REVISION: GASEOUS EXCHANGE & EXCRETION 11 SEPTEMBER 2013

Lesson Description

In this lesson we:

- Revise gaseous exchange in different animals and examine the structure of the kidney

Key Concepts

Important Terms for Gaseous Exchange

Breathing	Bronchi	Carbominohaemoglobin
Gaseous exchange	Bronchiole	Bicarbonate ions
Cellular respiration	c-shaped cartilaginous rings	Homeostasis
Ventilation	Ciliated epithelium	Chemoreceptor
Diffusion	Inhalation	Tidal volume
Diffusion gradient	Exhalation	Vital capacity
Trachea	Oxyhaemoglobin	Total volume

What is Gaseous Exchange?

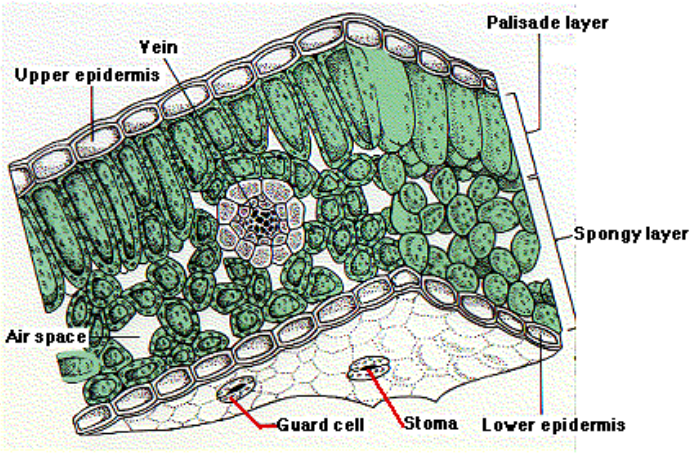
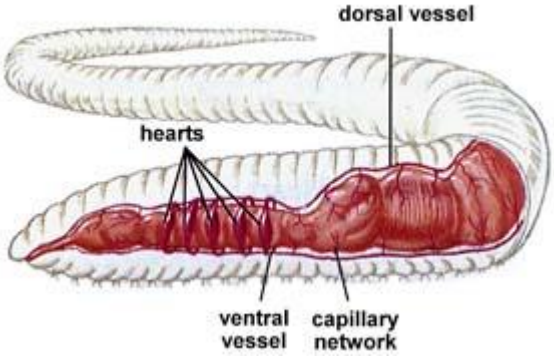
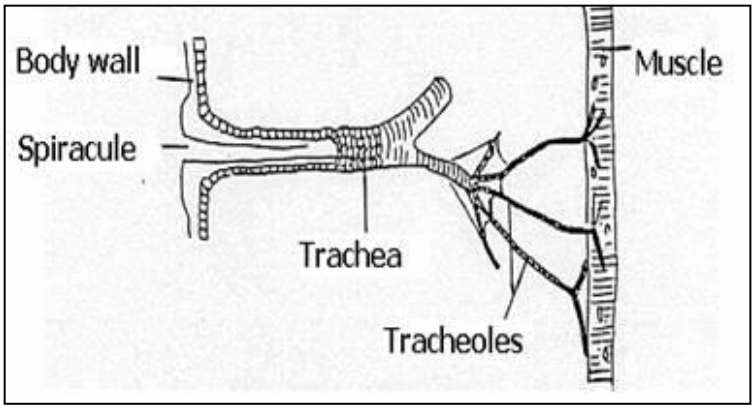
- The main function of the respiratory system is to take in oxygen from the atmosphere and make it available to the cells for cellular respiration.
- Carbon dioxide is produced during respiration and must be removed.
- Terms that are important that you can differentiate between:
    - **Breathing** – the mechanical process whereby air moves into and out of the lungs. (inhalation and exhalation)
    - **Gaseous exchange** – the exchange of oxygen and carbon dioxide across a gaseous exchange surface.
    - **Cellular respiration** – the release of energy from glucose in the presence of oxygen

