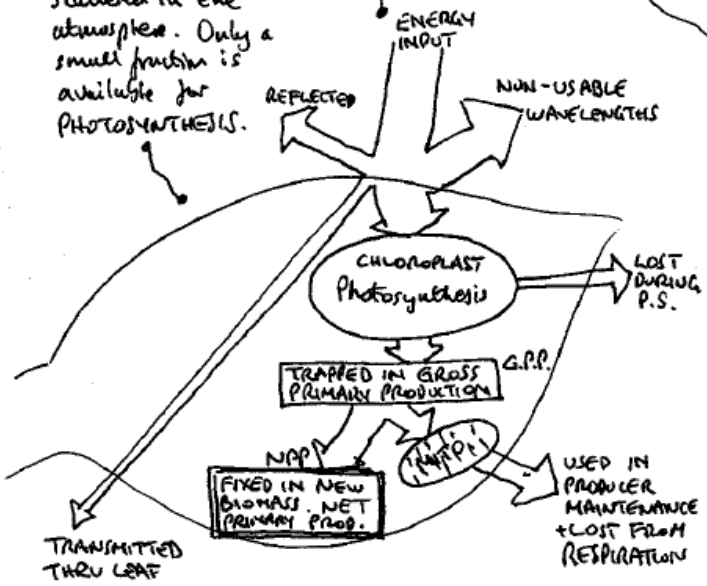
Most energy is absorbed, reflected or scattered in the atmosphere. Only a small fraction is available for PHOTOSYNTHESIS.

THE LENGTH OF A FOOD CHAIN is limited by:
- amount of incoming solar energy
- efficiency of the producer in N.P.P.
- the huge energy losses at and between each link in the chain.

These losses are typically 90% at each step.

REPERCUSSIONS FOR HUMANS:
1. Much more energy available if humans feed as primary not secondary consumers.
2. Modern agriculture aims to increase efficiency of NPP and of secondary production by:
   - selective breeding
   - genetic engineering
   - use of pesticides + weedkillers
   - artificial fertilizers
   - hormones + antibiotics
   - intensive husbandry.
   etc.
3. Ethical + human health issues
4. Consequences for the environment + conservation
   - habitat loss
   - species loss
   - agricultural pollution
   - soil erosion
   - depletion of fossil fuels
   - global warming

etc.



DETRITIVORES are consumers which feed on detritus. DECOMPOSERS break down (by extracellular digestion) organic matter and are VITAL in the RECYCLING of materials. (see C+N cycles)

N.P.P. is available for next stage in food chain.
N.P.P. is typically above 50-60% of G.P.P.

LOSSES FROM RESPIRATION -
All organisms require energy from respiration to drive cellular activities:
- active transport
- biosynthesis
- movement.

Respiration is at best 40% efficient. All energy is eventually lost as HEAT, (which is of value to ENDOTHERMS).

4.4.2 Distinguish between r- and K-selected species:

- features of r-selected species;
- features of K-selected species;
- growth curves for r- and K-selected species (population growth equations NOT required).

Table 11 The features of r-selected and K-selected species

Feature	r-selected (r-strategist)	K-selected (K-strategist)
Length of life cycle	Short — quick to mature	Long — takes time before individuals become reproductively mature
Generation time	Short	Long
Numbers of offspring	Many	Few
Population density	Highly variable; often overshoots K, resulting in 'boom-and-bust' dynamics	Less variable; usually near K
Dispersal (ability to migrate)	High; species migrate readily and are able to re-colonise easily	Low; re-colonisation is uncommon
Competitive ability	Weak competitor	Strong competitor
Body size	Small	Large
Amount of parental care	Little	Considerable
Habitat	Unstable or disturbed	Stable and/or stressful

4.4.7 Understand the concept of an ecological community:

- a community as the biotic component of an ecosystem and involving interactions between autotrophic and heterotrophic populations.

4.4.8 Understand the concept of an ecosystem:

- a community of different species which are interdependent and interact with each other and their abiotic environment, involving energy flow, nutrient and gas exchanges.

