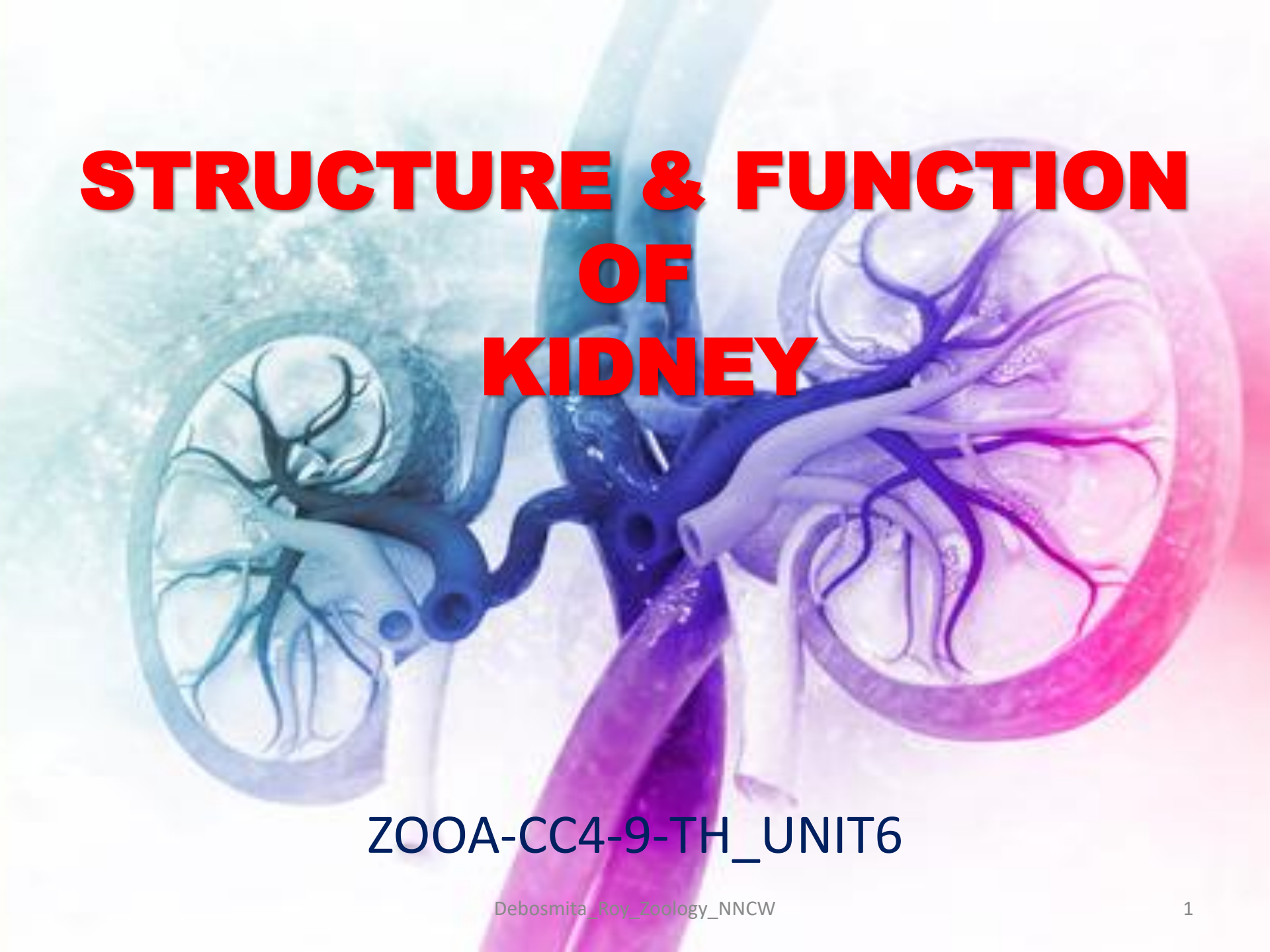
STRUCTURE & FUNCTION OF KIDNEY



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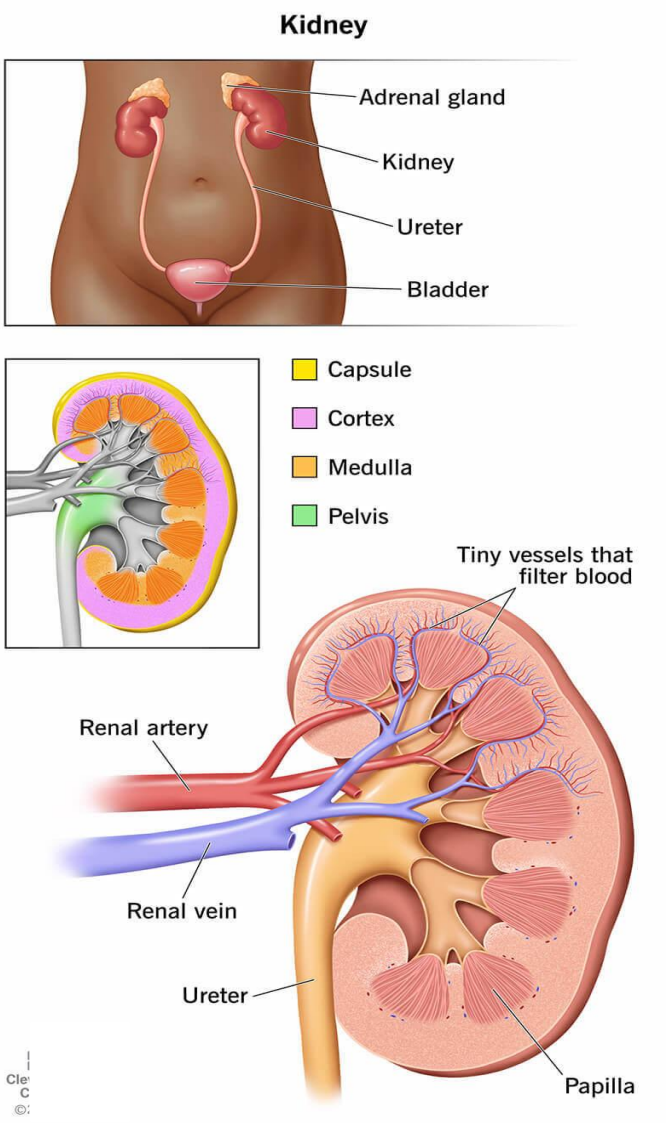
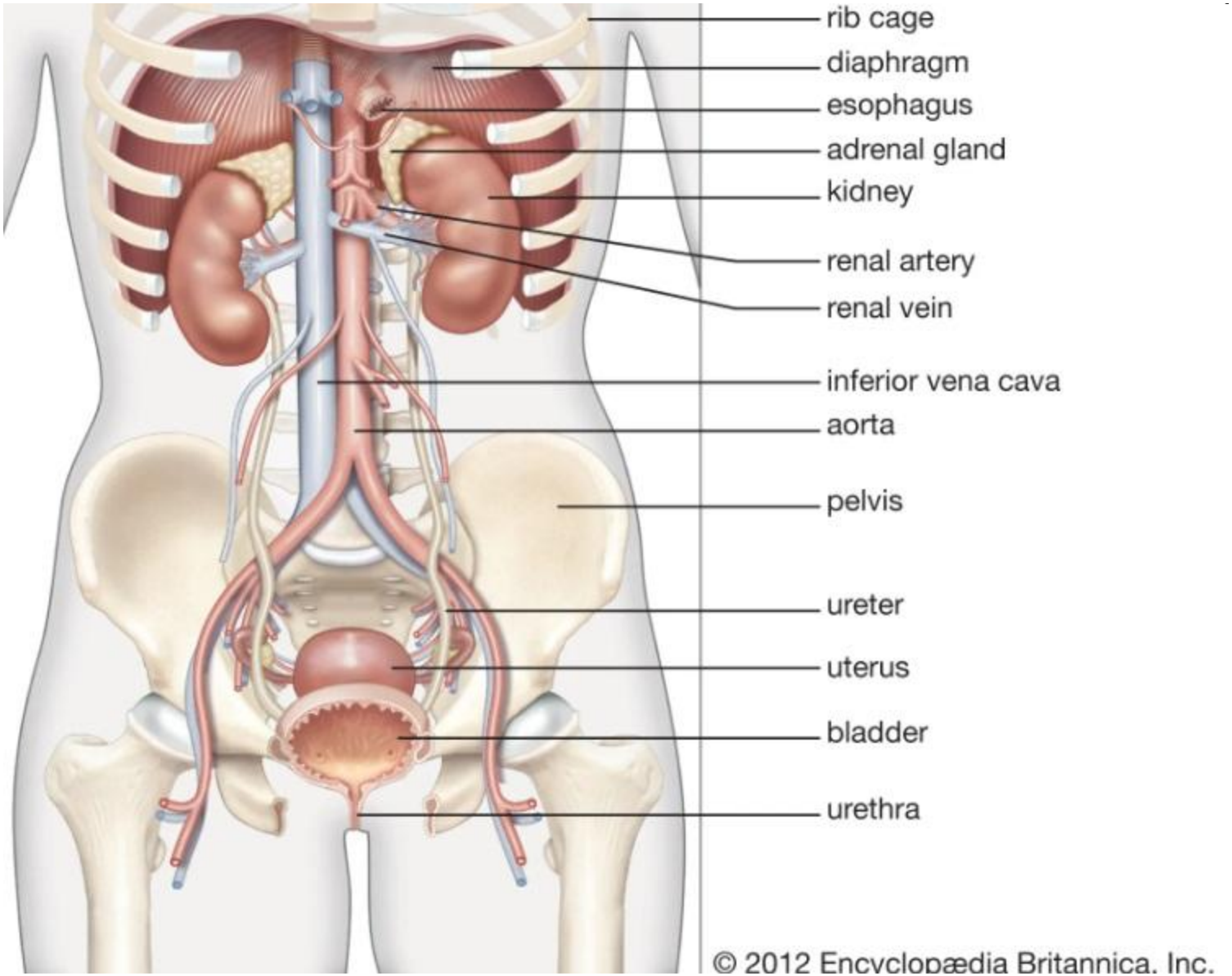
Location