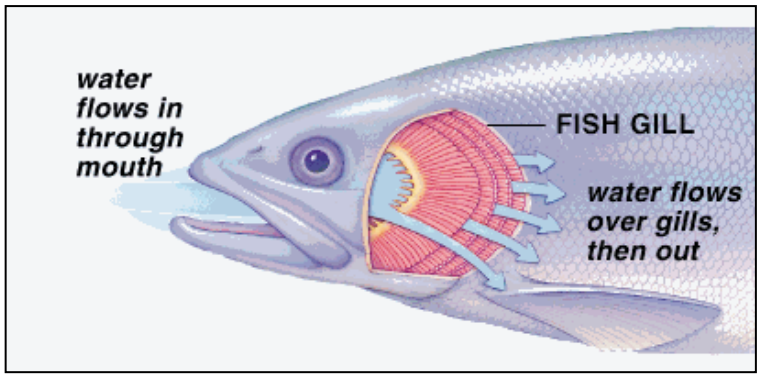
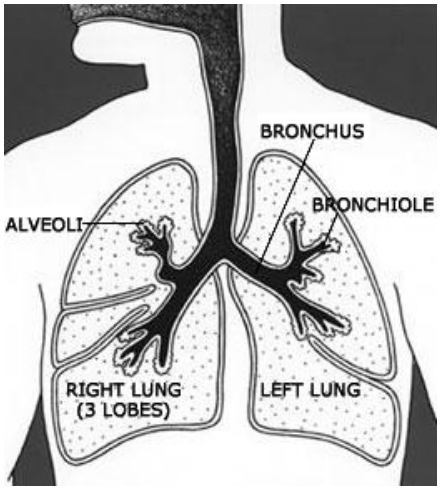
Requirements of an Effective Gaseous Exchange Surface

- To enable oxygen and carbon dioxide to diffuse through it easily, it must be:
    - **Large** – to ensure the maximum exchange of gases can take place.
    - **Thin and permeable** – so that diffusion can take place easily and rapidly.
    - **Moist** – so that gases can dissolve to form a solution.
    - **Well ventilated** – good oxygen supply and carbon dioxide removal. (maintain a diffusion gradient)
    - **Efficient transport system** – for effective transport of gases.
    - **Well protected -** to prevent desiccation (drying out) and mechanical injury.

Diversity in Gas Exchange Systems

- The way in which gaseous exchange is brought about depends on the body form of the organisms and on the environment in which it lives

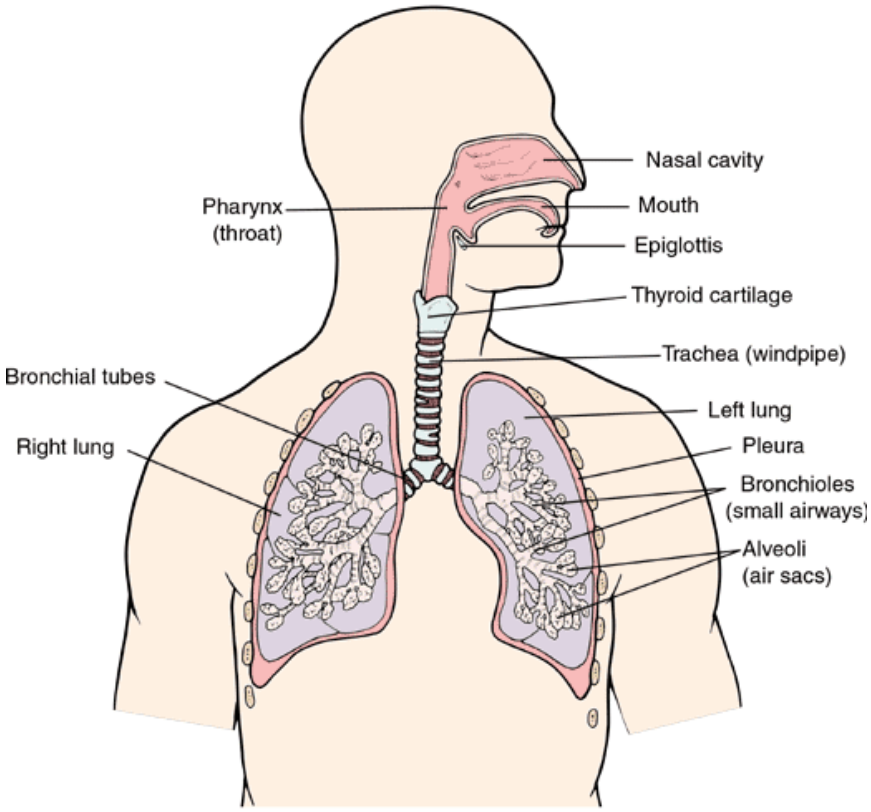
Organism		Gaseous Exchange Structure
Dicot leaf	**Terrestrial**	• Gaseous exchange takes place in the leaves. • The main gaseous exchange surface is the spongy mesophyll. • These have a large outer surface and moist cell walls. • Gases enter and leave through the stomata – their opening and closing regulates gaseous exchange
		