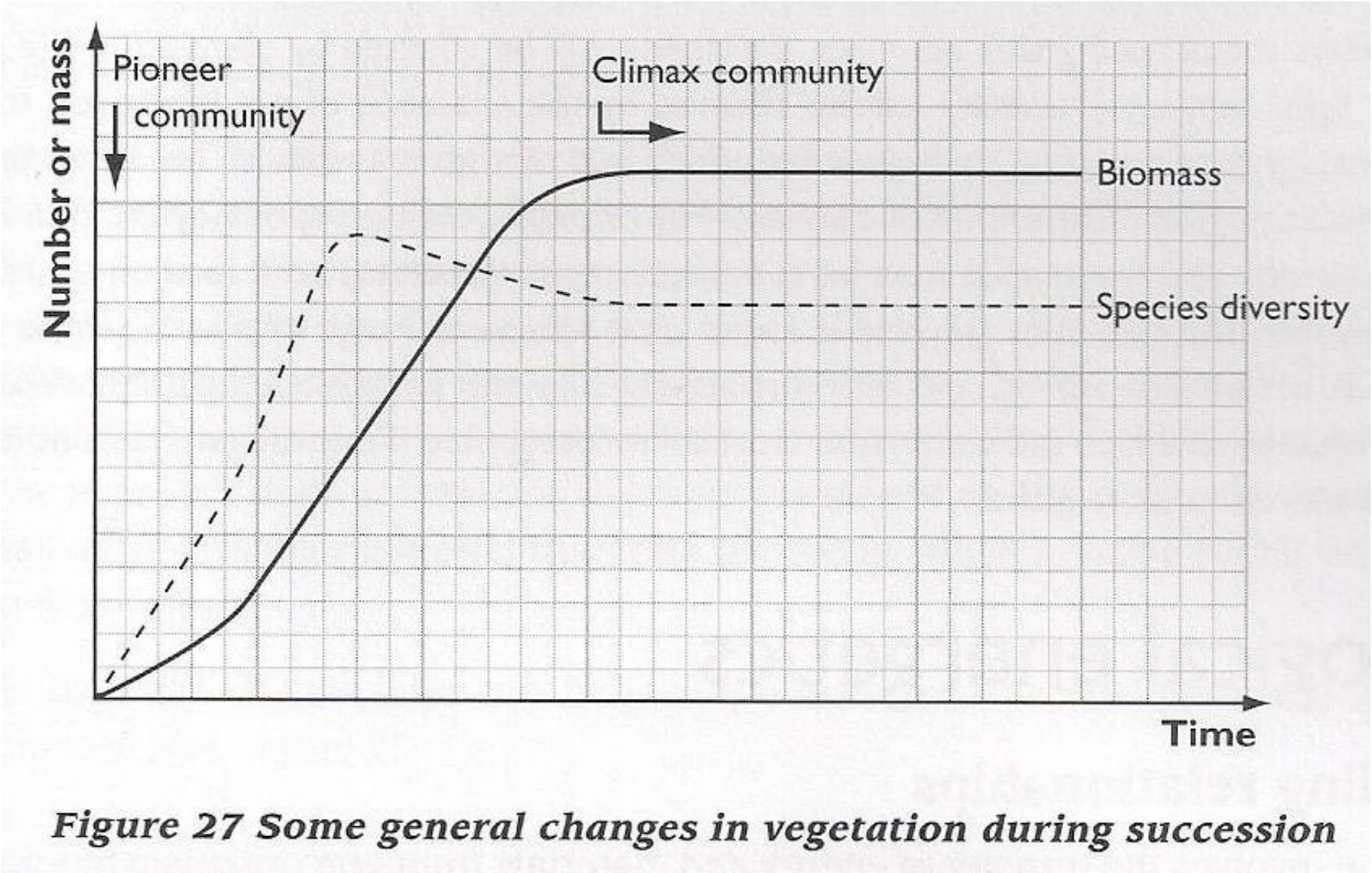


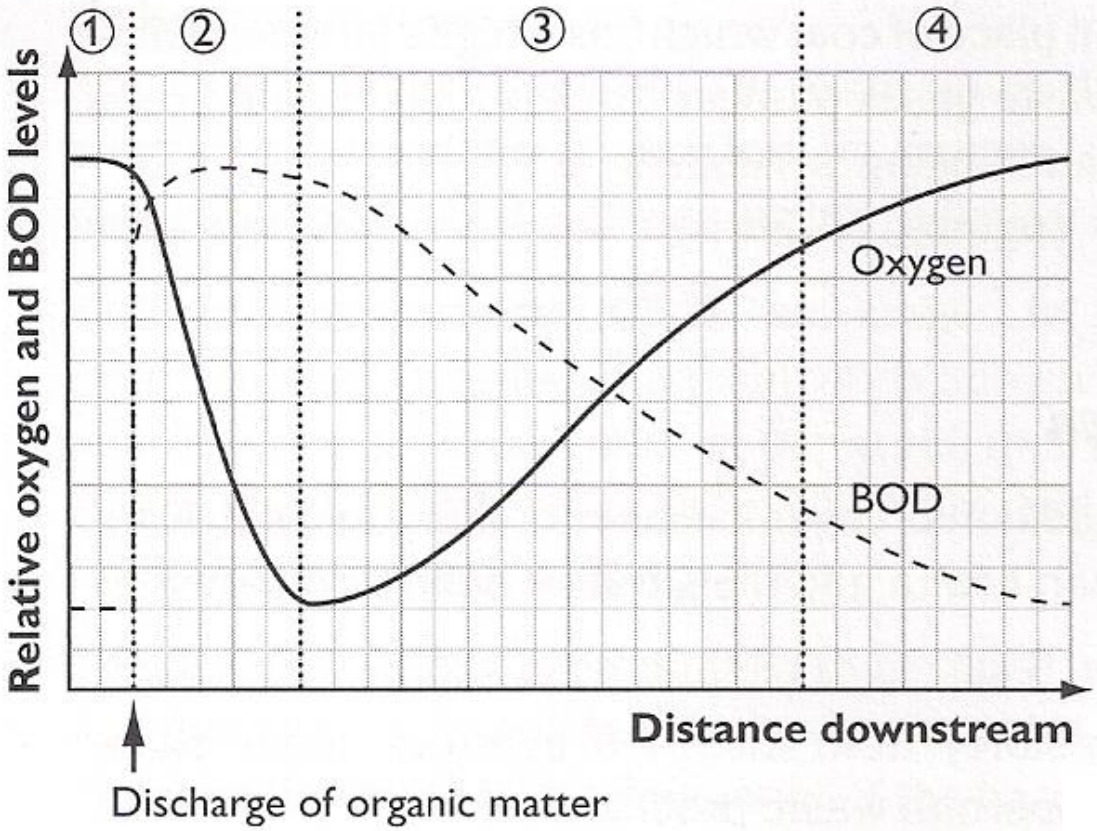
Figure 27 Some general changes in vegetation during succession

Why the drop in spp diversity?

4.4	Ecosystems		
(b)	Communities (cont.)	4.4.9	Understand the process of community development: • initial colonisation of a habitat by pioneer species; • succession as a change in the species composition in a community with time culminating in a climax community; • climax community as the stable end stage of a succession which is in equilibrium with the environment; • biotic and climatic climaxes; • primary succession as a relatively slow process of community development in a previously unoccupied area; • secondary succession as a predictable, repeatable and faster process of community development in an area where the climax community was destroyed by fire, flooding, wind damage or human interference; • appreciate that complex communities are relatively more stable when compared with simple communities.

- organic pollution by slurry and silage effluent;
  - effect on BOD values in water bodies
  - effect on flora/fauna/biodiversity in water bodies
- appreciate the need for monitoring of water bodies, eg the use of aquatic invertebrates as 'Indicator Species';
- appreciate issues with slurry application including;
  - need for optimal soil/weather conditions to minimise the risk of pollution
  - the need for 'closed periods'
- appreciate the potential use of constructed reed beds to treat lightly contaminated farm waste.

Figure 36 The discharge of organic matter into a river causes changes in (a) oxygen levels and BOD



① Initially, the discharge of organic matter provides food for bacteria, which multiply dramatically — there is a high BOD