- **Typically, one kidney sits on either side of the spine.**
- **Two in Number.**
- **Bean shaped structure.**
- **Present below the ribcage.**
- **One ureter connects each kidney to the bladder.**




rib cage
diaphragm
esophagus
adrenal gland
kidney
renal artery
renal vein
inferior vena cava
aorta
pelvis
ureter
uterus
bladder
urethra
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GENERAL FEATURES

- Cover: Capsule.
- Convex part: Cortex,
- Concave part:Medulla

- Structural & functional unit of Kidney: **NEPHRON**

Kidney capsule (renal capsule)

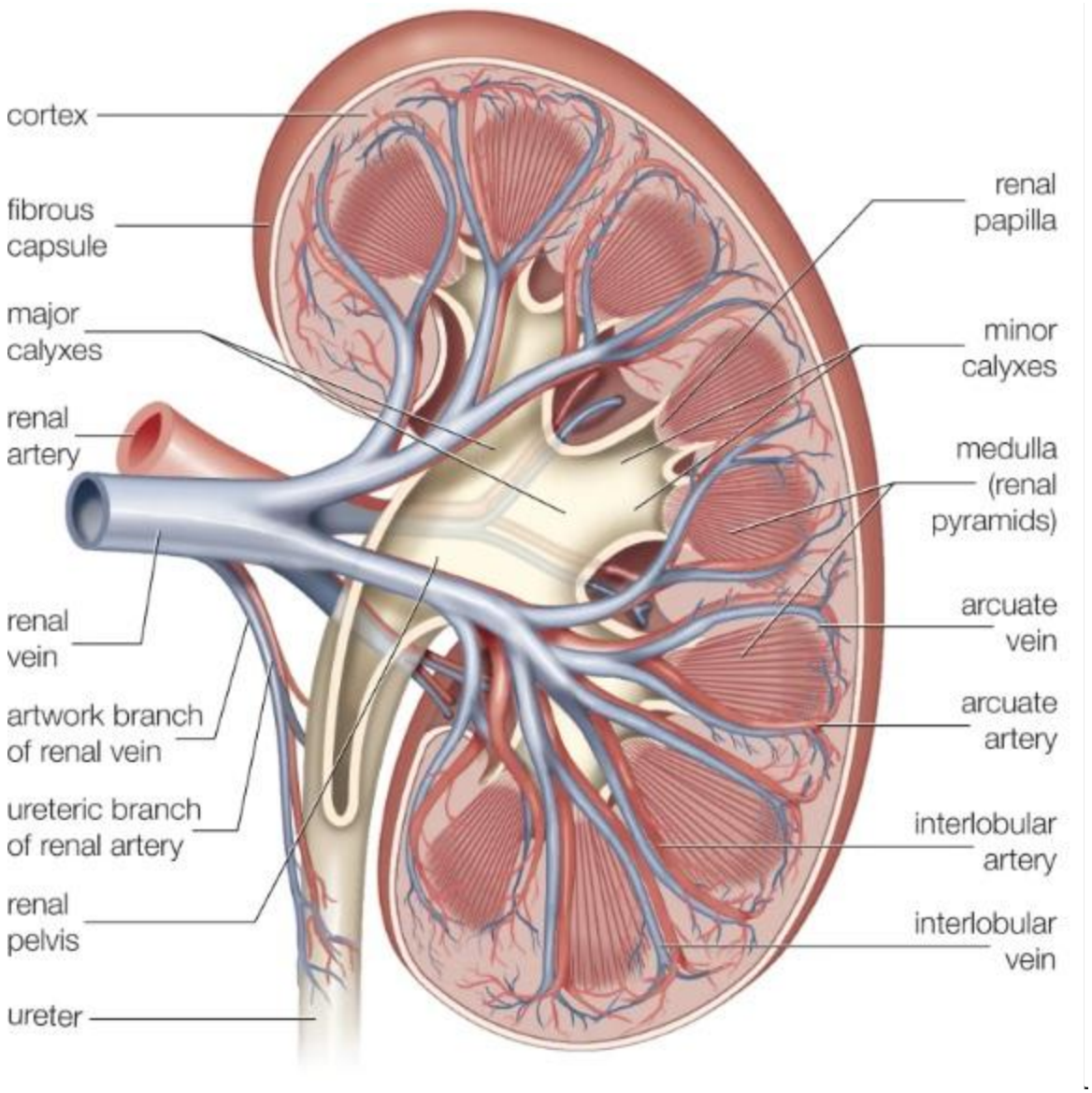
- 3 layers of connective tissue or fat.
- It protects your kidneys from injury,
  increases their stability .
  and connects kidneys to surrounding tissues.

