VISWASS SCHOOL & COLLEGE OF NURSING

GNM 1ST YEAR

ANATOMY AND PHYSIOLOGY

UNIT-8

THE EXCRETORY SYSTEM

LONG QUESTIONS AND ANSWERS

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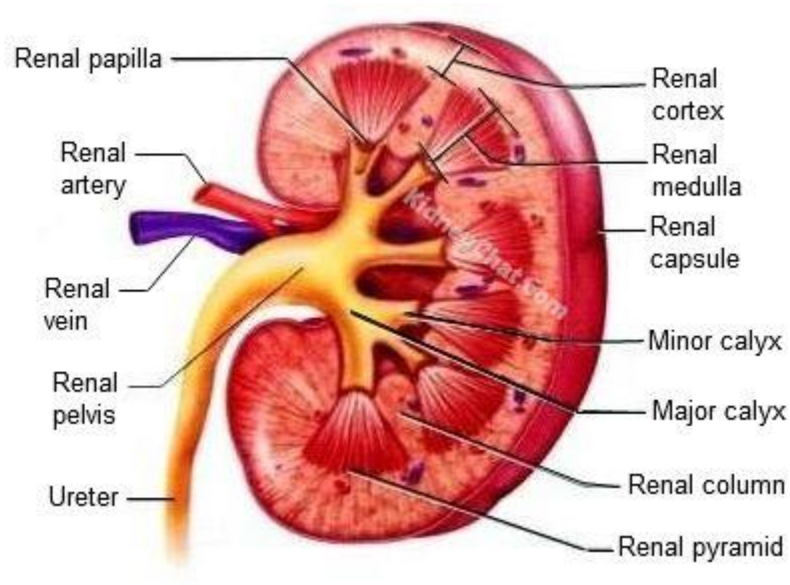
1)A)Draw the diagram of kidney and describe the microscopic structure of the kidney.

B)Discuss the structure of bladder.

C)Explain how urine is form. (6+3+6)

A)<u>Kidney:</u>

- The kidneys lies on the posterior abdominal wall, one on each side of the vertebral column, behind the peritoneum and below the diaphragm.
- They extend from the level of the 12th thoracic vertebra to the 3rd lumber vertebra, receiving some protection from the lower ribcage.
- The right kidney is usually slightly lower then the left, probably because of the considerable space occupied by the liver.
- Kidney are bean-shaped organs, about 11cm long, 6cm wide and 3cm thick;they weigh around 150g.
- They are embedded in, and held in position by, a mass of fat.
- A sheath of fibrous connective tissue, the renal fascia, encloses the kidney and the renal fat.



Organs associated with the kidneys:

- ➢ The kidney lies on either side of the vertebral column and each is associated with different structures.
- ➢ Right kidney:
  - Superiorly-the right adrenal gland.
  - Anteriorly- the right lobe of the liver, duodenum and the hepatic flexure of the colon.
  - Posteriorly-the diaphragm, and muscles of the posterior abdominal wall.
- ➢ Left kidney:
  - Superiorly-the left adrenal gland
  - Anteriorly-the spleen, stomach, pancreas, jejunum and splenic flexure of the colon.
  - Posteriorly-the diaphragm, and muscles of the posterior abdominal wall.

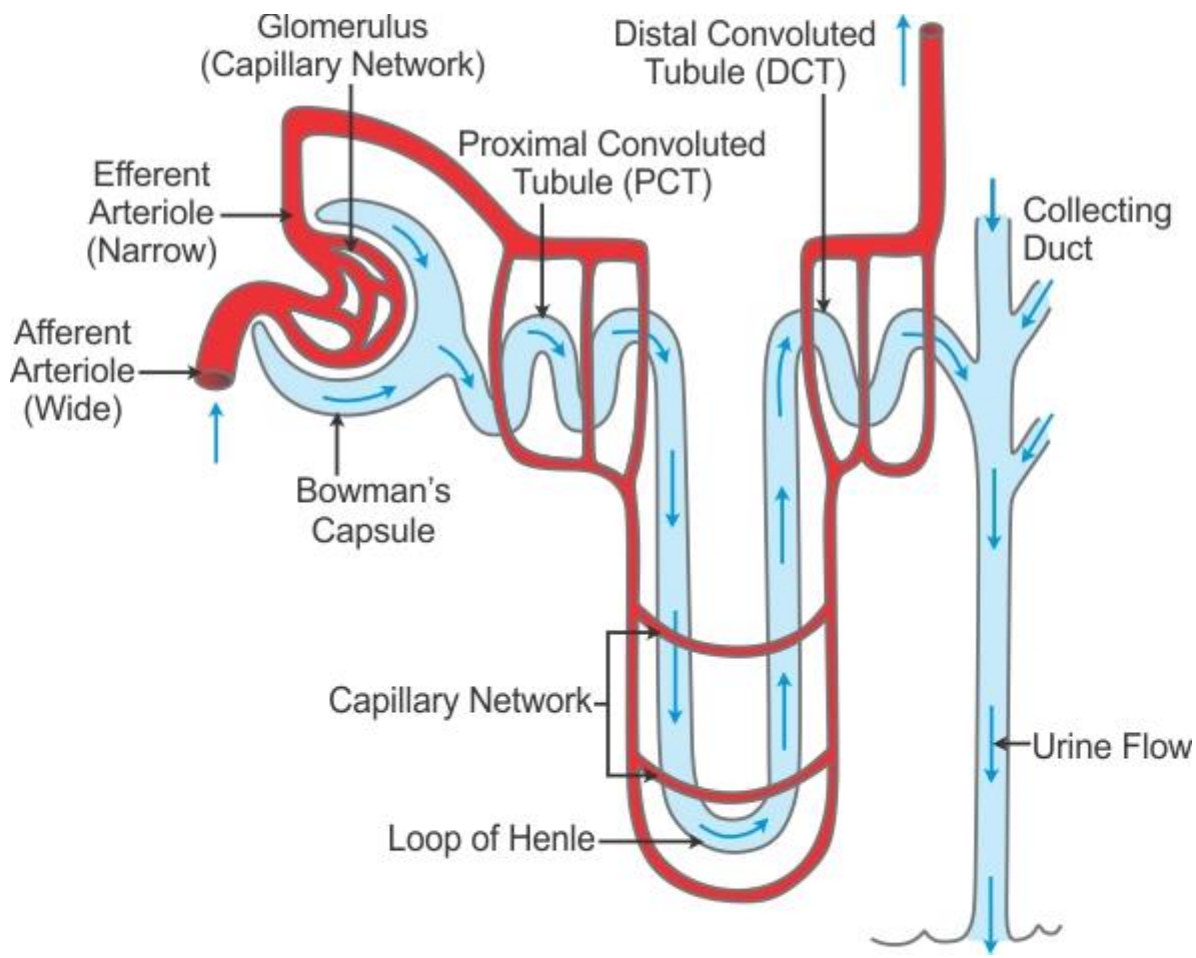
Microscopic structure of kidney:

- ➢ The kidney contains 1-2 million functional units, the nephrons, and a much smaller number of collecting ducts.
- ➢ The collecting ducts transport urine through the pyramids to the calyces, giving the pyramids their striped appearance.
- ➢ The collecting ducts are supported by connective tissue, containing blood vessels, nerves and lymph vessels.

The nephron:

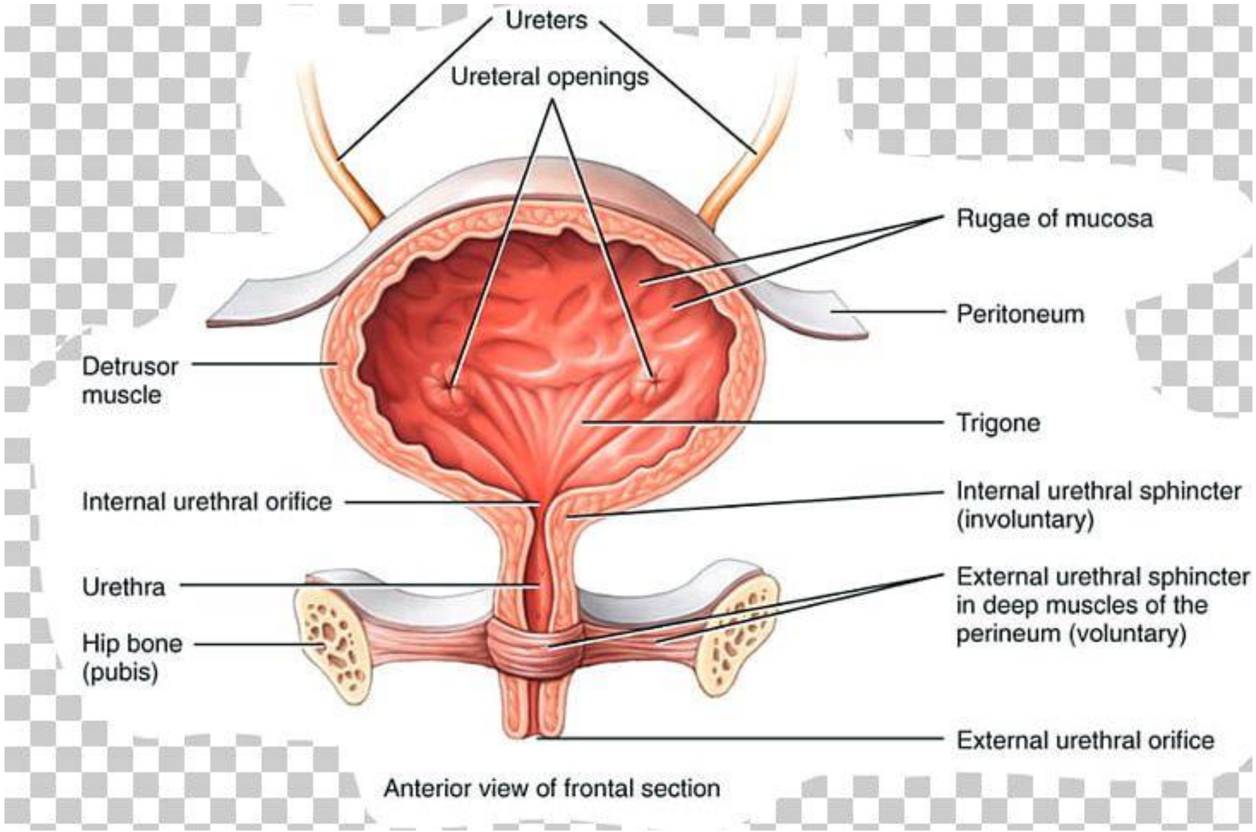
- The **nephron** is essentially a tubule that is closed at one end and opens into a collecting duct at the other end.
- The closed or blind end forms the cup-shaped glomerular (Bowman`s capsule)capsule, the **glomerulus**.
- Continuing from the glomerular capsule, the remainder of the nephron is about **3 cm long** and described in t**hree** parts;
    - The proximal convoluted tubule
    - The medullary loop(loop of Henle)
    - The distal convoluted tubule, leading into a collecting duct.
- The collecting ducts unite, forming larger ducts that empty into the minor calyces.