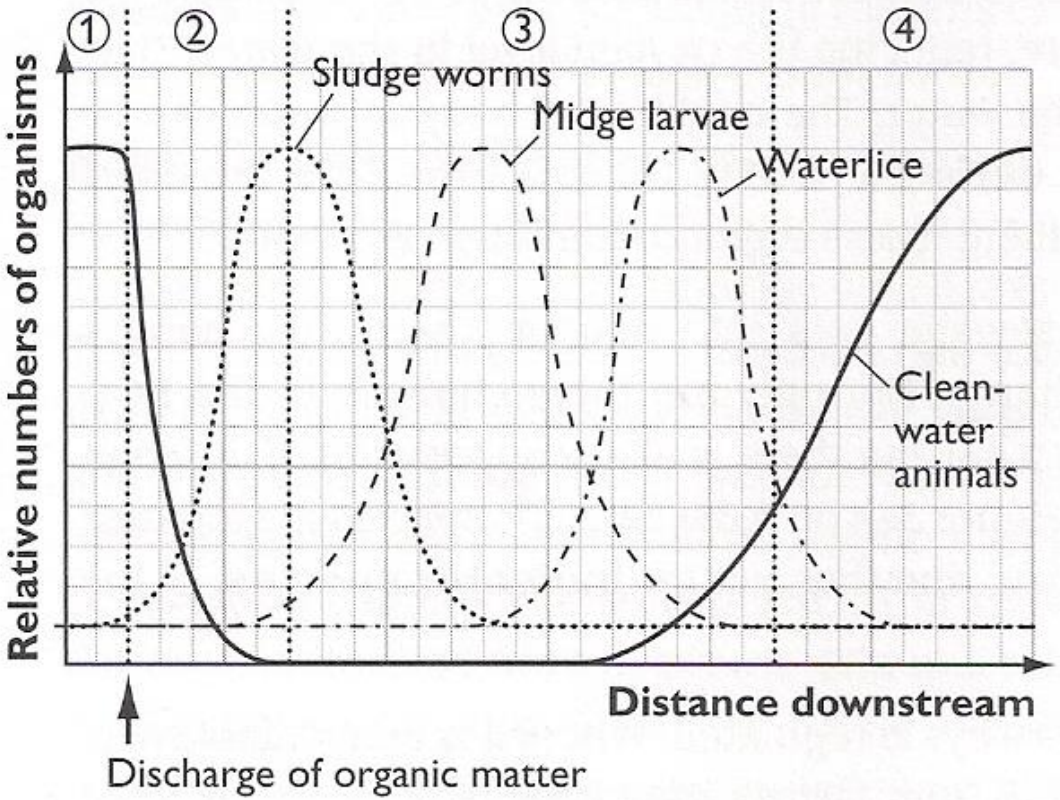
② The bacteria use up oxygen so that oxygen levels fall

③ As the organic matter is decomposed the oxygen levels start to rise and the BOD falls

④ Eventually, much of the organic matter is used and the oxygen levels return to the normal level

BOD = Biological Oxygen Demand (demand is high when there is little oxygen!)

Figure 36 The discharge of organic matter into a river causes changes in (b) the distribution of organisms in the river



① Clean-water invertebrates, such as stonefly larvae and mayfly nymphs, and fish, such as trout, swim away or are killed since they cannot survive in water with little oxygen

② Only organisms adapted to survive in water with very low levels of oxygen, such as sludge worms (*Tubifex*), can survive, so their numbers increase

③ As oxygen levels gradually rise there is a succession of organisms adapted to lower-than-normal oxygen levels, such as midge larvae (*Chironomus*) and waterlice (*Asellus*)

④ As oxygen levels return to normal, pollution-tolerant species decline due to increased predation and competition from returning pollution-intolerant (clean-water) species