Earthworm	**Terrestrial**	• Gaseous exchange takes place though the skin from the air. • The skin is kept mist by mucous secretions from the skin • Oxygen dissolves in the moisture of the skin to the surface blood vessels to the rest of the body • Carbon dioxide is transported to the skin and then diffuses out of the body
		
Insect e.g. Locust	**Terrestrial**	• The locust has a tracheole system. • Air enters the body through small openings known as spiracles. • They open into tracheas that form extensive network of tubes that become even smaller to form tracheoles • Oxygen diffuses out of the tracheoles, which have very thin walls into the cells. air sacs are also present as a ventilation system • Air sacs are neat to muscles and ensure air moves quickly to and from the tissues. • Exoskeleton prevents water loss
		

Fish	Aquatic	
		• Fish have gills for gaseous exchange • Gills consist of a large number of filaments and are richly supplied with blood capillaries • Water flows into the mouth and over the gills • Dissolved oxygen in the water diffuses into the blood of the capillary vessels • Carbon dioxide diffuses into the water.
Mammals	**Terrestrial**	• Mammals have lungs and a blood supply
		

Structure and Adaptation of the Human Gaseous Exchange Surface

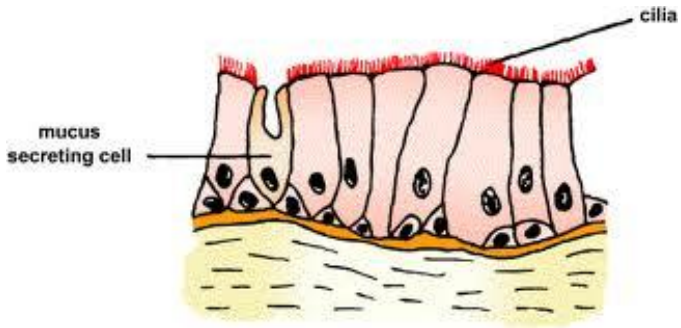
- The ventilation is made up of :
  - Air passages through which the air enters and leaves the lungs
  - Two lungs that provide the gaseous exchange surface area
  - Breathing muscles that move the chest up and down, causing air to enter and leave the lungs
  - Breathing centre in the brain which controls the rate and depth of breathing

Respiratory System



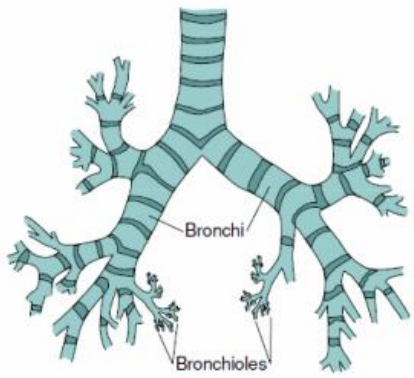
Trachea

- Lined with ciliated epithelium
- C-shaped cartilaginous rings hold the trachea open
- Dust particles trapped by mucous and transported to the exterior by mucous