Renal artery

- Large blood vessel that controls blood flow in kidneys.
- At rest, it pump a little over 1.2 liters of blood
  to kidneys each minute.

Renal cortex

- The outer layer of kidney, where the nephron begin.
- The renal cortex also creates the hormone erythropoietin (EPO),
  which helps make red blood cells in bone marrow.


cortex
fibrous capsule
major calyxes
renal artery
renal vein
artwork branch of renal vein
ureteric branch of renal artery
renal pelvis
ureter
renal papilla
minor calyxes
medulla (renal pyramids)
arcuate vein
arcuate artery
interlobular artery
interlobular vein

Renal medulla

- Inner part of your kidney.
- It contains most of the nephrons with their glomeruli and renal tubules.

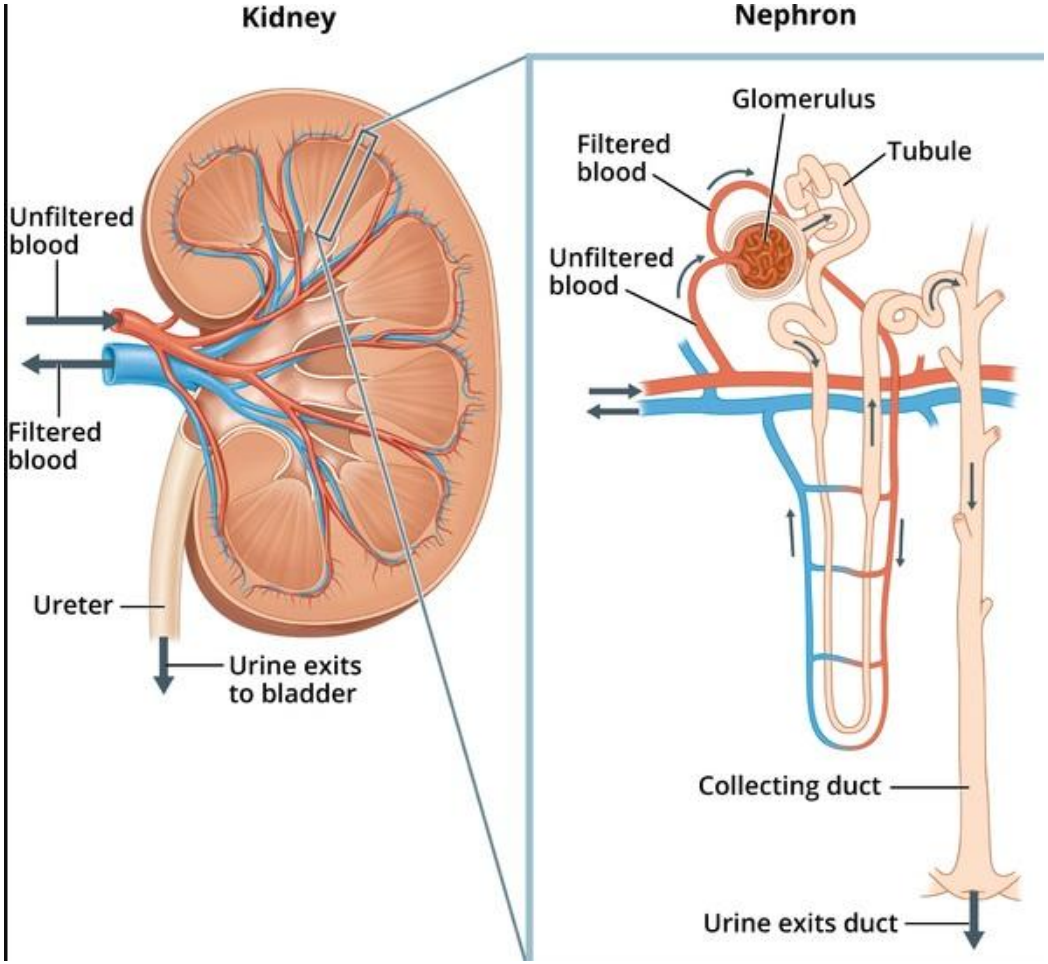
The renal tubules carry urine to the renal pelvis.

Renal papilla

- Pyramid-shaped structures transfer urine to the ureters.
- This funnel-shaped structure collects urine and passes it down two ureters.
- Urine travels from the ureters to the bladder, where it's stored.

Renal vein

- Each kidney has one Renal vein.
- This vein is the main blood vessel that carries filtered blood out of kidneys and back to heart.



Uriniferous Tubules

They consist of:

1. Secretory portion or nephron.
2. Non-secretory portion or collecting portion or duct system.

ANATOMY OF NEPHRON

- Made by epithelial cells.
- Number:10-40 Lakhs
- Covering: Basal Lamina ;Reticular fibre network.
- Bunches of Renal corpuscles > filter like Glomerules originated.
- Cup like end: Bowman's capsule, (Location: Cortex)

Inner layer:Visceral layer;