- The kidneys receive about 20% of the cardiac output. After entering the kidney at the hilum, the renal artery divides into smaller arteries and arterioles.
- In the cortex an arterioles, the **afferent arterioles**, enters each glomerular capsule and then subdivides into a cluster of tiny arterial capillaries, forming the glomerulus.
- Between these capillary loops are connective tissue phagocytic mesangial cells, which are part of the mononuclear phagocytes defence system.
- The blood vessel leading away from the glomerulus is the **efferent arterioles**.
- The afferent arterioles has a larger diameter than the efferent arterioles, which increases pressure inside the glomerulus and drives filtration across the glomerular capillary walls.
- The efferent arterioles divided into a second peritubular capillary network, which wraps around the remainder of the tubule, allowing exchange between the fluid in the tubule and the blood stream.
- This supplies tubular tissues with oxygen and nutrients, and removes waste products.
- Venous blood drained from this capillary bed eventually leaves the kidney in the renal vein, which empties into the inferior vena cava.
- The walls of the glomerulus and the glomerular capsule consist of a single layer of flattened epithelial cells.
- The glomerular walls are very permeable , to facilitate filtration.
- The walls of the remainder of the nephron and the collecting duct are formed by a single layer of simple squamous epithelium.
- Renal blood vessels are supplied by both sympathetic and parasympathetic nerves.
- The presence of both divisions of the autonomic nervous system controls renal blood vessel diameter and renal blood flow independently of autoregulation.



B)**Structure Of Bladder**

The urinary bladder is a reservoir for urine. It lies in the pelvic cavity and its size and position vary, depending on the volume of urine it contains. When distended, the bladder rises into the abdominal cavity.



<u>Structure:</u>

- The bladder is roughly pear-shaped, but become more ballon-shaped as it fills with urine.
- The posterior surface is the base.
- The bladder opens into the urethra at its lower point, the neck.
- The peritoneum covers only the superior surface before it turns upward as the parietal peritoneum, lining the anterior abdominal wall.
- Posteriorly it surrounds the uterus in the female and the rectum in the male.
- The bladder wall is composed of three layers.
  - The outer layer of loose connective tissue, containing blood and lymphatic vesselsand nerves, covered on the upper surface by the peritoneum.
  - The middle layer consisting of interlacking smooth muscle fibres and elastic tissue loosely arranged in three layers. This is called the detrusor muscle, and when it contracts, it empties the bladder.
  - The inner mucosa, composed of transitional epithelium that readily permits distension of the bladder as it fills.
- When the bladder is empty the inner lining is arranged in folds, or rugai, which gradually disappear as it fills.
- The bladder is distensible, but as it fills, awareness of the need to pass urine is felt.

- The total capacity is rarely more than about 600mL.
- The three orifices of the bladder wall form a triangle or trigone
- The upper two orifices on the posterior wall are the openings of the ureters; the lower orifice is the opening into the urethra.
- The internal urethral sphincter, the thickening of the urethral smooth muscle layer in the upper part of the urethra, controls outflow of the urine from the bladder.
- This sphincter is not under voluntary control.