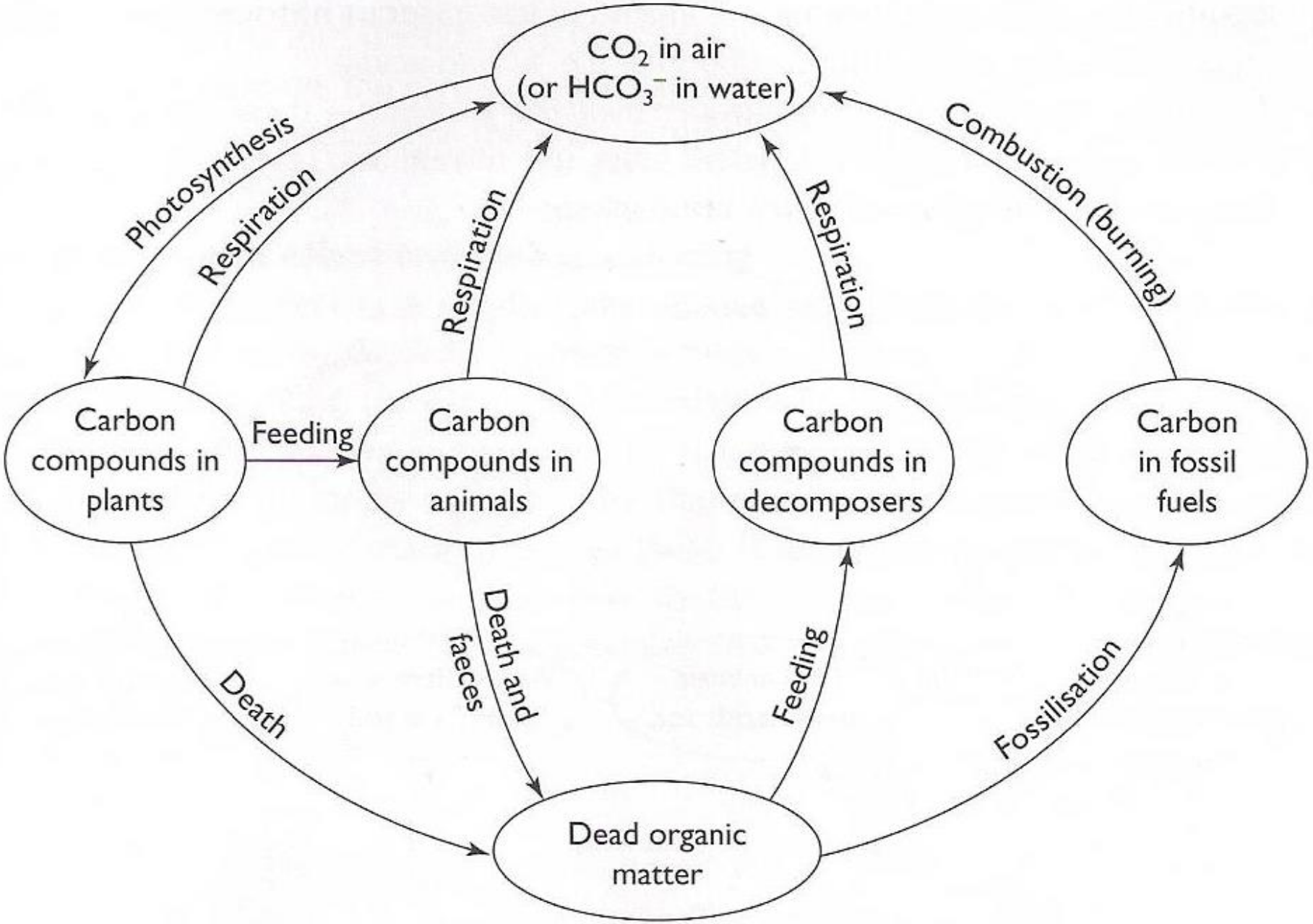


Figure 33 The carbon cycle

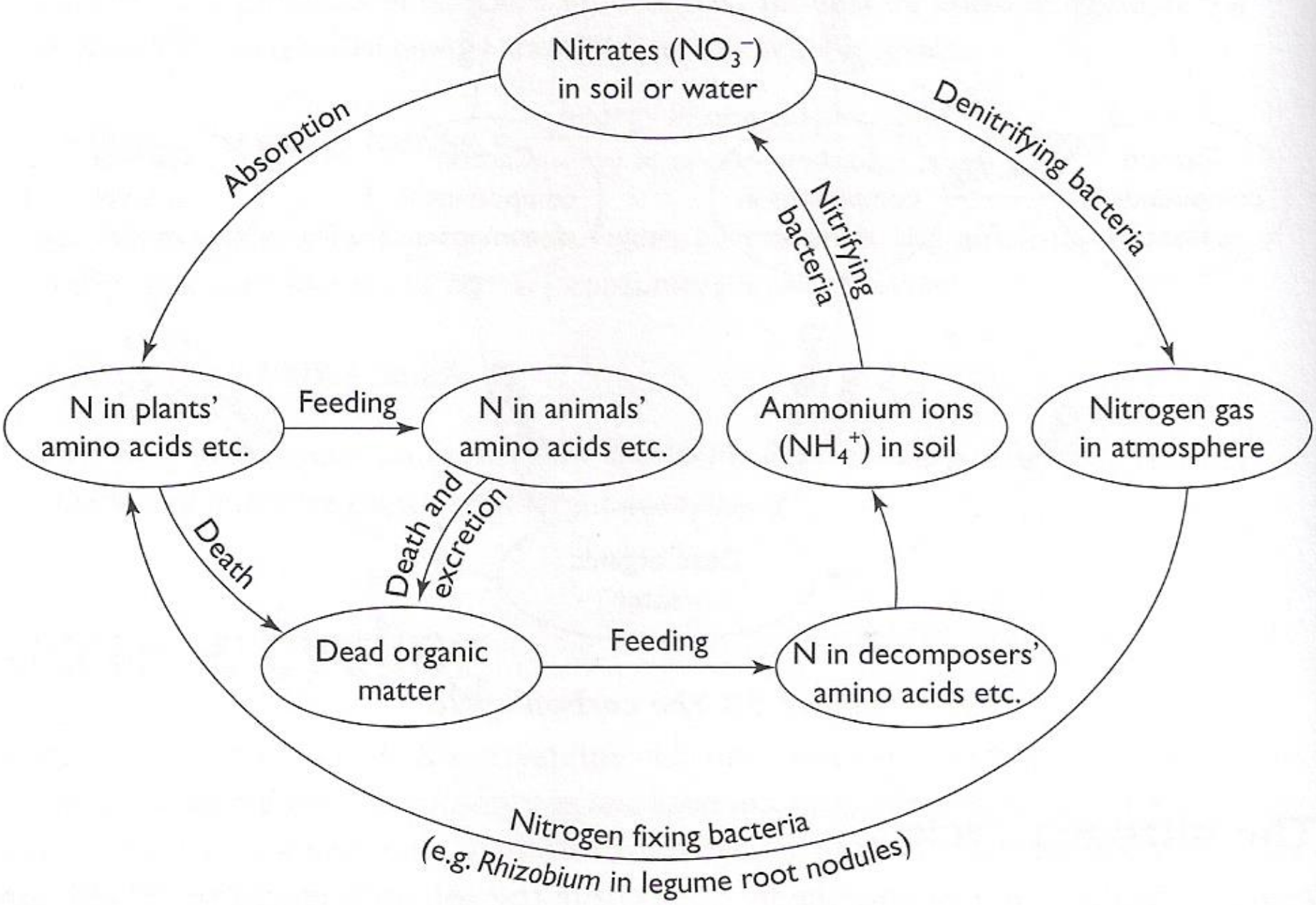
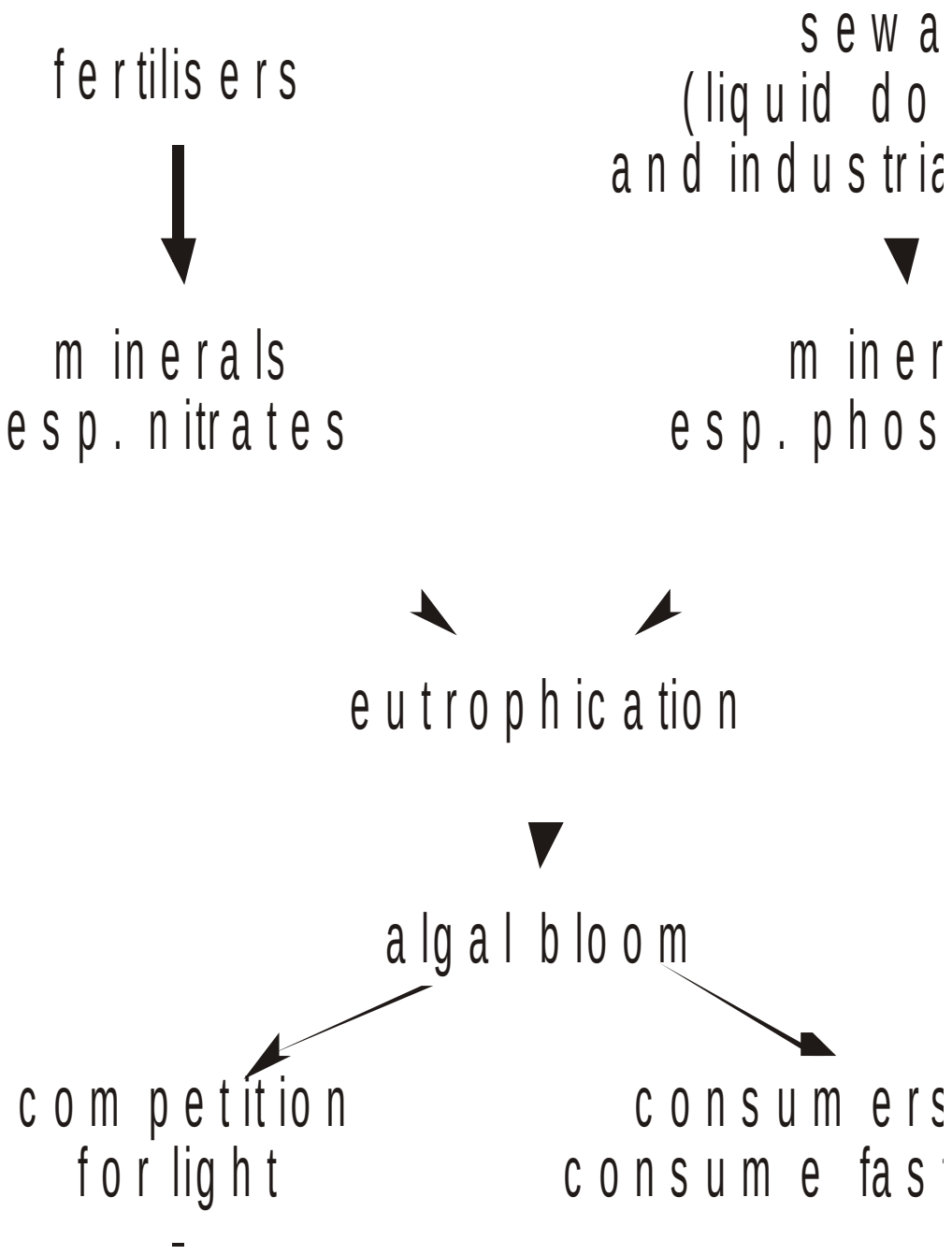