Outer layer:Parietal layer

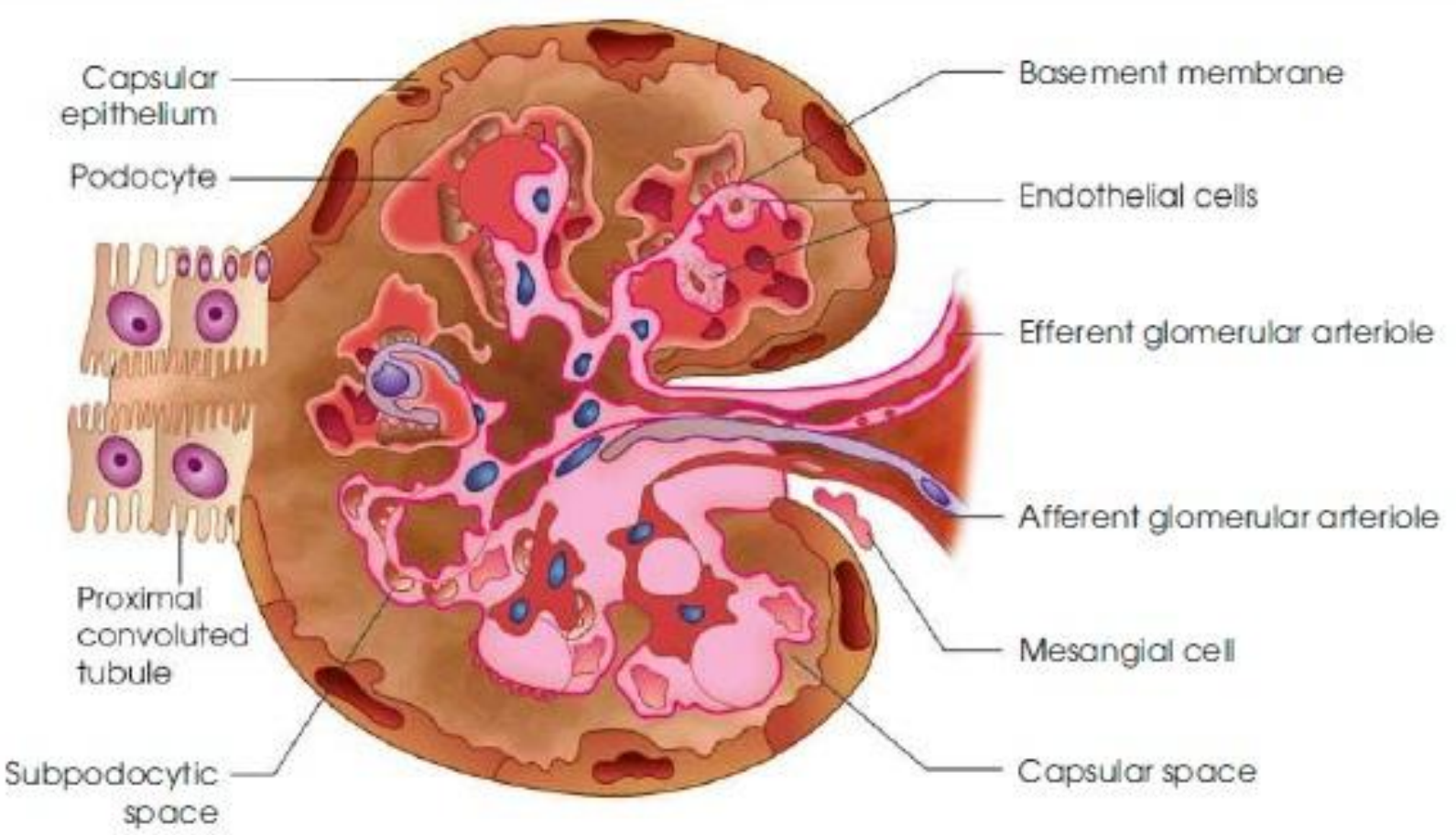
The nephrons consist of the following parts:

a. Renal or Malpighian corpuscle
b. Proximal convoluted tubule
c. Loop of Henle
d. Distal convoluted tubule.
e. Collecting Tubule

Glomerulus

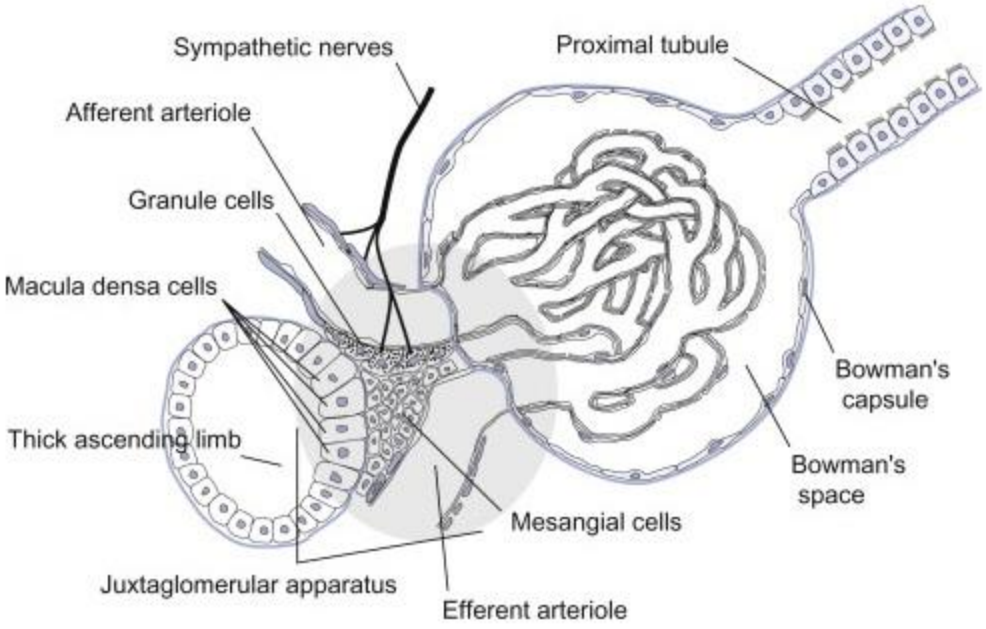
- Each nephron starts with a tuft of 6 to 8 renal blood capillaries invaginated into the end of a tubule. This structure is named as **glomerulus.**
- The **afferent arteriole** breaks up into about fifty capillary loops and forms the glomerular tuft which lies within **Bowman's capsule**,a double-walled epithelial sac.
- The capillary tuft reunites and forms the **efferent arteriole** which passes out of the glomerulus.
- The afferent vessel is short and wide whereas the efferent vessel is narrow and long.

  Utility: This arrangement makes the glomerular blood pressure much higher (70 mm Hg)than the capillary bed elsewhere and facilitates filtration.


Capsular epithelium
Podocyte
Proximal convoluted tubule
Subpodocytic space
Basement membrane
Endothelial cells
Efferent glomerular arteriole
Afferent glomerular arteriole
Mesangial cell
Capsular space