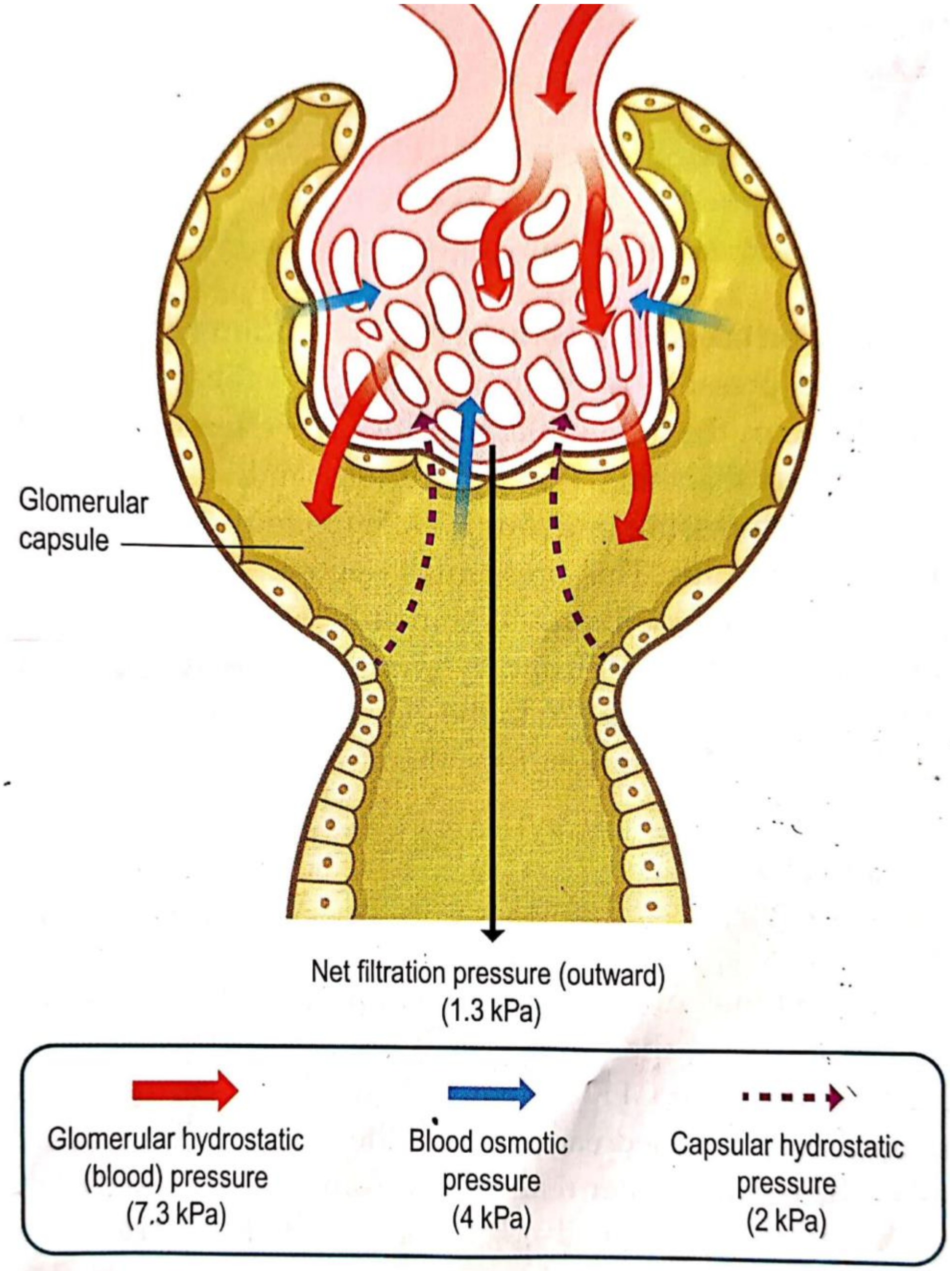
C)**<u>Urin Formation:</u>**

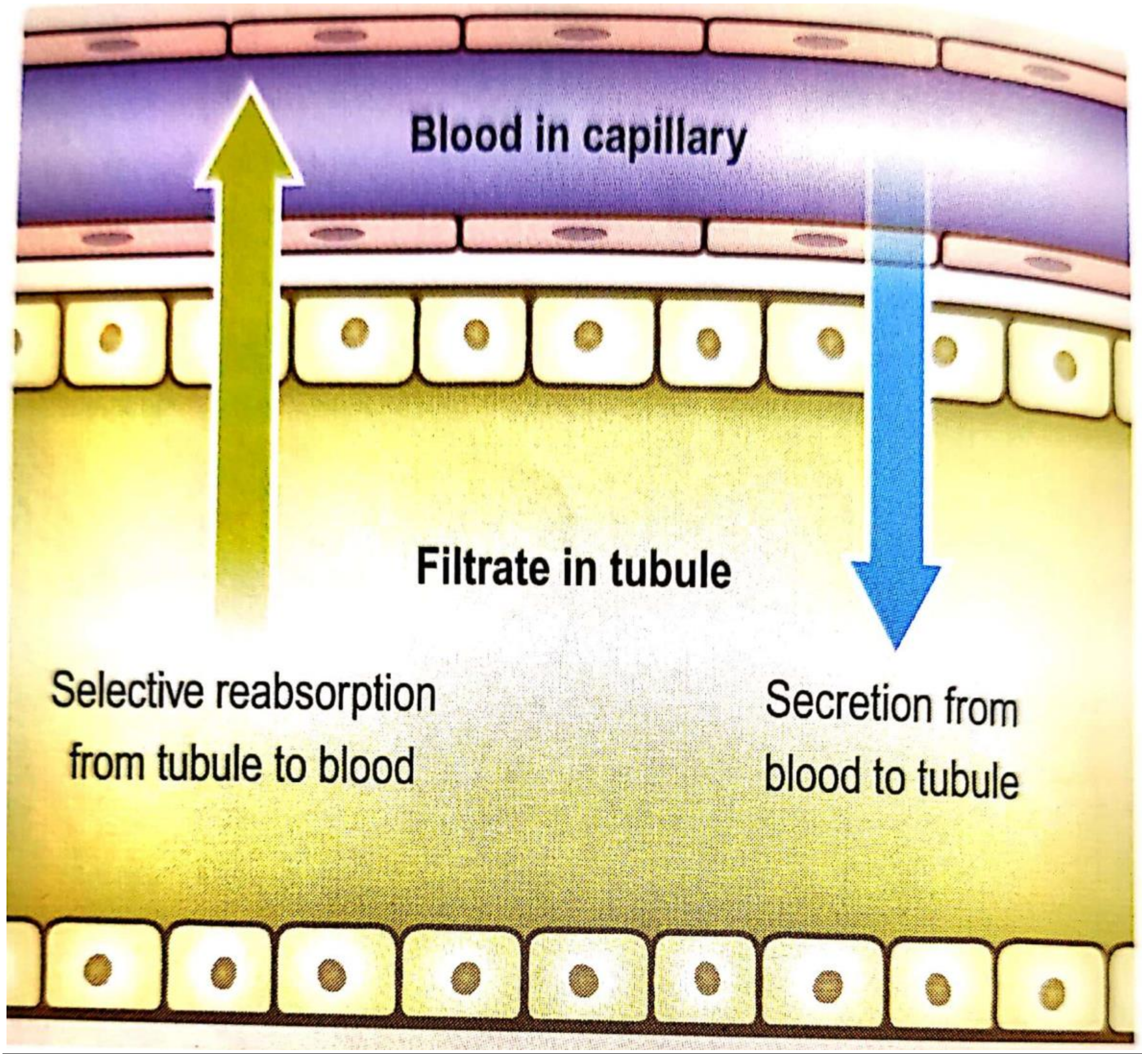
- The kidneys form urine, which passes to the bladder for storage prior to excretion.
- The composition of urine reflects the exchange of substances between the nephron and the blood in the renal capillaries.
- Waste products of protein metabolism are excreted, water and electrolyte levels are controlled, and Ph is maintained by excretion of hydrogen ions.
- There are three processes involved in the formation of urine:
  - Filtration
  - Selective reabsorption
  - Secretion