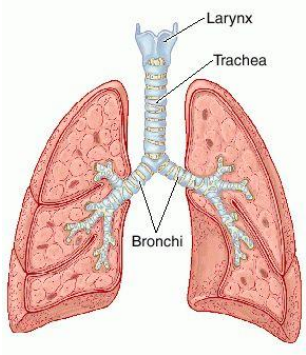
Bronchi and Bronchiole

- The trachea divides into the right and left bronchus which enter the lung.
- Inside the lung they divide into smaller branches called bronchiole
- Lined with mucous membrane and kept open by O-shaped cartilaginous rings
- Smaller the bronchiole the cartilage is no longer present



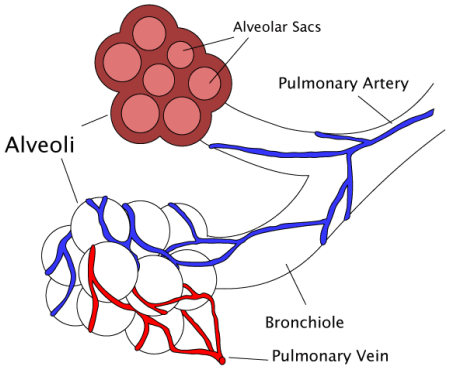
External Structure of the Lungs

- Two lungs. The right lung has three lobes and the left two
- Protected by the intercostal muscles between the ribs.
- Spongy and elastic
- Surrounded by a double pleural membrane with pleural fluid in between to stop friction
- The lungs rest on a dome shaped muscular plate, the diaphragm



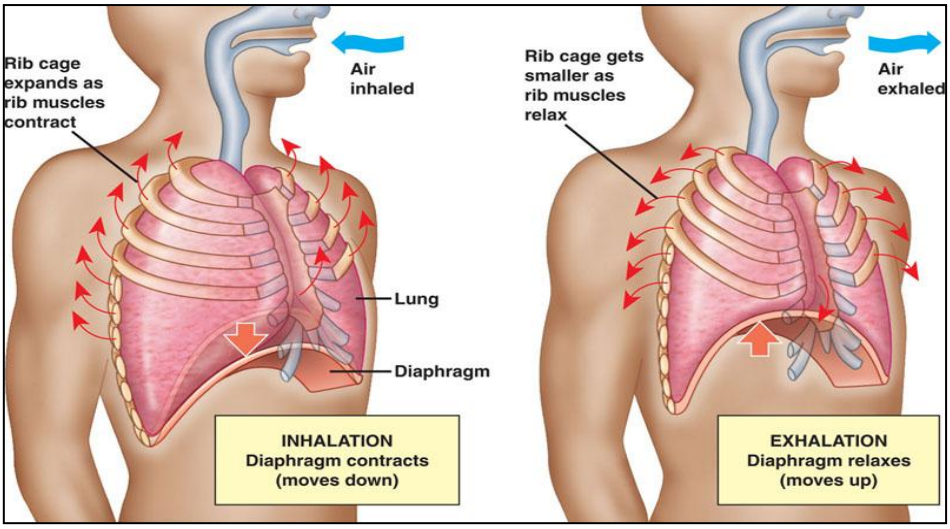
Internal Structure of the Lungs

- Bronchiole end in small air sacs called alveoli
- Gaseous exchange takes place in the alveoli
- The wall of the alveoli is thin and consists of a single layer of squamous epithelium.
- The alveoli are surrounded by a system of capillary blood vessels



Mechanism of Breathing

INHALATION	EXHALATION
• **Active** process • Diaphragms **contracts and flattens** • Thoracic cavity **enlarges** • External intercostals muscles **contract** • The ribs **move up and outward** and enlarges the thoracic cavity • **Abdominal muscle relax** to accommodate the intestines that are pushed down by the diaphragm • Total volume of the thoracic cavity **increases** • **Decrease** in air pressure • The elastic lungs **expand** and air flows **into** the lungs	• **Passive** process • Diaphragm **relaxes** and returns to dome shape • External intercostals **relax** • The ribs move down and inwards • Decrease in the volume of the thoracic cavity • Increase in air pressure • Air flows out of the lungs