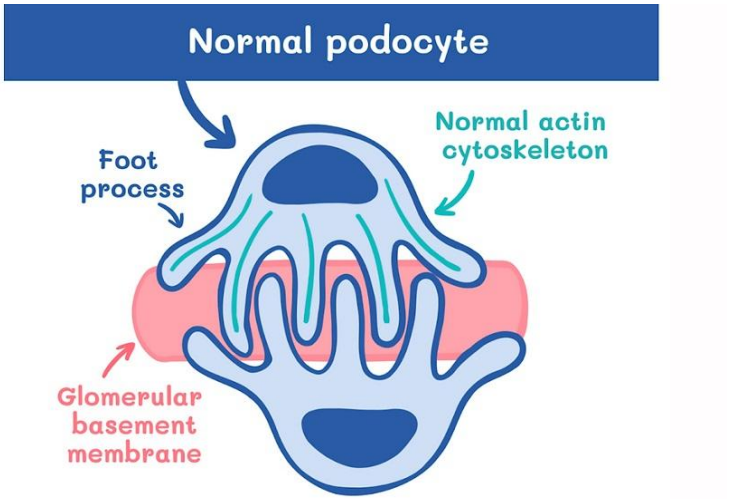
Juxtaglomerular cells

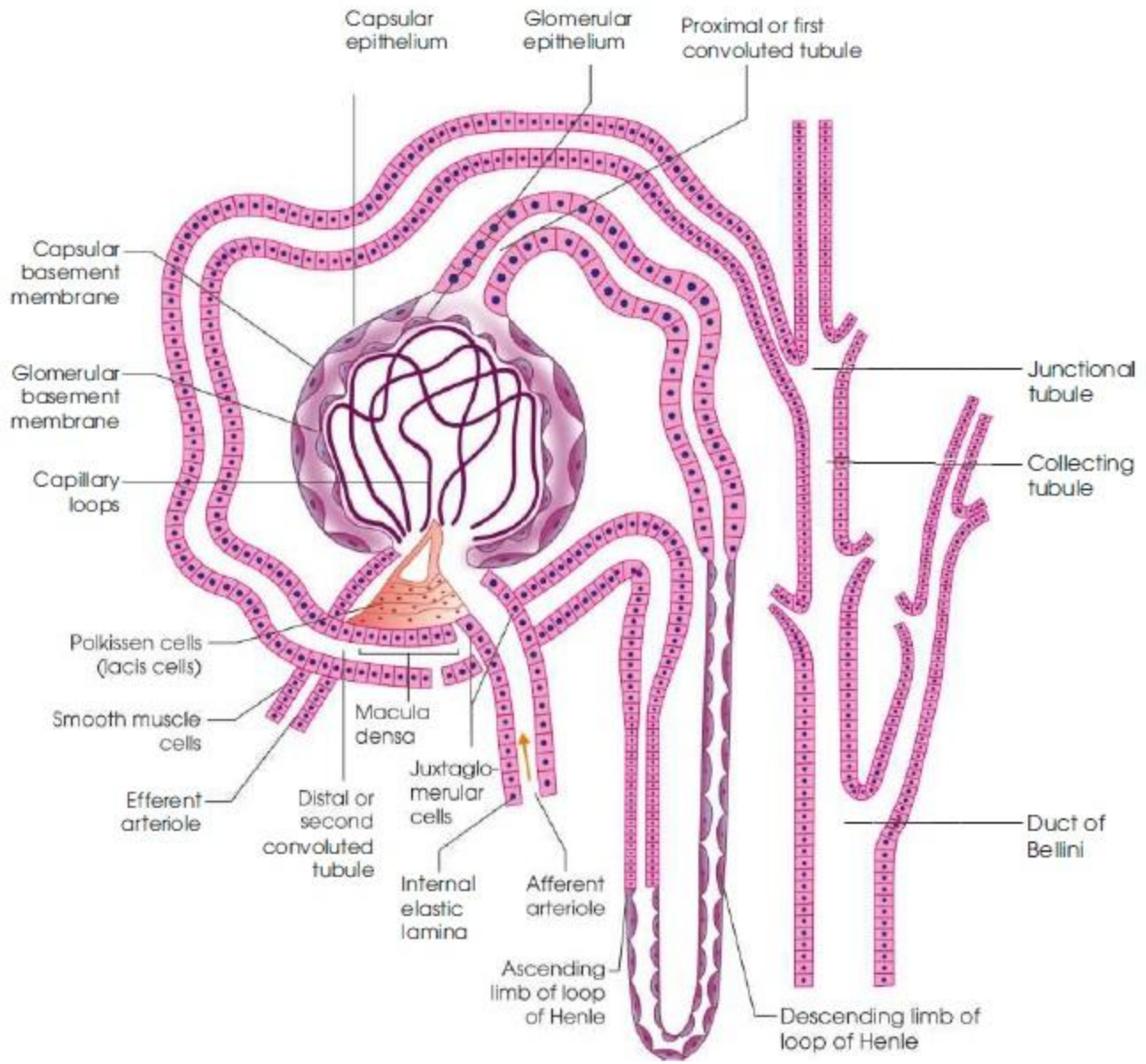
- Just before entering the glomerulus, the media of the afferent arteriole is found to contain a thick cuff of large modified muscle cells.



Bowman's Capsule

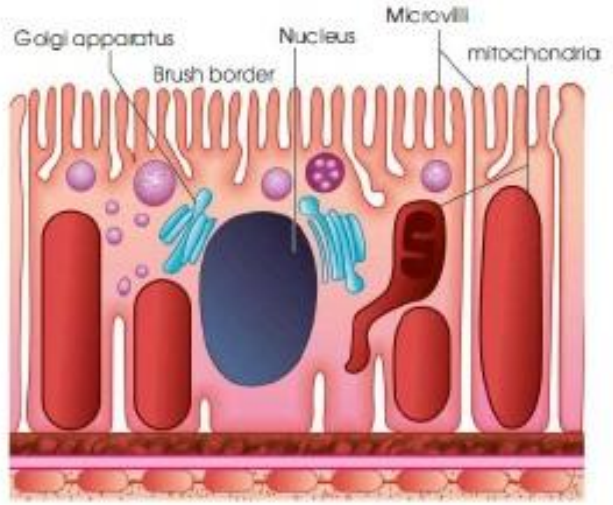
- Dilated blind end of the nephron, invaginated by the glomerular tuft.
- It consists of two layers-
- The parietal layer : squamous epithelium of flat polygonal cells.
- Visceral layer: Modified Epithelial cells,known as podocytes,with a large number of small branches-the pedicles or end feet.
- Subpodocytic space : The space between the basement membrane and the podocyte.




Capsular epithelium
Glomerular epithelium
Proximal or first convoluted tubule
Capsular basement membrane
Glomerular basement membrane
Capillary loops
Junctional tubule
Collecting tubule
Polkissen cells (lacis cells)
Smooth muscle cells
Macula densa
Efferent arteriole
Distal or second convoluted tubule
Juxtaglomerular cells
Internal elastic lamina
Afferent arteriole
Duct of Bellini
Ascending limb of loop of Henle
Descending limb of loop of Henle

PCT

- Lined by simple cuboidal epithelium comprising brush borders.
- Length :14mm
- Nucleus:Large,spherical.
- Eosinophilic cytoplasm.
- Terminates into 'u' shaped loop of Henle.
- Function:Absorbs 85% NaCl,water,glucose,aa,vitamins & release Urea,Uric Acid,Creatinine etc.



Loop of Henle

- U shaped loop .
- Descending & Ascending limb,dips into medulla.
- Thick (Cuboidal cells without microvilli) & thin segments(Lining of Squamous epithelium with microvilli).
- Terminate into DCT
- Function: Act as Counter current multiplier.

Making of hypotonic Urine

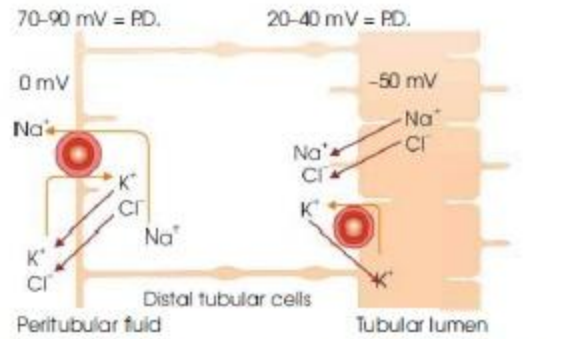
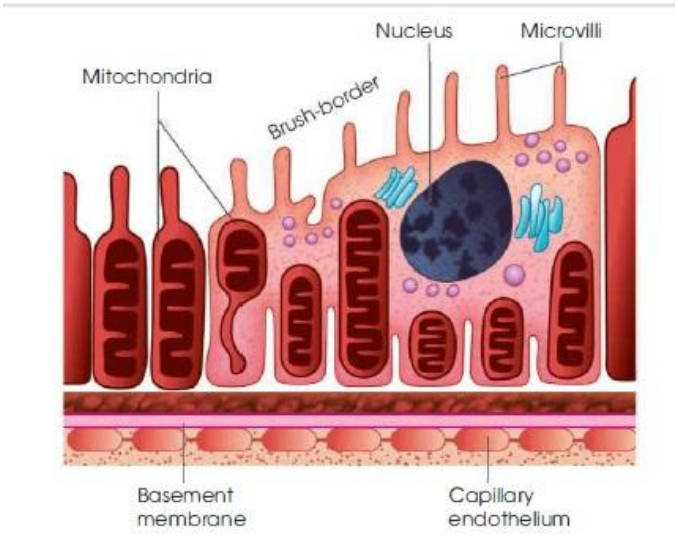