❖ <u>Filtration:</u>

- Filtration takes place through the semipermeable walls of the glomerulus and glomerular capsule.
- Water and other small molecules readily pass through, although some are reabsorbed later.
- The fluid filtered from the blood stream into the glomerular capsule is now called filtrate, and its composition will be adjusted as it passes through the other parts of the renal tubule.
- blood cells, plasma proteins and other large molecules are too large to filter through and therefore remain in the capillaries.
- The filtrate is very similar in composition to plasma, with the important exceptions of plasma proteins and blood cells.
- Filtration takes place because there is a difference between the blood pressure in the glomerulus and the pressure of the filtrate in the glomerular capsule.
- The efferent arterioles is narrower then the afferent arterioles, and so a capillary hydrostatic pressure of about 7.3kPa(55mmHg)builds up in the glomerulus.

- This pressure is opposed by the osmotic pressure of the blood, provided mainly by the plasma proteins, about 4kPa(30mmHg) and by filtrate hydrostatic pressure of about 2kPa(15mmHg), in the glomerular capsule.
- The volume of filtrate formed by both kidneys each minute is called the **glomerular filtrate rate** (GFR)
- In a healthy adult the GFR is about 125mL/min, i.e. 180litres of filtrate are formed each day by the two kidneys.





❖ <u>Selective reabsorption:</u>

- Most reabsorption from the filtrate back into the blood takes place in the proximal convoulated tubule, whose epithelial lining processes microvilli to increase surface area for absorption.
- Many substances are reabsorbed here, including water, electrolytes and organic nutrients such as glucose and amino acids.
- Some reabsorption is passive but some substances, e.g. glucose, are actively transported.
- Only 60-70% of filtrate reaches the mudullary loop.Much of this, especially water, sodium and chloride, is reabsorbed in the loop, so that only 15-20% of the original filtrate reaches the distal convoluted tubule, and the composition of the filtrate is now very different.
- More electrolytes are reabsorbed here, especially sodium, so the filtrate entering the collecting ducts is to reabsorb as much water as the body needs.
- Active transport takes place at carrier sites in the epithelial membrane, using chemical energy to transport substances against their concentration gradients.

- Some constituents of glomerular filtrate do not normally appear in urin because they are completely reabsorbed, unless blood levels are excessive.
- Reabsorption og nitrogenous waste products, such as urea, uric acid, is creatinine, is very limited.
- The kidneys maximum capacity for reabsorption of a substance is the transport maximum, or renal threshold.
- other substance reabsorbed by active transport include sodium, calcium, potassium, phosphate and chloride.
- The transport maximum, or renal threshold, of some substances varies according to body need at a particular time, and in some cases reabsorption is regulated by hormones.

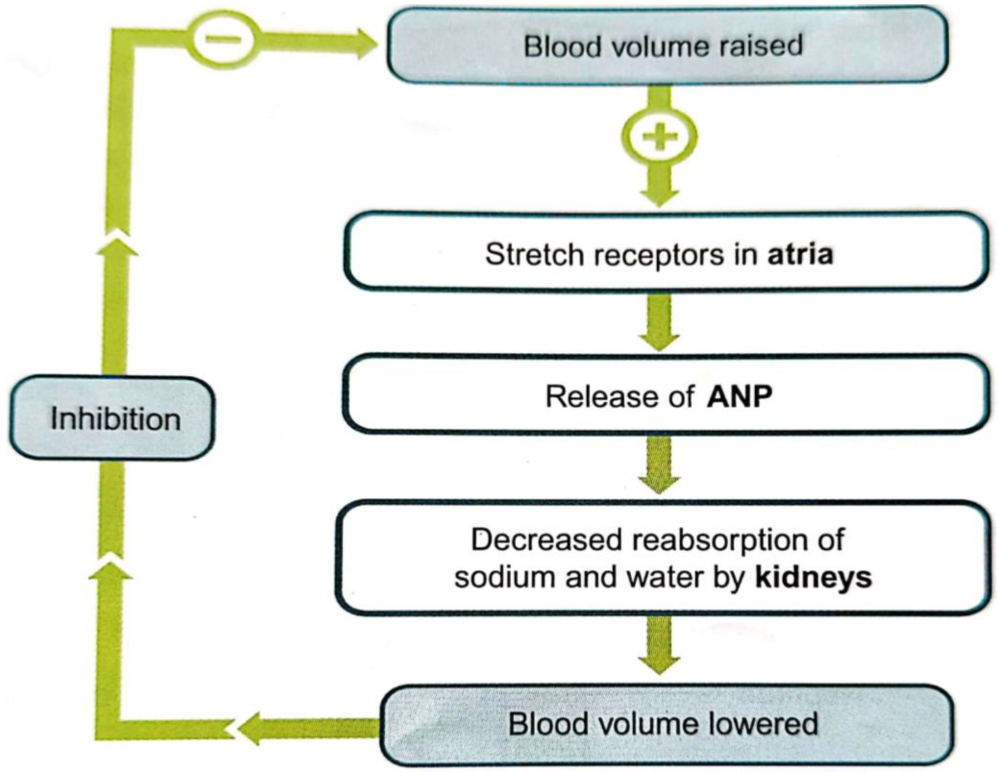
  Hormones that influencing selecting reabsorption:

  Several hormones play such a role, each being regulated by a negative feedback mechanism.