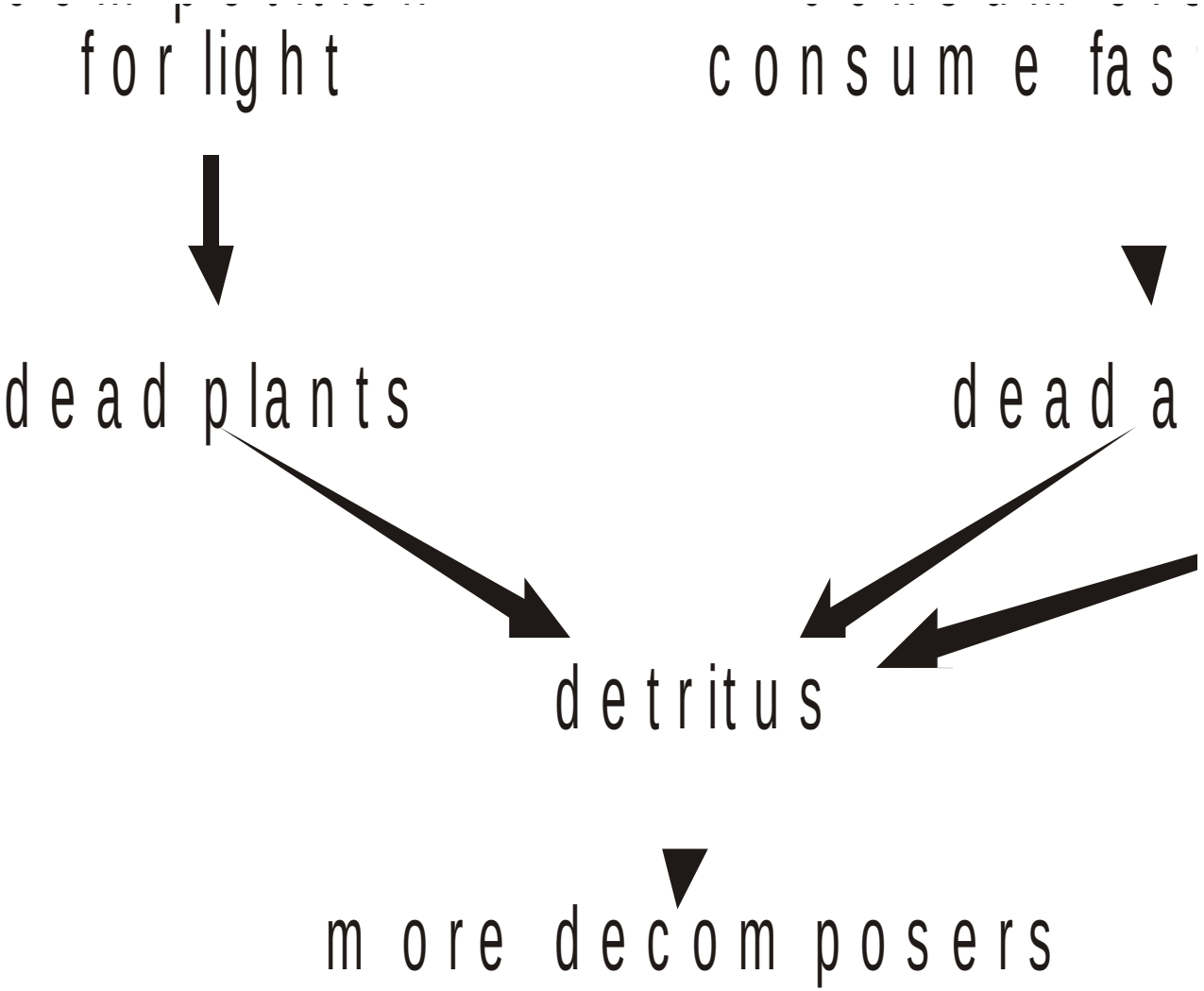
Figure 34 The nitrogen cycle

(e) Adverse impact of human activity on the environment (cont.)	4.4.19	Appreciate strategies to reduce the risk of eutrophication in water bodies due to leaching of artificial fertilisers: • careful calculation of application levels so that 'supply does not exceed demand' in the target crop; • only apply artificial fertiliser immediately prior to or during periods of vigorous plant growth; • do not apply artificial fertiliser when heavy rain is forecast; • do not apply artificial fertiliser adjacent to water bodies; • appreciate the existence of governmental guidelines (details NOT required); - DARD NI Code of Good Agricultural Practice for the Prevention of Pollution of Water - EC Nitrates Directive Action Programme (NI is a total territory designation for this EC Nitrates Directive).

The process of Eutrophication



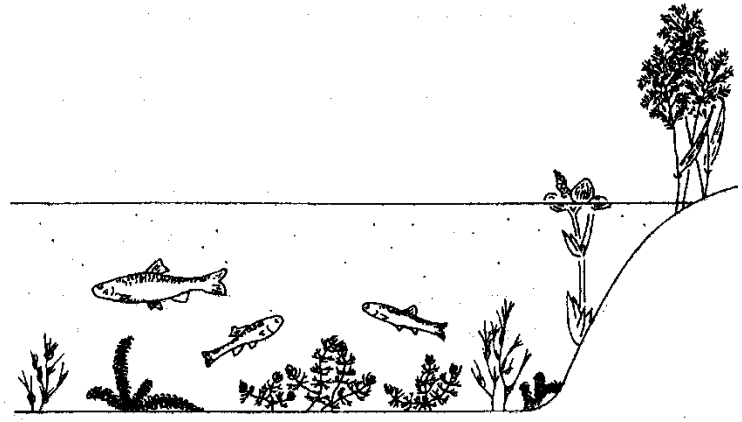
The process of Eutrophication cont.



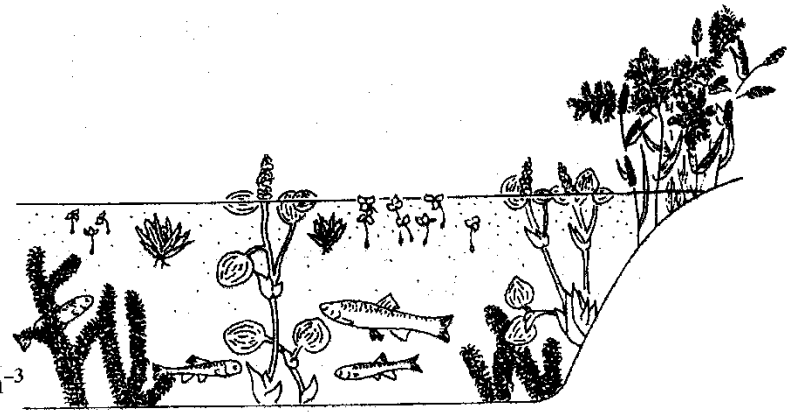
Biochemical Oxygen Demand (BOD).