Composition of Inhaled Air vs. Exhaled Air

Constituent	Inhaled Air	Exhaled Air
Oxygen	20.9%	16%
Carbon dioxide	0.03%	4.0%
Water vapour	Variable	Variable but more than in inhaled air
Nitrogen	78.1%	78.1%
Noble gases	0.94%	0.94%

Excretion

Is the removal of waste products from the body formed during metabolic reactions e.g. water, carbon dioxide and nitrogenous waste.

Important Terms for Excretion

Osmoregulation
Homeostasis
Macroscopic
Microscopic
Excretion
Nitrogenous waste
Nephron
Malpighian body
Renal tubules
Glomerulus
Afferent arteriole
Efferent arteriole
Podocytes
Glomerular filtration
Tubular reabsorbtion
Tubular excretion
Dialysis

Excretory Organs

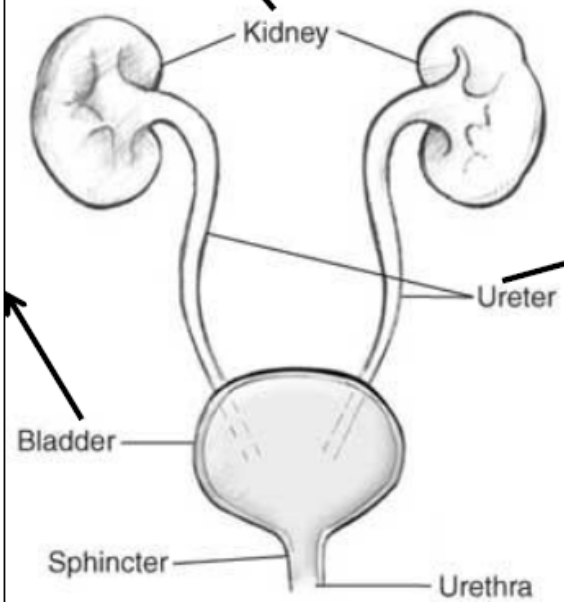
Organ	Waste product
Lungs	Carbon dioxide form cellular respiration
Skin	Water, salts released in the form of sweat
Alimentary canal	Bile pigments and cholesterol are excreted as bile pigments in the faeces
Liver (not an excretory organ)	Nitrogenous waste • Urea – deamination of excess amino acids • Uric acid – breakdown of nucleic acids Non –nitrogenous wastes • Creatinine – from the muscles • Toxins and drugs • alcohol
Kidneys	Nitrogenous waste from the liver. Non-nitrogenous waste, carbon dioxide, water, ions, hormones, poisons, drugs

The Structure of the Urinary System

The urinary system consists of two kidneys, two ureters, a urinary bladder and a urethra. The urine is made in the kidneys, travels to the bladder via the ureters and leaves the body via the urethra.

The kidneys are the primary organs of the urinary system. The kidneys are the **organs that filter the blood, remove the wastes, and excrete the wastes in the urine** (Campbell, 2008).

The urinary bladder is a **temporary storage reservoir for urine**. The size and shape of the urinary bladder varies with the amount of urine it contains and with pressure it receives from surrounding organs. The muscle in the bladder wall is called the detrusor muscle which relaxes to allow the bladder to fill and contracts during urination (Fox, 2009)