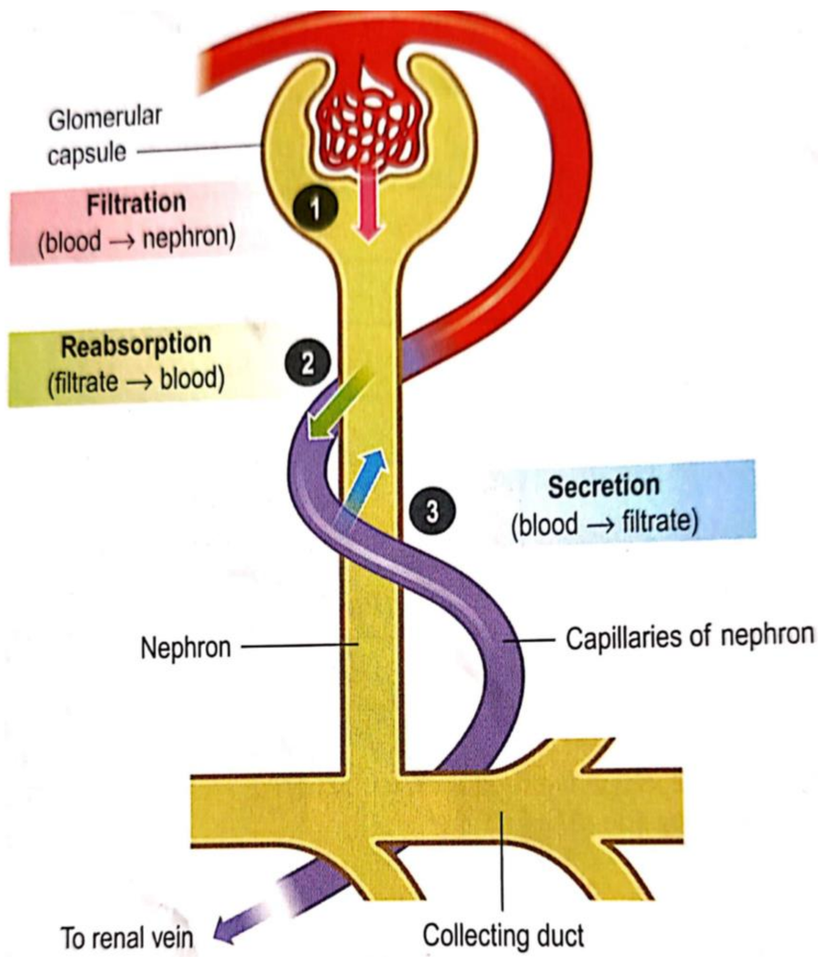
  - Parathyroid hormone: this is secreted by the parathyroid glands and, together with calcitonin from the thyroid gland, regulates the reabsorption of calcium and phosphate from the distal collecting tubules, so that normal blood vessels are maintained.
  - Antidiuretic hormone: (ADH) is secreted by the posterior pituitary gland, it increases the permeability of the distal convoluted tubules and collecting ducts, increasing water reabsorption.
  - Aldosterone: secreted by the adrenal cortex, this hormone increases the reabsorption of sodium and water, and the excretion of potassium.
  - Atrial natriuretic peptide: (ANP) is a hormone secreted by the atria of the heart in response to stretching of the atrial wall when blood volume is increased.

❖ Tubular secretion:

- Filtration occurs as blood flows through the glomerulus.
- Substances not required and foreign materials, e.g. drugs including penicillin and aspirin, may not be entirely filtrated out of the blood because of the short time they remain in the glomerulus are too large to pass through the filtration pores.
- Such substances are cleared by secretion from the peritubular capillaries into the filtrate with in the convoluted tubules.
- Tubular secretion of hydrogen ions is important in maintaining normal blood pH.



The processes that form urine



2)A)Write down the structure and functions of skin? (8+7)

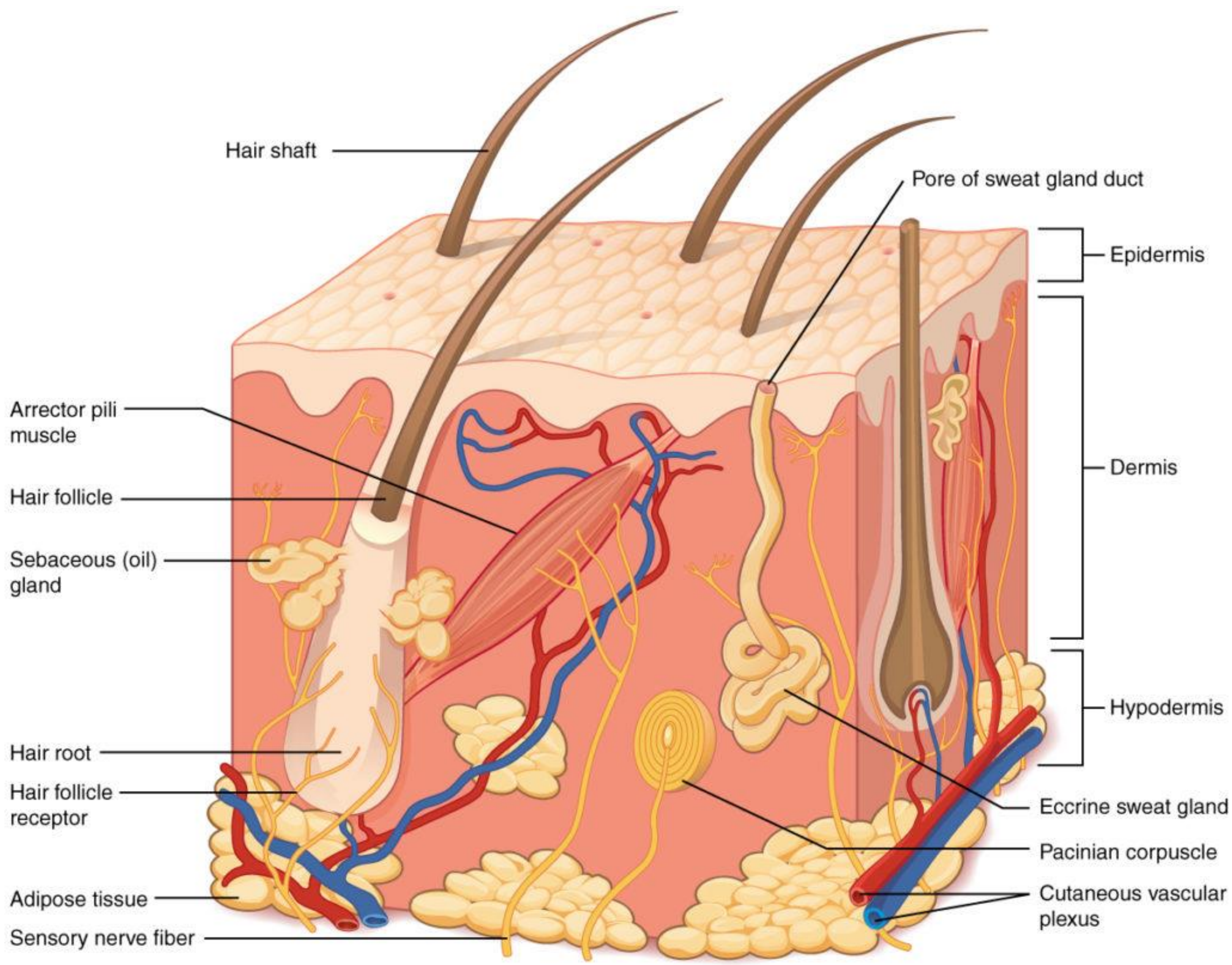
B)Briefly explain the regulation of the body temperature?