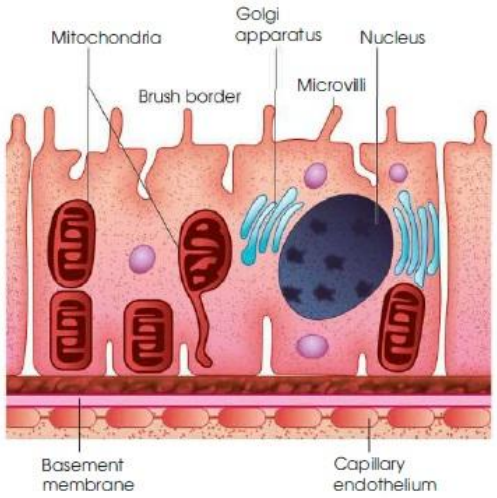
Fig. 62.10: Diagrammatic representation of electron microscopic structure of a cell living the descending limb of loop of Henle



DCT

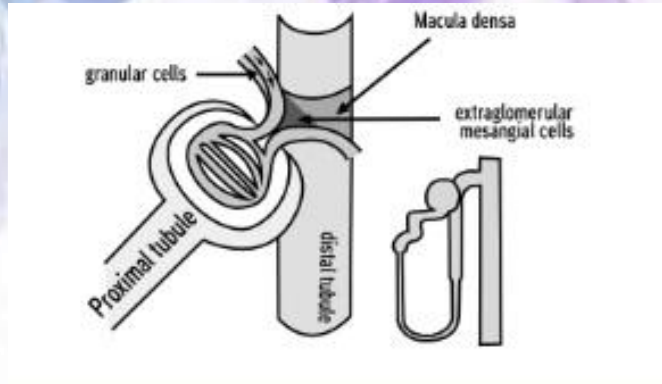
- Situated in the cortex.
- Average length of 4.6 to 5.2 mm and diameter 20-50 µm and lined by cubical epithelium without any true brush border.
- There is extensive infolding of the cell membrane.
- It has a much smaller number of microvilli .
- The diameter of the lumen of distal convoluted tubule is greater than that of proximal one and the tubules contain a larger number of cells.

Function: Reabsorb small quantities of water and electrolytes due to a small number of microvilli in addition to determining urinary acid-base balance.