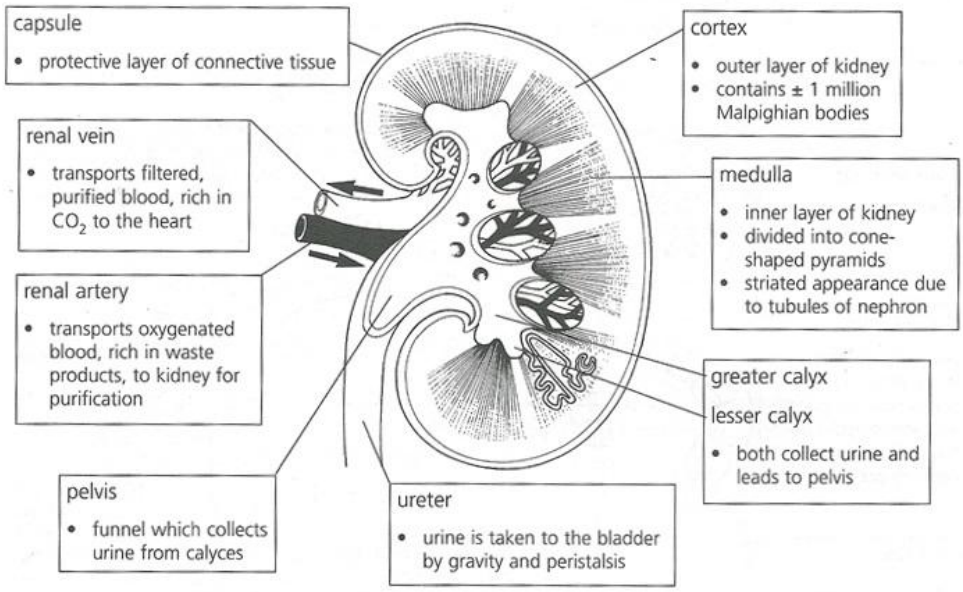


Each **ureter** is a narrow tube, about 25 cm long that **carries urine from each kidney to the urinary bladder**. It extends from the renal pelvis (an area where urine is collected in the kidney), and enters the urinary bladder.

The final passageway for the flow of urine is the urethra, a thin-walled tube that conveys urine from the floor of the urinary bladder to the outside.

In females, the urethra is short, only 3 to 4 cm long and opens to the outside just anterior to the opening for the vagina. In males, the urethra is much longer, about 20 cm in length, and transports both urine and semen. The external urethral opening opens to the outside at the tip of the penis (Campbell, 2008).