A) <u>Skin</u>

The skin is one of the largest organs in the body in surface area and weight.

Skin is completely covers the body and is continuous with the membranes lining the body orifices.it:

- Protects the underlying structures from injury and from invasion by microbes.
- Contains sensory nerve endings that enable discrimination of pain , temperature and touch.
- Is involved the regulation of body temperature.



<u>Structure:</u>

➢ Skin has a surface area of about 1.5-2 square metres in adults.

- In many parts of the body, it contains accessory structures; glands, hair and nails.
- It varies in thickness, being thickest on the palms of the hands and soles of the feet.
- There are two main layers: the superficial layer is called the **epidermis,** and the layer below is the **dermis**.
- Between the dermis and underlying structures is a subcutaneous layer composed of areolar tissue and adipose (fat) tissue.

❖ Epidermis:

- this is composed of stratified keratinised squamous epithelium
- there are no blood vessels or nerve endings in the epidermis, but its deeper layers are bathed in interstitial fluids from the dermis, which provides oxygen and nutrients and drains away as lymph.
- There are several layers of cells in the epidermis, which extended from the deepest basal layer to the most superficial stratum corneum(a thick horny layer)
- The cells of the epidermis originate in the basal layer, which is made up of cuboidal, nucleated, highly active epithelial cells that are constantly dividing.
- As new cells are formed, they are pushed upwards, away from the basal layer and further from their blood and nutrient supply.
- As they progress towards the skin surface, their shape and structure gradually change.
- By the time they reach the skin surface, they are flat, thin, non-nucleated, dead cells, or squames, in which the cytoplasm has been replaced by the fibrous protein keratin.
- The surface cells are constantly rubbed off and replaced by those beneath.
- Complete replacement of the epidermis takes about a month.
- Hairs, secretions from sebaceous glands and ducts of sweat glands pass through the epidermis to reach the skin surface.
- Upward projections of the dermal layer, the dermal papillae, anchor the dermis securely to the epidermis and allow passage and exchange of nutrients and wastes to the lower part of the epidermis.
- This arrangement stabilises the two layers, preventing damage due to shearing forces.
- Blisters develop when trauma separates the dermis and epidermis, and serous fluid collects between the two layers.
- Where the skin is subject to greater wear and tear.
- Skin colour is affected by various factors.

    - Melanin, a dark pigment derived from amino acid tyrosine and secreted by melanocytes in the deep germinative layer, is absorbed by surrounding epithelial cells. The amount is genetically determined and varies between different parts of the body, between people of the same ethnic origin and between ethnic groups. The number of melanocytes is fairly constant, so the differences in colour depend on the amount of melanin secreted. It protects the skin from the harmful effects of ultraviolet rays in sunlight. Exposure to sunlight promotes synthesis of melanin.
    - Normal saturation of haemoglobin and the amount of blood circulating in the dermis give white skin its pink colour. When oxygen saturation is very low, the skin is white people may appear bluish(cyanosis)
    - Excessive levels of bile pigments in blood and carotenes in subcutaneous fat gives the skin a yellowish colour.

- Dermis:
  - The dermis is tough and elastic.
  - It is formed from connective tissue, and the metrix contains collagen fibres interlaced with elastic fibres.
  - Rupture of elastic fibres occurs when the skin is overstretched, resulting in permanent striae, or stretch marks, which are typically found in pregnancy and obesity.
  - Collagen fibres bind water and give the skin its tensile strength, but as this ability declines with age, wrinkles develop.
  - Fibroblasts, macrophages and mast cells are the main cells found in the dermis.
  - The subcutaneous layer, containing areolar tissue and varying amounts of adipose tissue, lies under the dermis.
  - Structure founds in the dermis are:
    - small blood and lymph vessels
    - sensory nerve endings
    - sweat glands and their ducts
    - hairs, arrector pili muscles and sebaceous glands.