This measures the rate of oxygen consumption by a sample of water, and therefore gives a good indication of eutrophication. A high BOD means lots of organic material and aerobic microbes, i.e. eutrophication

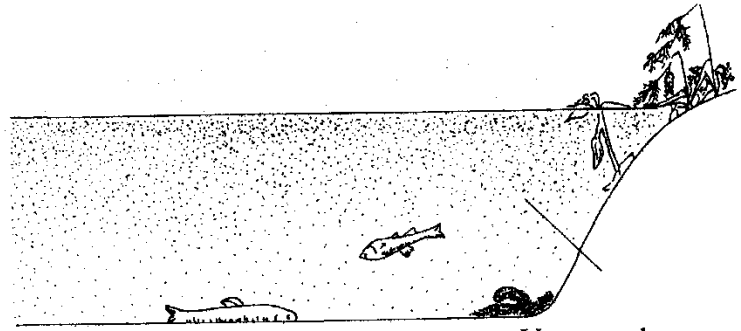
23 The Norfolk Broads (large areas of fresh water) have become heavily contaminated with phosphate over the last 100 years. The drawings show the effect this has had on the community of plants and animals which live there.



Nineteenth century.
Phosphate concentration 20μgdm^{-3}
Sedimentation rate 1mm per year



Mid twentieth century.
Phosphate concentration 100mgdm^{-3}
Sedimentation rate 2mm per year



Late twentieth century.
Phosphate concentration 1000mgdm^{-3}
Sedimentation rate 10mm per year

Vast numbers
of phytoplankton

(e) Adverse impact of human activity on the environment (cont.)

- use of photodegradable plastic around/between crop plants (eg maize) to prevent growth of weeds and reduce dependence on herbicides;
- integrated Pest Management Systems that include use of;
  - specific, natural predators/parasites of pests
  - non-persistent pesticides
  - sterile males of pest species
  - crop rotation (more difficult for pest species to become established)
  - selective breeding/genetically modified varieties of crops with improved pest/disease resistance.

4.4.21 Understand the concept of managed timber production as a sustainable resource:

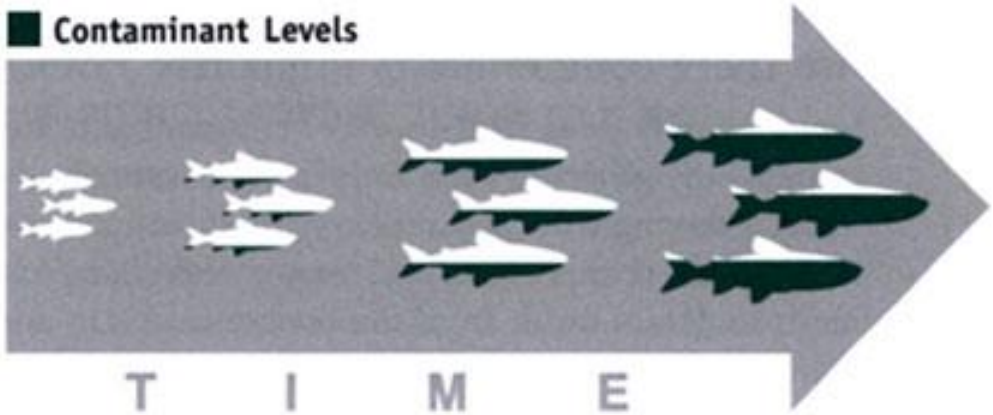
- timber as a renewable resource with a sustainable yield;
- 'set-aside' land schemes;
- coppicing allows harvesting of wood eg ash and willow, while maintaining the forest ecosystem;
- appreciate the advantages/disadvantages of softwood and hardwood forests;
  - softwood forests eg larch and spruce grow more quickly
  - the high density of softwood forest planting decreases biodiversity
  - indigenous hardwood forest, eg ash and oak provides greater variety of habitats and increased biodiversity compared to introduced larch and spruce.

