

Orenburg State Medical Academy
Department of Histology, Cytology and Embryology

Organ Histology
Lecture N 4

Nephron.

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Kidney is a paired organ in which we have continuous production of urine

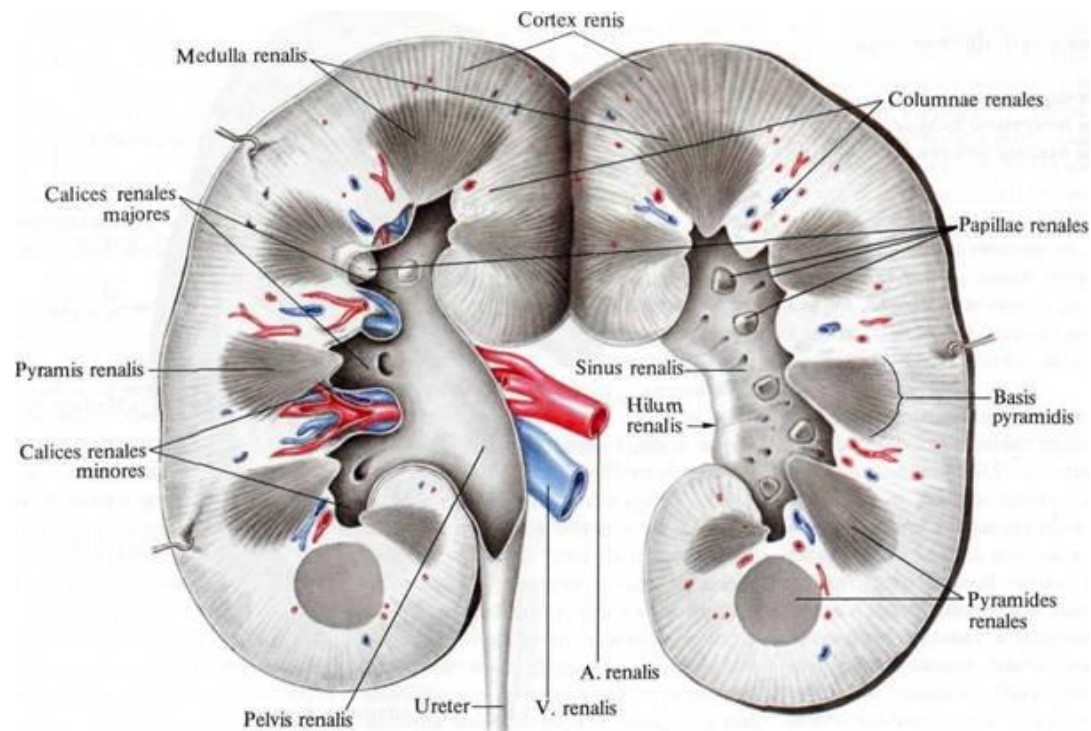
Functions:

- Urine formation
- Excretion of the waste products
- Endocrine function

The microanatomical structure of the kidney.

General structure of kidney:

- Capsule (капсула)
- Cortex (кора)
- Medulla (мозговое вещество)



Capsule:

Consists of two distinct layers:

- an outer layer of fibroblasts and collagen fibers,
- an inner layer with myofibroblasts.

Cortex consists of:

**renal corpuscles +
their associated tubules
(proximal and distal convoluted tubules)**

Cortical labyrinths - the regions between medullary rays, that contain the renal corpuscles, the convoluted tubules of the nephrons, and the collecting tubules.

Renal columns (of Bertin) - the parts of cortical tissue that extend peripherally around the lateral portion of the pyramids and are regarded as part of the medulla.