Blood and lymph vessels: Arterioles form a fine network with capillary branches supplying sweat glands, sebaceous glands, hair follicles and the dermis. Lymph vessels also form a network throughoutthe dermis.

Sensory nerve endings: Sensory receptors sensitive to touch, temperature, pressure, and pain are widely distributed in the dermis.

Sweat glands:These are widely distributed through out the skin and are most numerous in the palms of the hands, soles of the feet, axillae and groins. They are formed from epithelial cells.

There are two types of sweat gland:

Eccrine sweat glands are the more common type and open on to the skin surface through tiny pores.

Apocrine sweat glands open into hair follicles and become active at puberty.

The most important functions of sweat is in the regulation of body temperature.

Hairs: these grow outwards from hair follicles, downgrowths of epidermal cells into the dermis or subcutaneous tissue. At the base of the follicle is a cluster of cells called the hair papilla or bulb.

A hair is formed by multiplication of cells of the bulb and as the hairs are pushed upwards, away from their source of nutrition, the cells die and become keratinised.

Arrector pili: arrector pili are little bundles of smooth muscle fibres attached to the hair follicles.

Sebaceous glands: sebaceous glands consist of secretory epithelial cells derived from the same tissue as the hair follicles. They secret an oily antimicrobial substances, sebum, into the hair follicles and are present in the skin of all parts of the body expect the palms of the hands and the soles of the feet.

Nails: human nails are equivalent to the claws, horns and hooves of animals. Derived from the same cells as epidermis and hair, these are hard, horny keratin plates that protect the tips of the fingers and toes.

Function

- Protection
- Regulation of body temperature
- Formation of vitamin-D
- Cutaneous sensation
- Absorption
- Excreation

B)Regulation Of Body Temprature:

- Core body temperature remains fairly constant at around 36.8^{o} C across a wide range of environmental temperatures, ensuring that the optimal range for enzyme activity required for metabolism is maintained.
- In health, variation are usually limited to between 0.5 and 0.75^{o}C, although temperature rises slightly in the evening, during exercise and in women just after ovulation.
- To maintain this constant temperature, a nehgative feedback system regulates the balance between heat produced in the body and heat lost to the environment.

  <u>Heat production</u>

  - When metabolic rate increases, body temperature rises, when it decreases, body temperature fall.
  - Some of all energy released during metabolic activity is in the form of heat; the most active organs involved are:
    - Skeletal muscle contraction, which produces a large amount of heat
    - The liver is very active metabolically, and so generates considerable heat as a by- product.
    - The digestive organs generate heat during peristalsis and the chemical reactions involved in digestion.

<u>Heat loss</u>

- Most heat loss from the body occurs through the skin
- Small amounts are lost in expired air, urine and faeces.
- Only heat loss through the skin can be regulated; heat lost by the other routes can not be controlled.
- Heat loss through the skin is affected by the difference between body and environmental temperature, the amount of the body surface exposed and the type of clothes worn.
- Air insulates against heat loss when trapped in layers of clothing and between the skin and clothing.
- For this reason, several layers of light weight clothes provide more effective insulation against low environmental temperatures than one heavy garment.

Mechanisms of heat loss:

- There are four mechanism of heat loss;

- Radiation, the main mechanism, when exposed parts of the body radiate heat away from the body.
- Evaporation, when the body is cooled as body heat converts the water in sweat to water vapour.
- Conduction, when clothes and other objects in direct contact with the skin take up heat.
- Convection,. When air passing over exposed parts of the body is heated and rises, and cool air replaces it, setting up convection currents.

Control of body temperature:

- Temperature regulating centre in the hypothalamus is sensitive to the temperature of circulating blood.
- This centre response to decreasing temperature by sending nerve impulses to:
- (Arterioles in the dermis, which constrict, decreasing blood flow to the skin)
- (Skeletal muscles, stimulating shivering)
- As heat is conserved, body temperature rises;when it returns to the normal range, the negative feedback mechanism is switched off.

Activity of the sweat glands:

- When body temperature is increased by 0.25-0.5^{o}C the sweat glands secrete sweat on the skin surface.
- Evaporation of sweat cools the body, but is slower in humid conditions.
- Loss of heat from the body by evaporation of water through the skin and expired air still occurs even when the environmental temperature is low.
- This is called insensible water loss(around 500ml/day) and is accompanied by insensible heat loss.

Regulation of blood flow through the skin:

- The amount of heat lost from the skin depends largely on blood flow through dermal capillaries.
- As body temperature rises, the arterioles dilate and more blood enters the capillary network in the skin.
- The skin is warm and pink in colour.
- In addition to increasing the amount of sweat produced, the temperature of the skin rises and more heat is lost by radiation, conduction and convection.

Fever:

- This is often the result of infection and is caused by release of chemicals(called pyrogens) from inflammatory cells and invading bacteria.
- Pyrogens, e.g. interleukin 1, act on the hypothalamus, which releases prostaglandins that reset the hypothalamic thermostat to a higher temperature.
- The body response by activating heat-promoting mechanisms.
- When the thermostat is reset to the normal level, heat-loss mechanisms are activated.

Hypothermia:

- This is defined as a core(e.g. rectal) temperature below 35^{o}C.
- At a core temperature below 32^{o} C, compensatory mechanisms that normally restore body temperature fail.
- Death usually occurs when the temperature falls below 25^{o}C.
- Individuals at the extreames of age are prone to hypothermia, as temperature regulation is less effective in babies, young people and older adults.