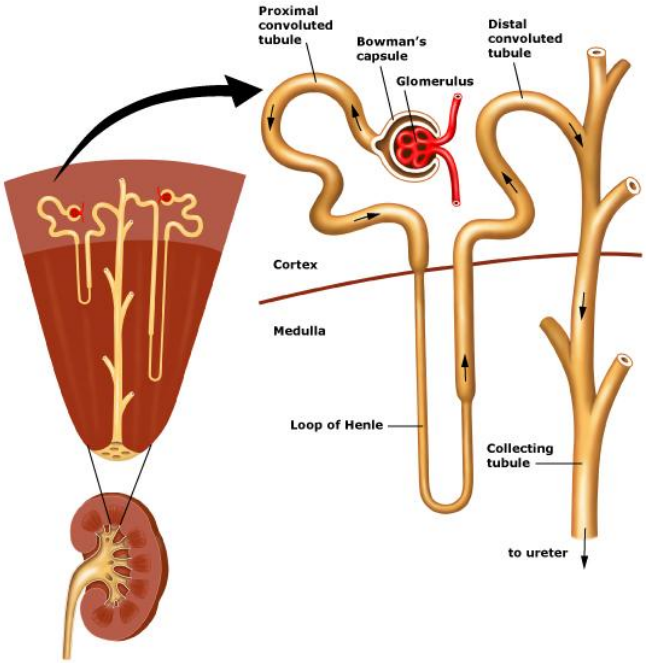
The Kidneys – Macroscopic Structure



Internal (macroscopic) structure of the kidney

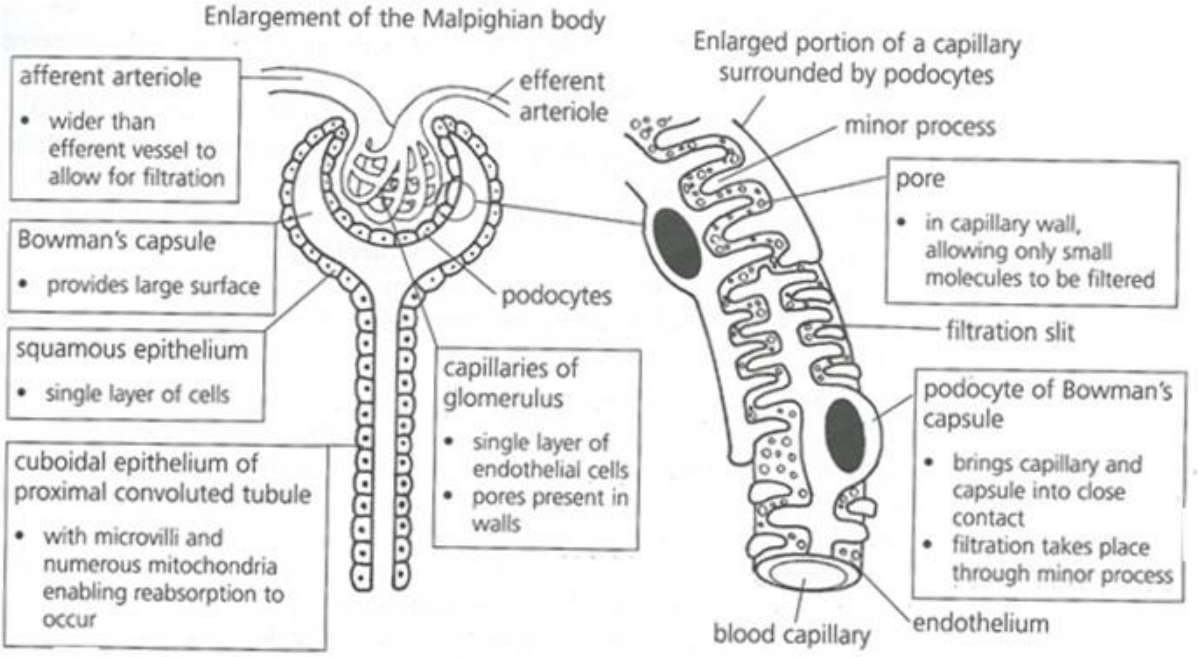
The Nephron – Microscopic Structure of the Kidney

- Each kidney is made up of about one million small tubes known as **nephrons**
- The nephrons are the structural and functional units of the kidney
- Each nephron consists of two main parts:
  - **Malpighian body/Renal corpuscle**
  - **Renal tubule**