Uriniferous tubule = Nephron + its collecting tubule

Medulla consists of:

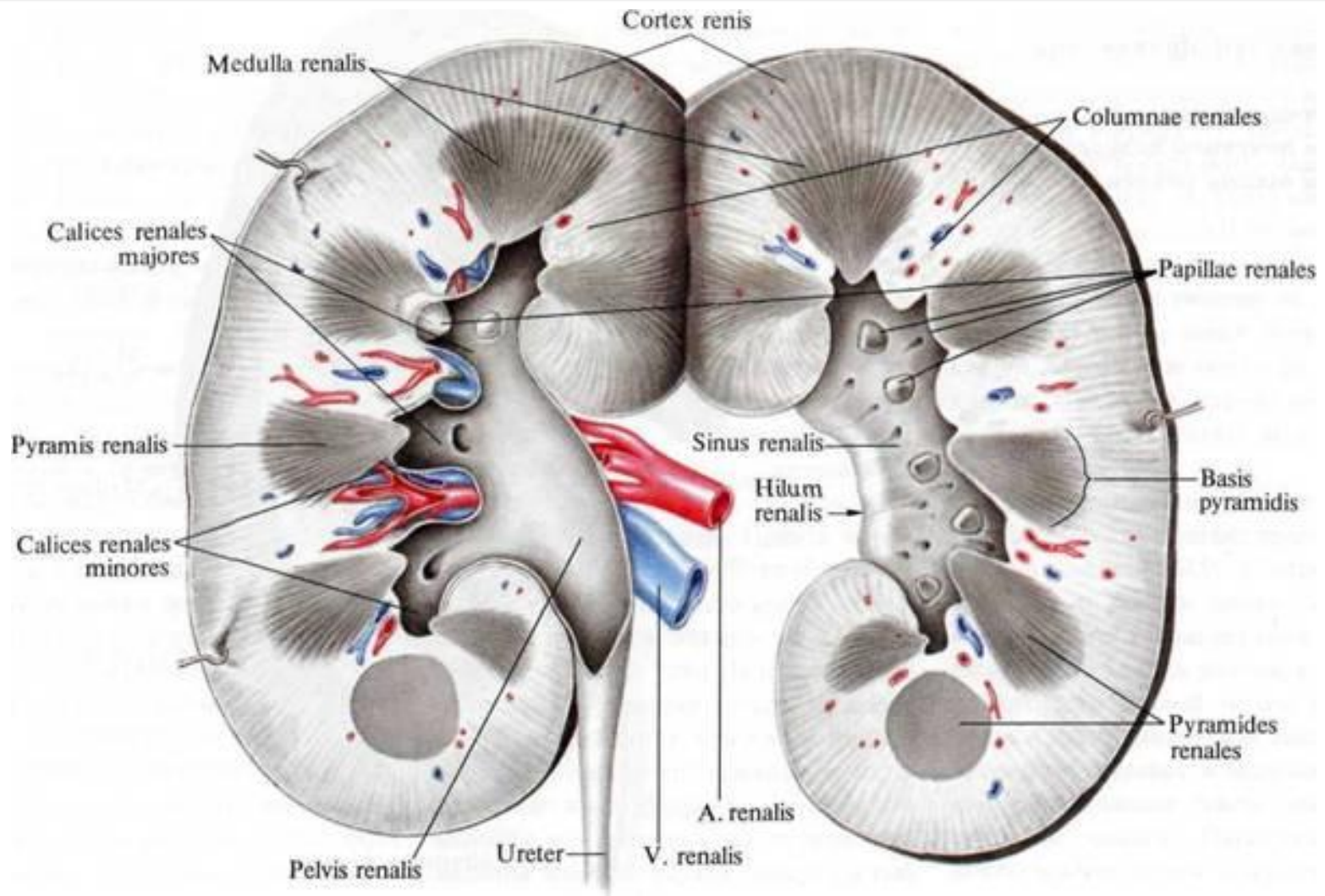
straight tubules + collecting ducts



8-12 (up to 18) pyramids:

- **outer medulla** (adjacent to the cortex),
 - a) inner stripe
 - b) outer stripe
- **inner medulla.**

Medullary ray is a vertical striation that appear to emanate from the medulla, it is an aggregation of straight tubules and collecting ducts.