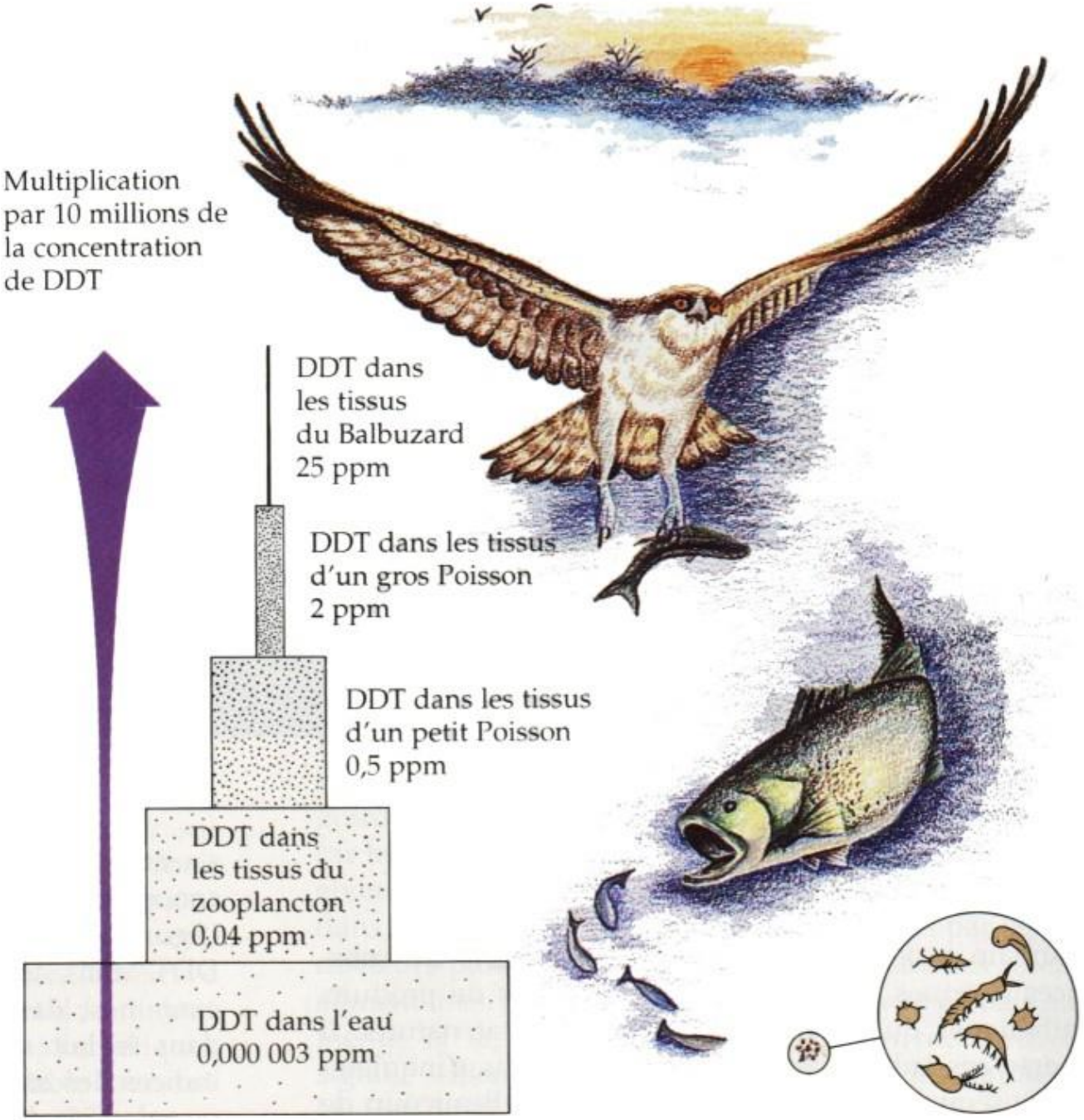
Pesticides

Persistence
+ Lipid solubility **= Bioacculmulation**

Bioaccumulation

E.g DDT

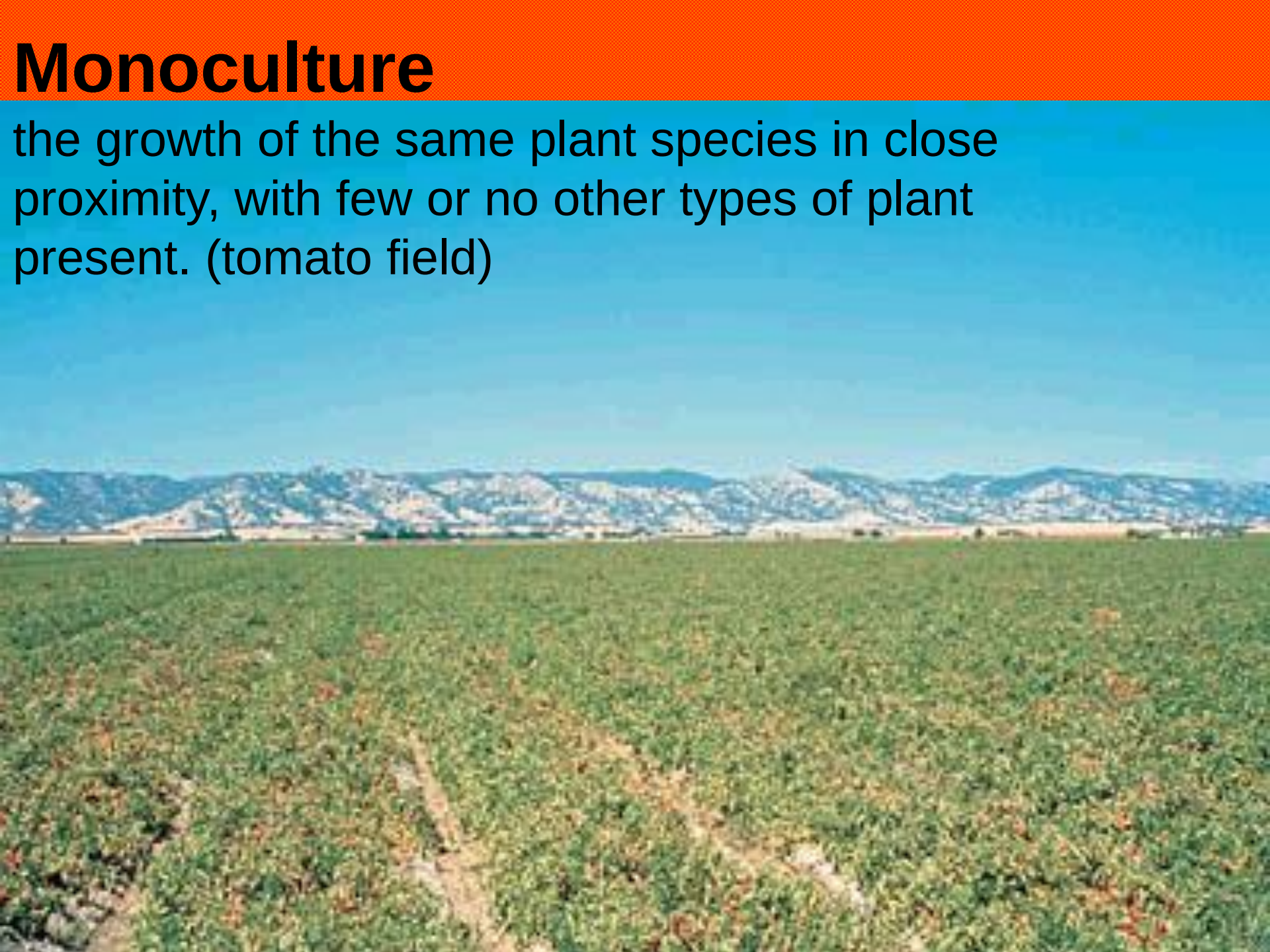



Multiplication par 10 millions de la concentration de DDT
DDT dans les tissus du Balbuzard 25 ppm
DDT dans les tissus d'un gros Poisson 2 ppm
DDT dans les tissus d'un petit Poisson 0,5 ppm
DDT dans les tissus du zooplancton 0,04 ppm
DDT dans l'eau 0,000 003 ppm


MONOCULTURE

Monoculture

the growth of the same plant species in close proximity, with few or no other types of plant present. (tomato field)



Monoculture:

- Increases the productivity of farmland by growing only the best variety of crop.
- Allows more than one crop per year.
- Simplifies sowing and harvesting of the crop.
- Reduces labour costs.

Monoculture has a major impact on the environment:

- Reduces genetic diversity and renders all crops in a region susceptible to disease.
- Fertilisers required to maintain soil fertility.
- Pesticides are required to keep crops healthy.
- Monoculture reduces species diversity.
- Less attractive countryside.

E.g of pests and monoculture.

The boll weevil eats the cotton plant. It wiped out much of the cotton crop in the affected states in the USA between 1895 and 1910. Severe economic consequences ensued, because cotton was the main crop, and only one strain of cotton was grown.

Traditional crop rotations, where different crops are grown in a field each year:

- Breaks the life cycles of pests (since their host is changing)
- Improves soil texture (since different crops have different root structures and methods of cultivation)
- Can increase soil nitrogen (by planting nitrogen-fixing legumes).