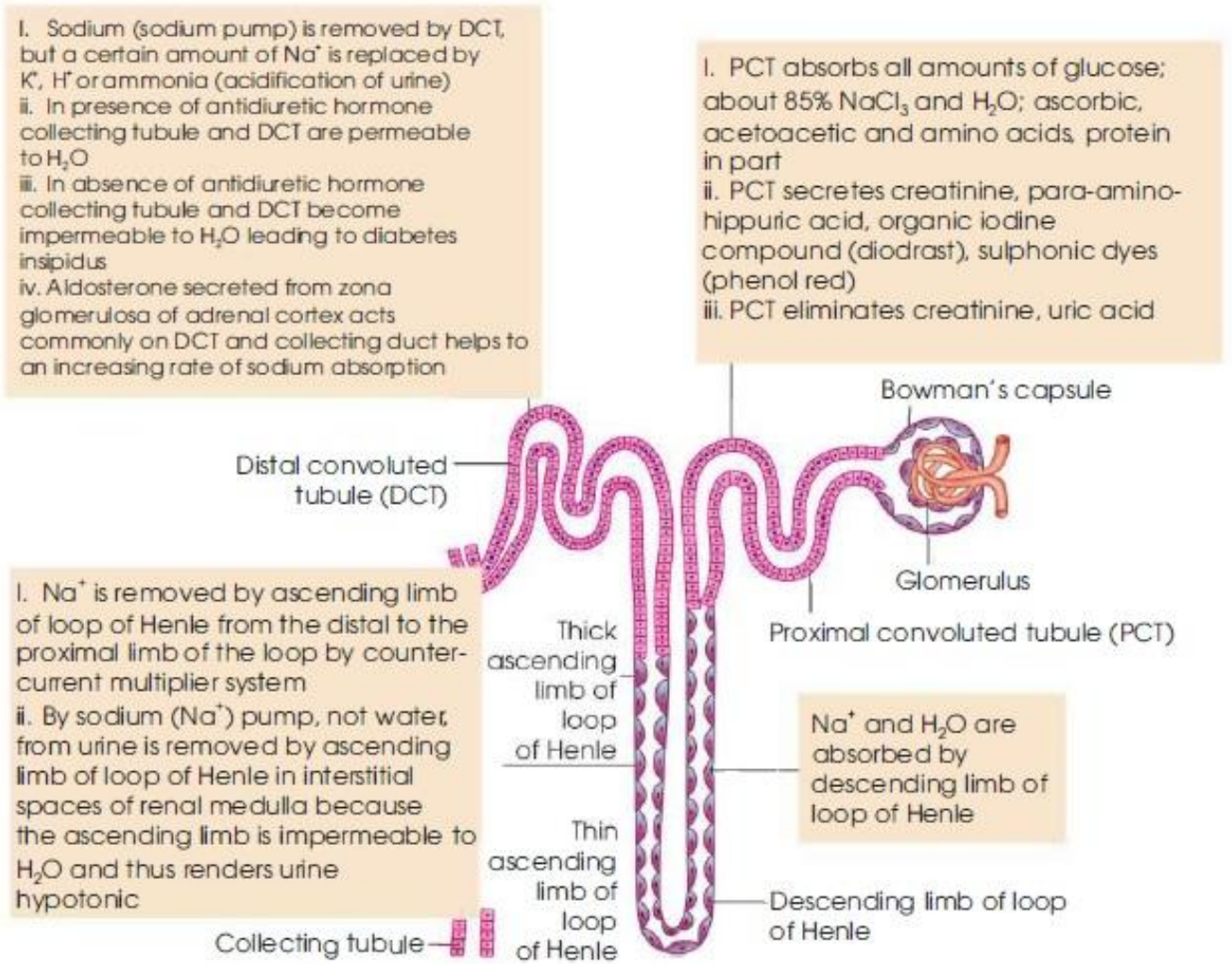
Macula Densa

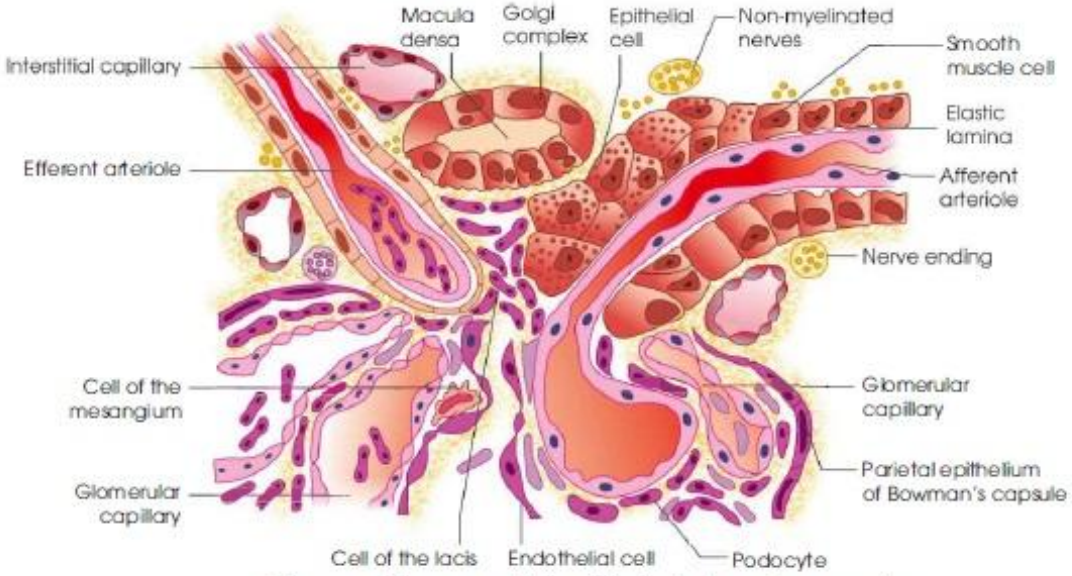
- The proximal part of the distal tubule actually comes in contact with the juxtaglomerular cells of the corresponding afferent vessel. Cells got closely packed nuclei and form the Macula Densa.
- **Location:** Cell lining of the distal convoluted tubule (DCT).
- **Function:** It helps in regulating important renal processes such glomerular filtration rate, renal blood flow, and renin release.
- The salt content (NaCl) in DCT, affects these cells.
- Macula densa cells, nearby juxtaglomerular cells and 'lacis' cells form **juxtaglomerular apparatus**.



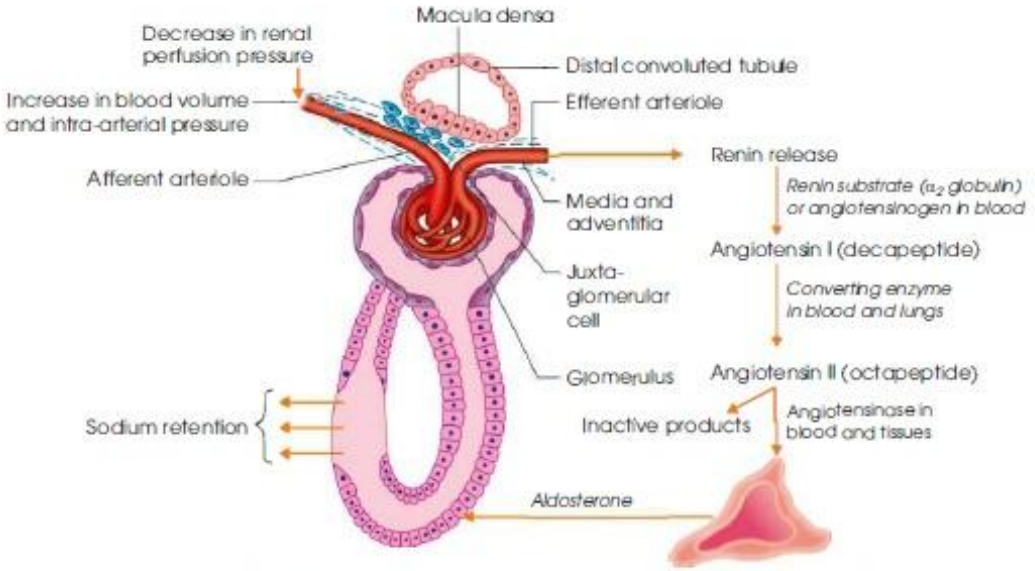
Collecting Tubule

- Series of tubules and ducts that connect the nephrons to the ureter.
- Includes connecting tubules, cortical collecting ducts, and medullary collecting ducts.
- The connecting tubules from numerous neighbouring nephrons join to form cortical collecting tubules, and these unite to form **cortical collecting ducts**.
- The collecting duct accounts for 4-5% of the kidney's reabsorption of sodium and nearly 5% of the kidney's reabsorption of water.
- The outer medullary and cortical collecting ducts are impermeable to water without the presence of antidiuretic hormone.


I. Sodium (sodium pump) is removed by DCT, but a certain amount of Na^+ is replaced by K^+, H^+ or ammonia (acidification of urine)
ii. In presence of antidiuretic hormone collecting tubule and DCT are permeable to H_2O
iii. In absence of antidiuretic hormone collecting tubule and DCT become impermeable to H_2O leading to diabetes insipidus
iv. Aldosterone secreted from zona glomerulosa of adrenal cortex acts commonly on DCT and collecting duct helps to an increasing rate of sodium absorption
I. PCT absorbs all amounts of glucose; about 85% $NaCl_3$ and H_2O; ascorbic, acetoacetic and amino acids, protein in part
ii. PCT secretes creatinine, para-amino-hippuric acid, organic iodine compound (diodrast), sulphonic dyes (phenol red)
iii. PCT eliminates creatinine, uric acid
Bowman's capsule
Distal convoluted tubule (DCT)
Glomerulus
Proximal convoluted tubule (PCT)
I. Na^+ is removed by ascending limb of loop of Henle from the distal to the proximal limb of the loop by counter-current multiplier system
ii. By sodium (Na^+) pump, not water, from urine is removed by ascending limb of loop of Henle in interstitial spaces of renal medulla because the ascending limb is impermeable to H_2O and thus renders urine hypotonic
Thick ascending limb of loop of Henle
Na^+ and H_2O are absorbed by descending limb of loop of Henle
Thin ascending limb of loop of Henle
Descending limb of loop of Henle
Collecting tubule



Diagrammatic representation of the juxtaglomerular apparatus



Regulation of aldosterone secretion (renin-angiotensin system)