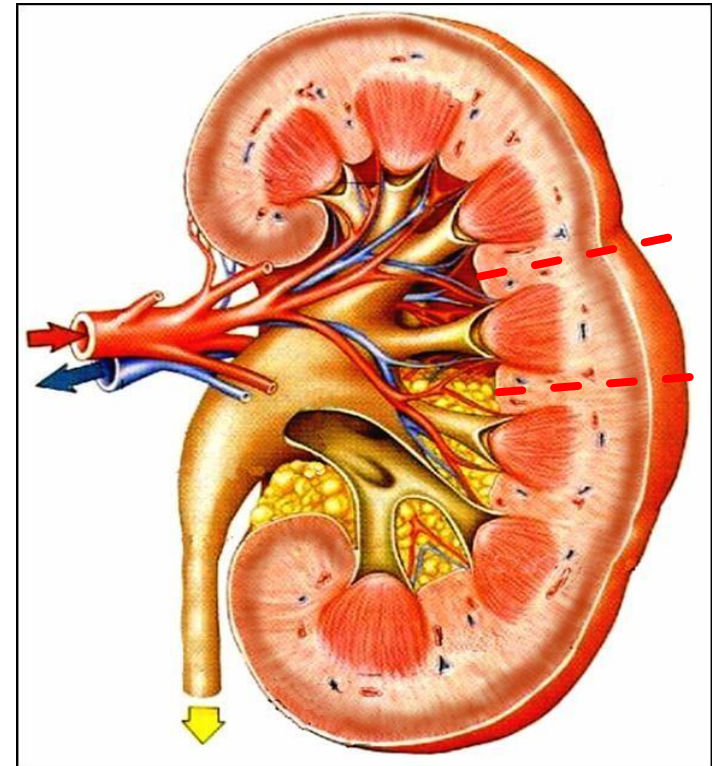
Kidney lobe and lobule:

Lobe of the kidney:

medullary pyramid + $\frac{1}{2}$ of each adjacent renal column.

Lobule of the kidney:

central medullary ray +
surrounding cortical material =
**collecting duct +
all the nephrons that it drains**



Kidney lobule



Medullary ray = middle of the lobule!

Histological structure:

- Stroma (строма)

loose connective tissue, blood vessels, nerves

- Parenchyma (паренхима)

urinary tubules

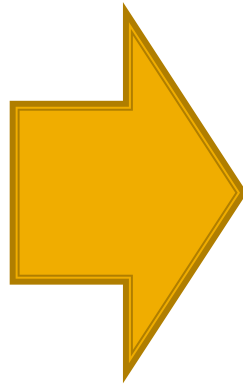
NB: Nephrons are the structures that are formed by tubules (parenchymal component) and blood vessels (stromal component)

The main structural and functional unit of the kidney is nephron.

Approximately 2 mln of nephrons are located in one kidney, length of the each nephron is about 50 mm, total length is 100 km

3 main processes:

- Filtration
- Resorption
- Secretion



Resulting fluid =
urine

Types of the nephrons:

Cortical

(subcapsular) 15 %

Location: renal corpuscles are located in the outer part of the cortex.

They have short loops of Henle, extending only into the outer medulla.

Function: formation of urine

Midcortical 70 %

Location: renal corpuscles are located in the midregion of the cortex. Their loops of Henle are of intermediate length.