HEDGEROWS
© Jon Marshall

HEDGEROW REMOVAL & CONSERVATION

RIP 'EM OUT

* THEY HARBOUR PESTS, DISEASES & WEEDS (ESP. IN WINTER)
* THEY OCCUPY SPACE AVAILABLE FOR CROPS
* THEY IMPEDE USE OF HEAVY MACHINERY
* THEY REDUCE CROP YIELDS BY ABSORBING MOISTURE & NUTRIENTS.

HEDGEROW REMOVAL & CONSERVATION

KEEP 'EM IN

- THEY PROVIDE HABITATS FOR ANIMAL & PLANT SPECIES
- PRODUCE FOOD FOR BIRDS WHICH DON'T LIVE IN THE HEDGEROW
- THEY ACT AS CORRIDORS FOR MIGRATION
- ACT AS WINDBREAKS — PREVENTING SOIL EROSION BY WIND
- ADD DIVERSITY & INTEREST TO THE LANDSCAPE.

In general the larger the hedge, the more birds and more species are found.

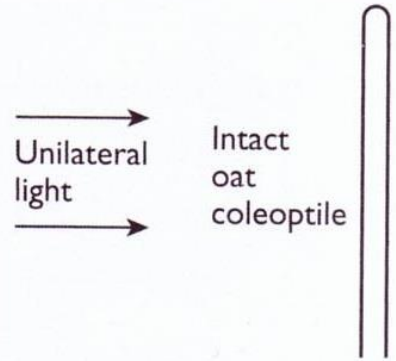
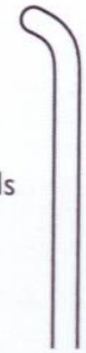
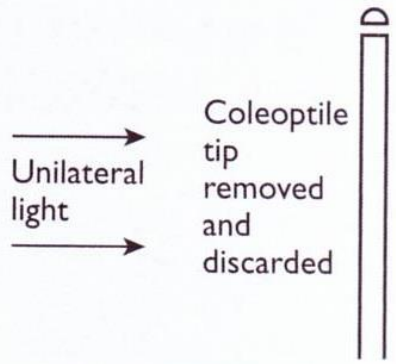
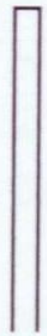
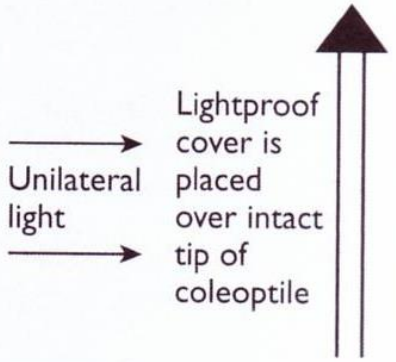
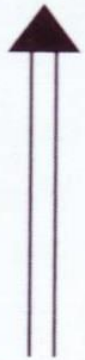
PLANT HORMONES

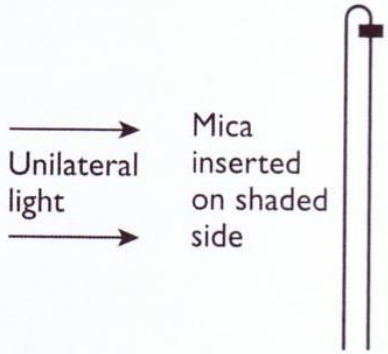
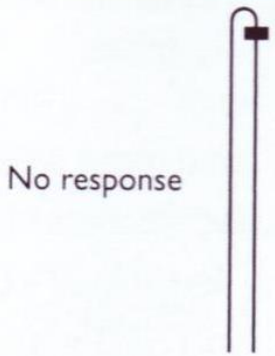
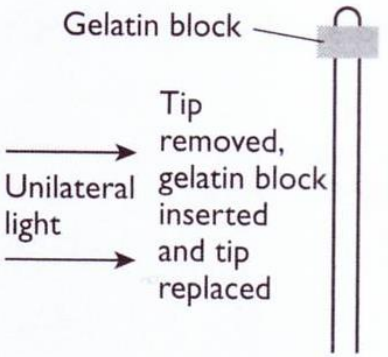
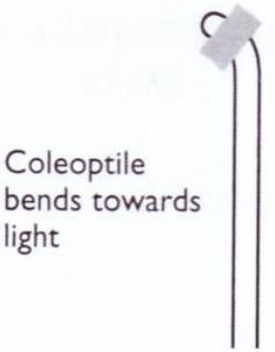
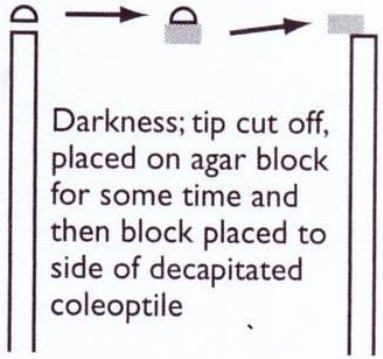
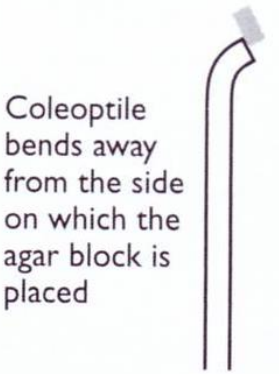
Understand the role of plant growth substances (hormones) in stem elongation:

- auxins promote cell elongation;
- cytokinins promote cell division;
- gibberellins promote elongation of internodal regions.

Understand the role of auxins in phototropism:

- directional light stimulus results in the lateral displacement of auxin to the non-illuminated side of the shoot;
- a differential growth response results in positive phototropism;
- appreciate the significance of positive phototropism in the shoots of plants;
- appreciate (in outline only) the experimental evidence for the role of auxins in phototropism (Darwin's experiments, Boysen-Jensen's experiments, Went's experiments).

Biologist (and year of experiment)	Experimental procedure	Observed result	Suggested explanation
Darwin (1880)			The coleoptile is positively phototropic. It bends towards the light by unequal elongation of the region just behind the tip.
			The tip must either perceive the stimulus or produce the messenger (or both), as the tip removal prevents any response.
			The tip of the coleoptile perceives light.

Boysen-Jensen (1913)			Auxin moves to the shaded side of the coleoptile but is prevented by the mica from moving further down. No auxin moves into the zone of elongation on either side, so no bending occurs.
			As gelatin allows chemicals to pass through it, the bending which occurs must be due to a chemical, e.g. auxin, passing from the tip.
Went (1928)			The auxin from the tip is collected in the agar block. When the block is placed to one side on a decapitated coleoptile, the auxin moves down that side, increasing growth and causing bending. The degree of curvature is proportional to the amount of auxin.