Counter Current Mechanism

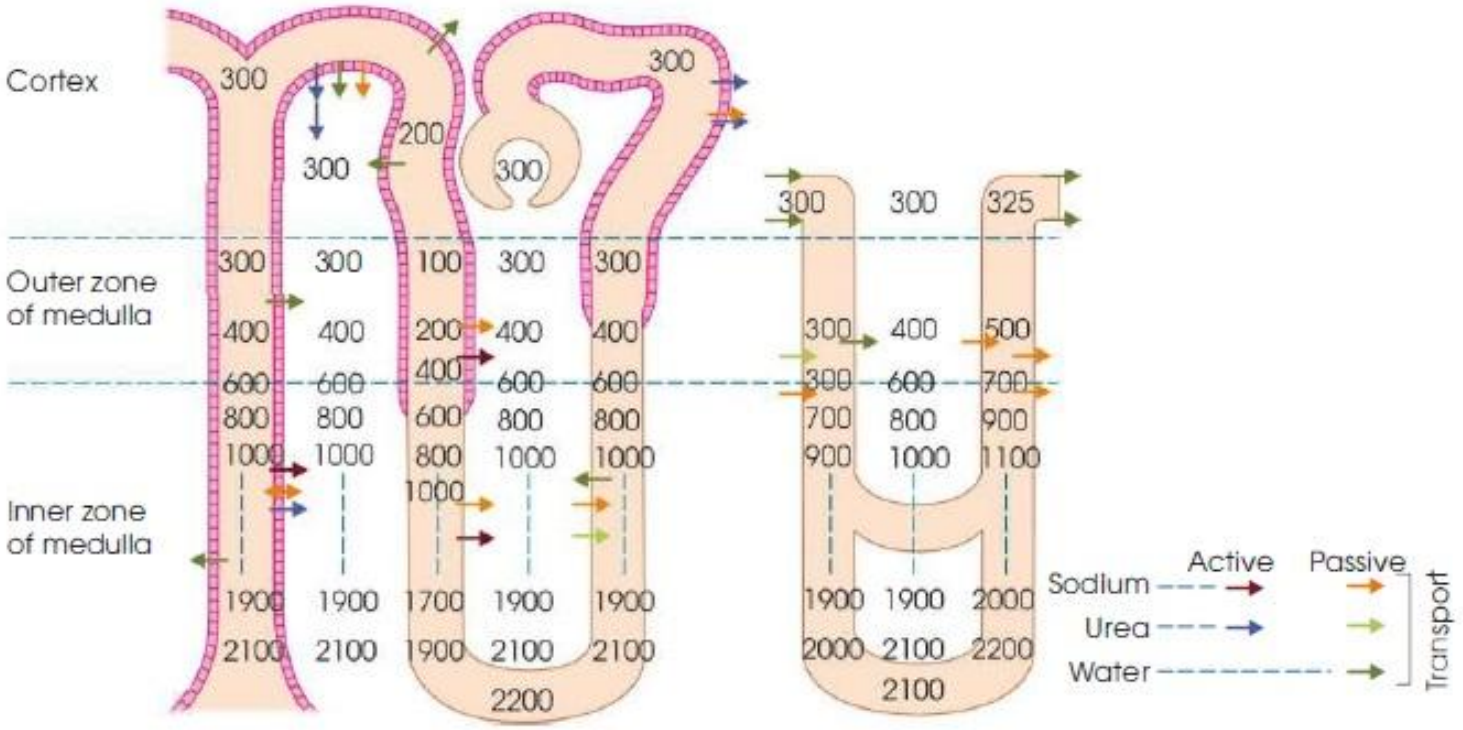
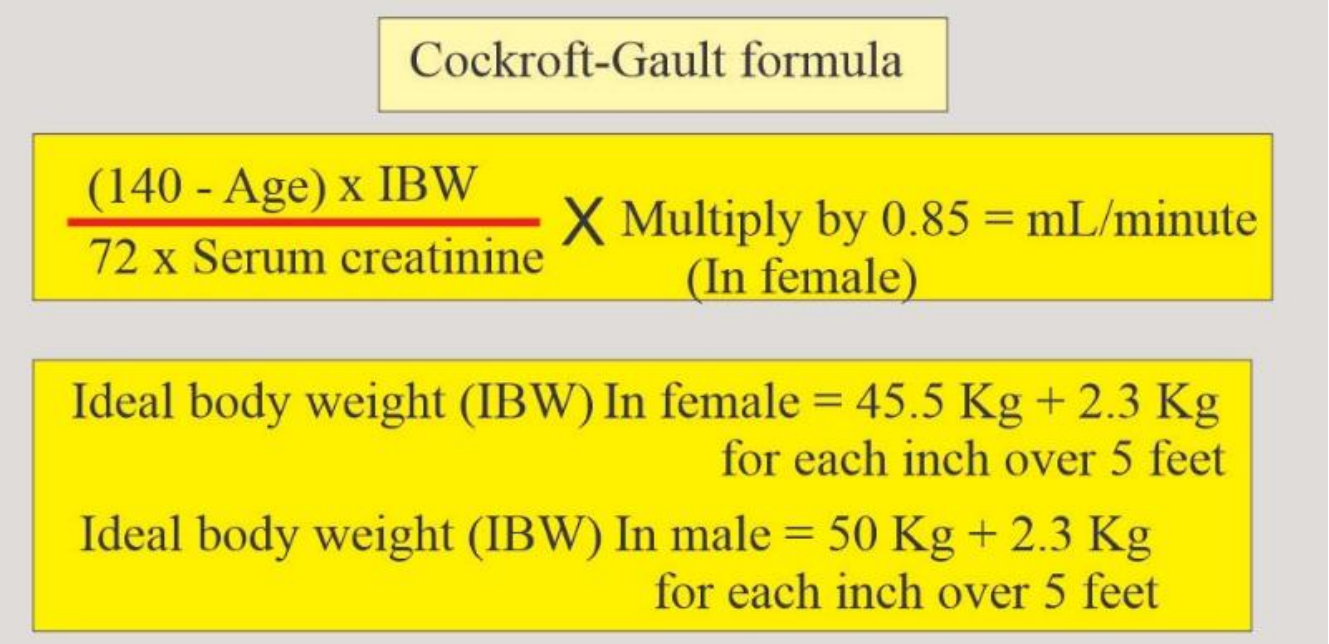


Diagram illustrating the counter-current mechanism as it is believed to operate in a nephron with a long loop and in the vasa recta (represent on the right). The numbers represent hypothetic osmolality values. No quantitative significance is to be attached to the number of arrows and only net movements are indicated

GFR

- kidney function measure by the flow of plasma from the glomerulus into Bowman's space over a specified period .



Function

- Filter the blood for urine formation.
- Excretes metabolic wastes like urea and uric into the urine.
- It secretes a number of hormones and enzymes such as:
  - Erythropoietin: It is released in response to hypoxia
  - Renin: It controls blood pressure by regulation of angiotensin and aldosterone
  - Calcitriol: It helps in the absorption of calcium in the intestines
- Maintains the acid-base balance of the body by reabsorbing bicarbonate from urine and excreting hydrogen ions and acid ions into the urine.
- Maintains the water and salt levels of the body by working together with the pituitary gland.

Reference:

- *Barrett KE, Barman SM, Yuan JX, Brooks H (2019). Ganong's review of medical physiology (26th ed.). New York.*
- Guyton AC, Hall JE. 2006. Textbook of Medical Physiology. Hercourt Asia P Ltd.
- Prosser C. L. and F. A. Brown – Comparative Animal Physiology; Saunders

Exercise

- *Describe the structure & function of a mammalian Nephron.*
- *What is Podocyte?*
- *Define Macula Densa.*
- *What is JG cells.*
- *Define GFR.*
- *Write a short note on:*
  - *Loop of Henle*
  - *Structure of a Glomerulus*

Thank You