Function: formation of urine

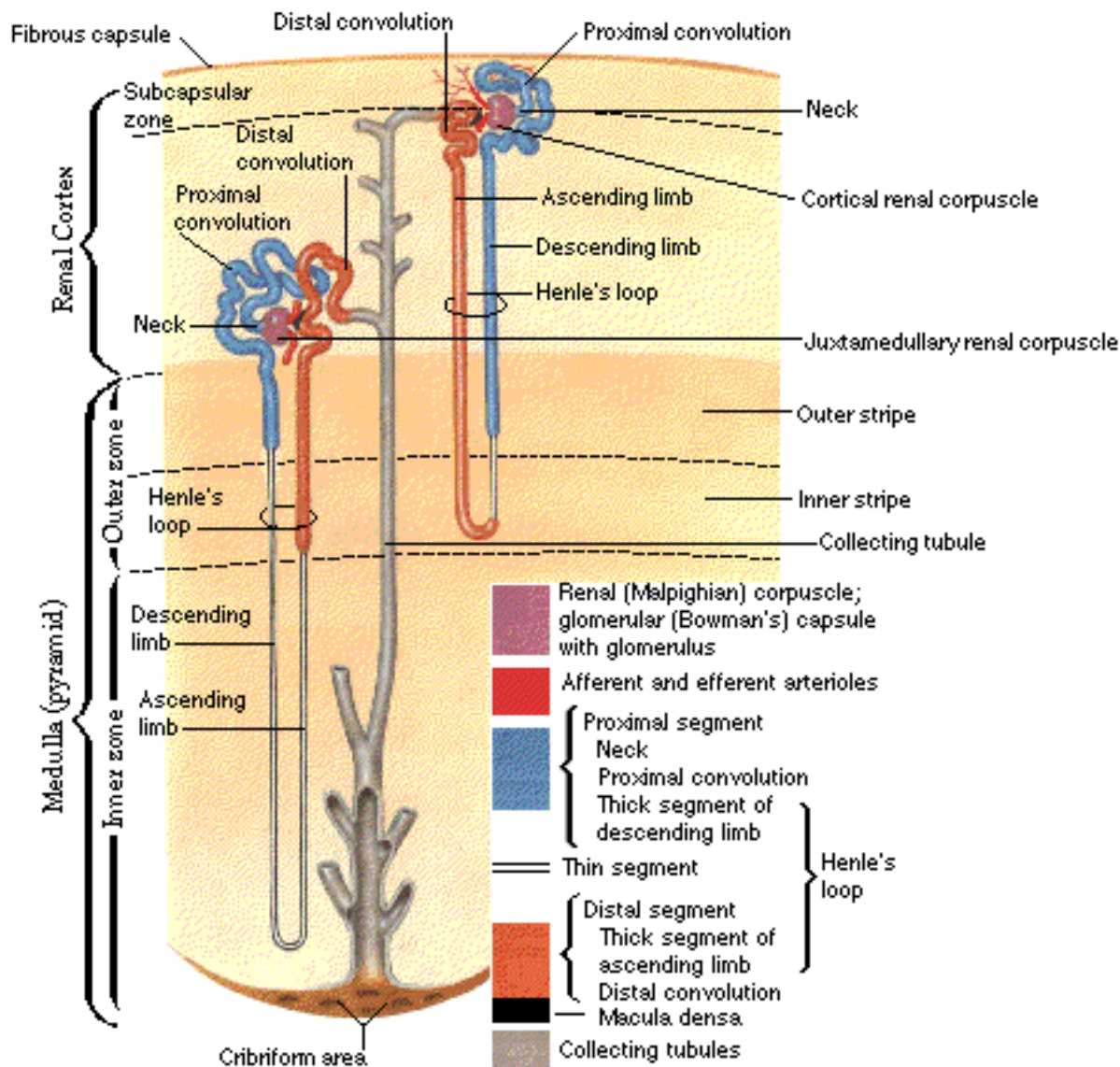
Juxtamedullar

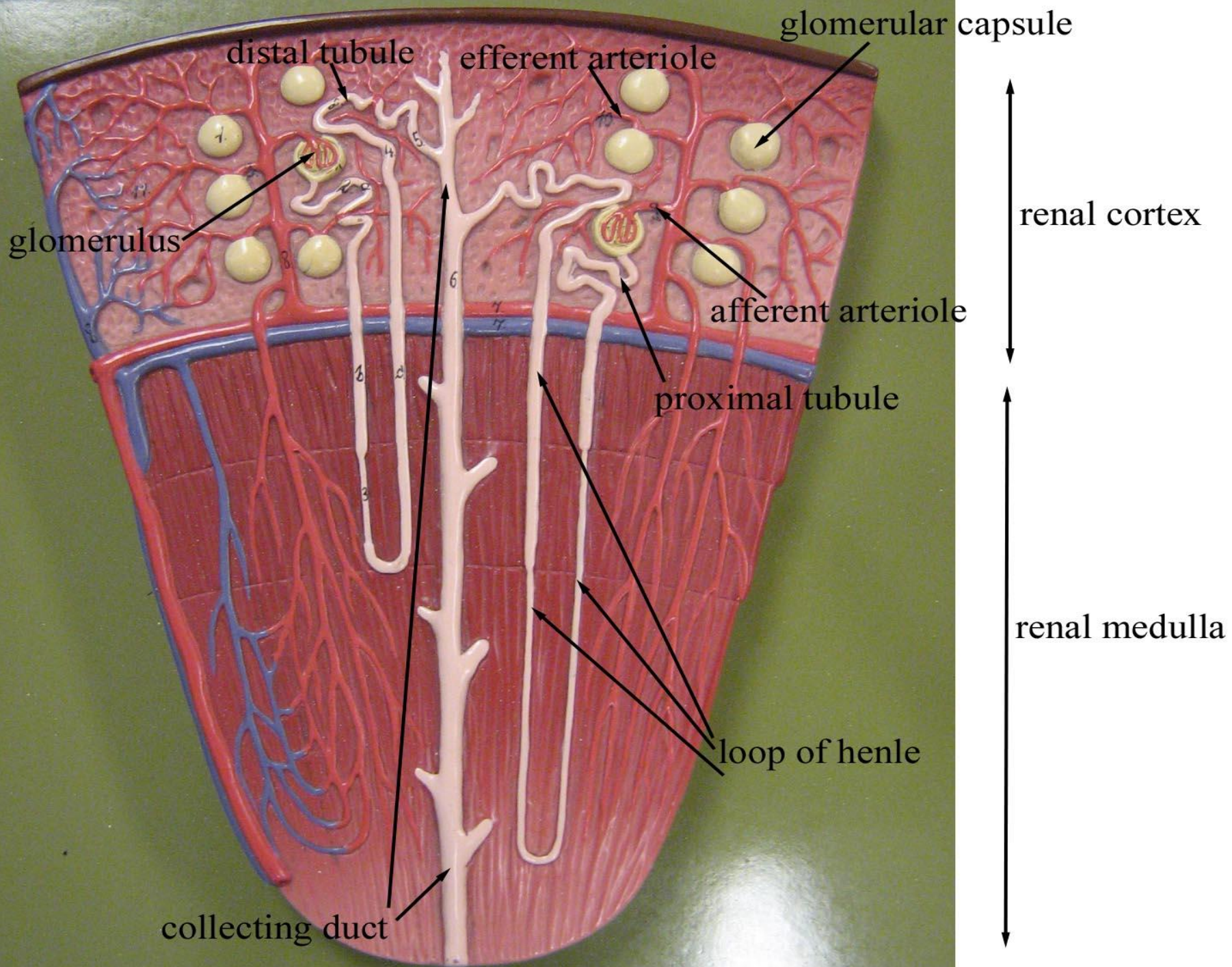
(long) 15 %

Location: renal corpuscles are located in proximity to the base of a medullary pyramid. They have long loops of Henle with long ascending thin segments that extend well into the inner region of the pyramid.