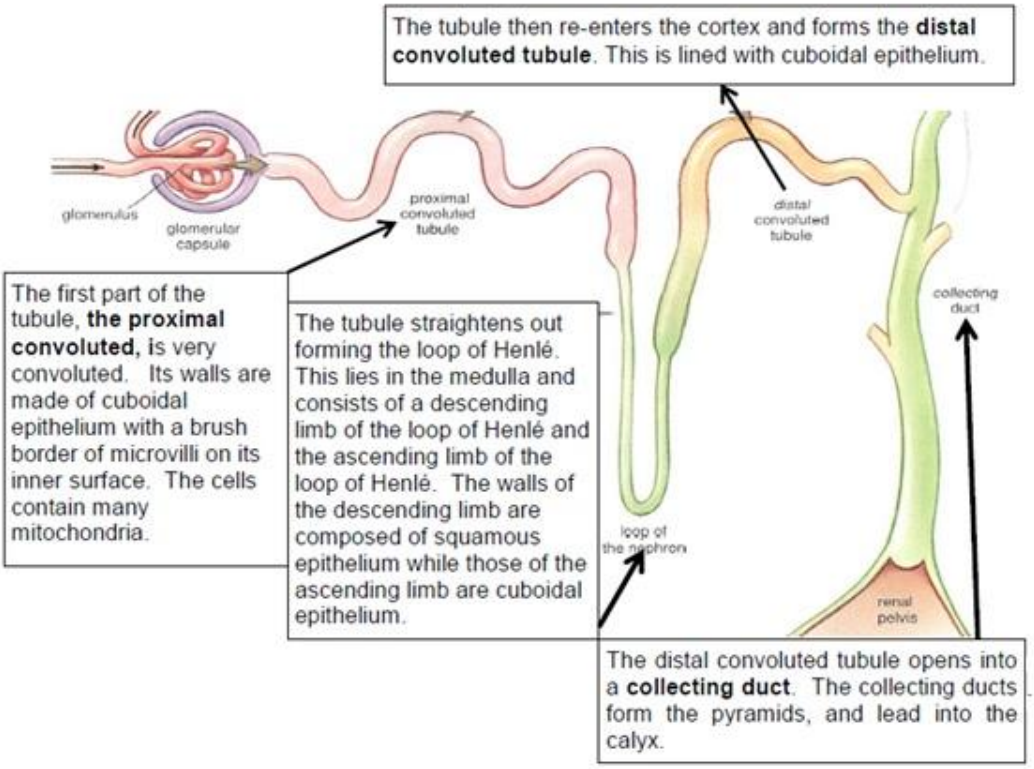
The Malpighian Body

- It consists of a double walled cup surrounding a network of capillaries.
- The cup is known as the **Bowman's capsule** while the capillary network is the **glomerulus**.
- A small arteriole - the **afferent arteriole** (ultimately a branch of the renal artery), leads into the glomerulus and divides into many capillaries. These unite to form the **efferent arteriole** leaving the glomerulus.
- The bore (diameter of the lumen) of the afferent arteriole is greater than that of the efferent arteriole.
- The walls of the capillaries are composed of squamous endothelium resting on basement membrane (towards the outside of the capillary).
- There are many tiny pores - called **micropores** - between the cells and also in the cells of the capillary wall
- The wall lining the hollow Bowman's capsule is composed of squamous epithelium.
- The cells of this epithelium rest on the basement membrane and are modified to form specialised cells known as podocytes



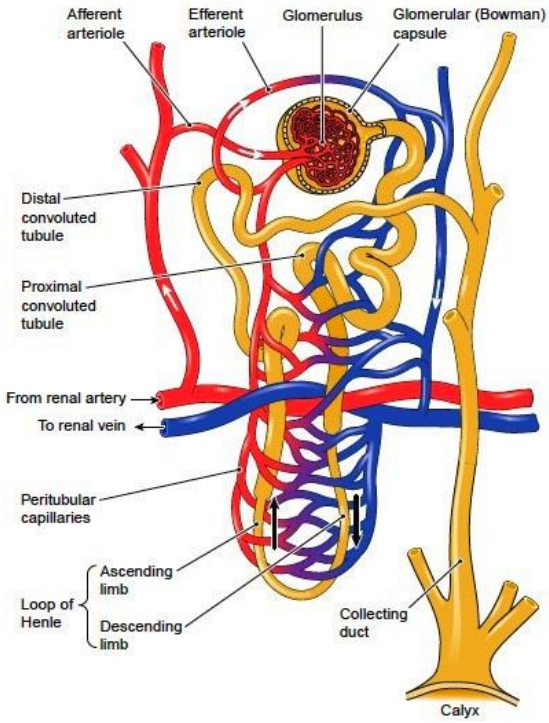
The Renal Tubules

- This is a tube that extends from the Malpighian body, and it consists of the following parts



The Blood Supply to the Kidney

- Branches of the **renal artery** divide into tiny **arterioles**.
- An **afferent arteriole** enters the Malpighian body
- It sub-divides in the Bowman's capsule to form a network of capillaries – the **glomerulus**.
- The capillaries reunite to form an **efferent arteriole** leaving the glomerulus. This has a narrower bore than the afferent arteriole has.
- The efferent arteriole sub-divides to form a network of capillaries that surround the loop of Henle and the convoluted tubules. This is known as the **peritubular capillary network**.
- These capillaries reunite to form a small venule which drains into the renal vein.



The Functioning of the Kidney

- The functioning of the kidney can be divided into three main processes:
  - **Glomerular filtration**
  - **Tubular reabsorbtion**
  - **Tubular excretion/secretion**