Function: concentration of urine

Nephron and Collecting Tubule Schema





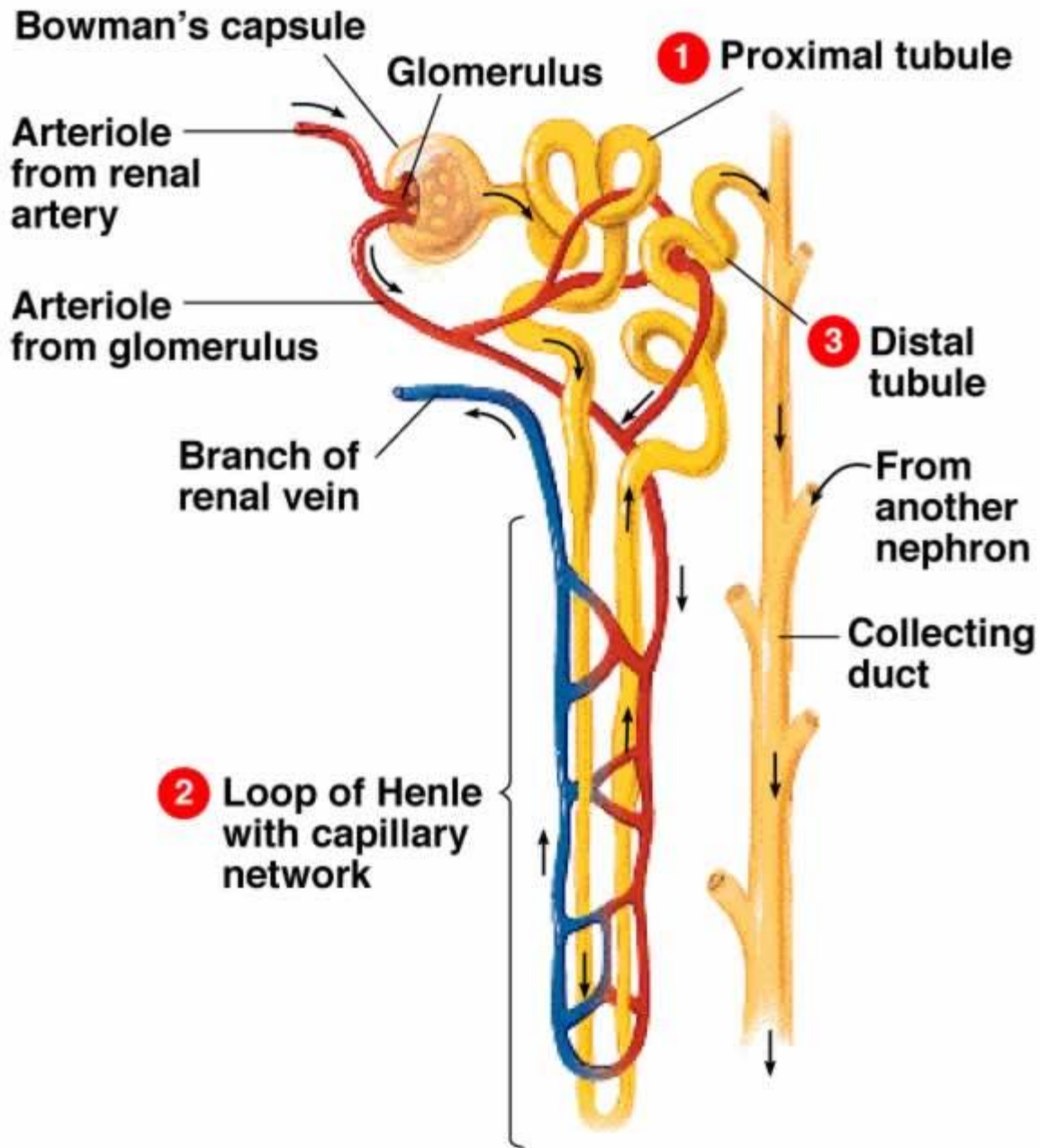
Nephron consists of:

➤ Renal corpuscle:

- glomerulus (10 to 20 capillary loops)
- double-layered renal or Bowman's capsule.

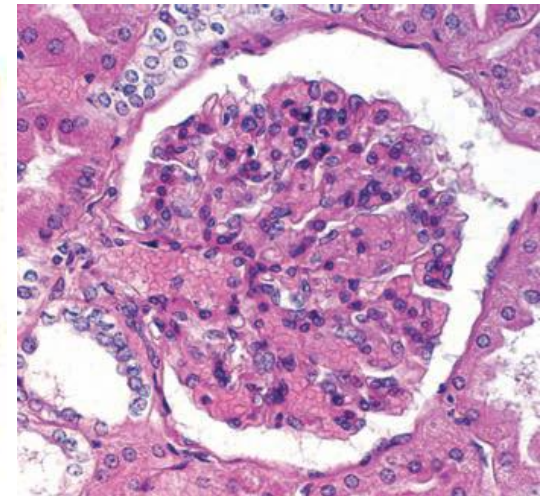
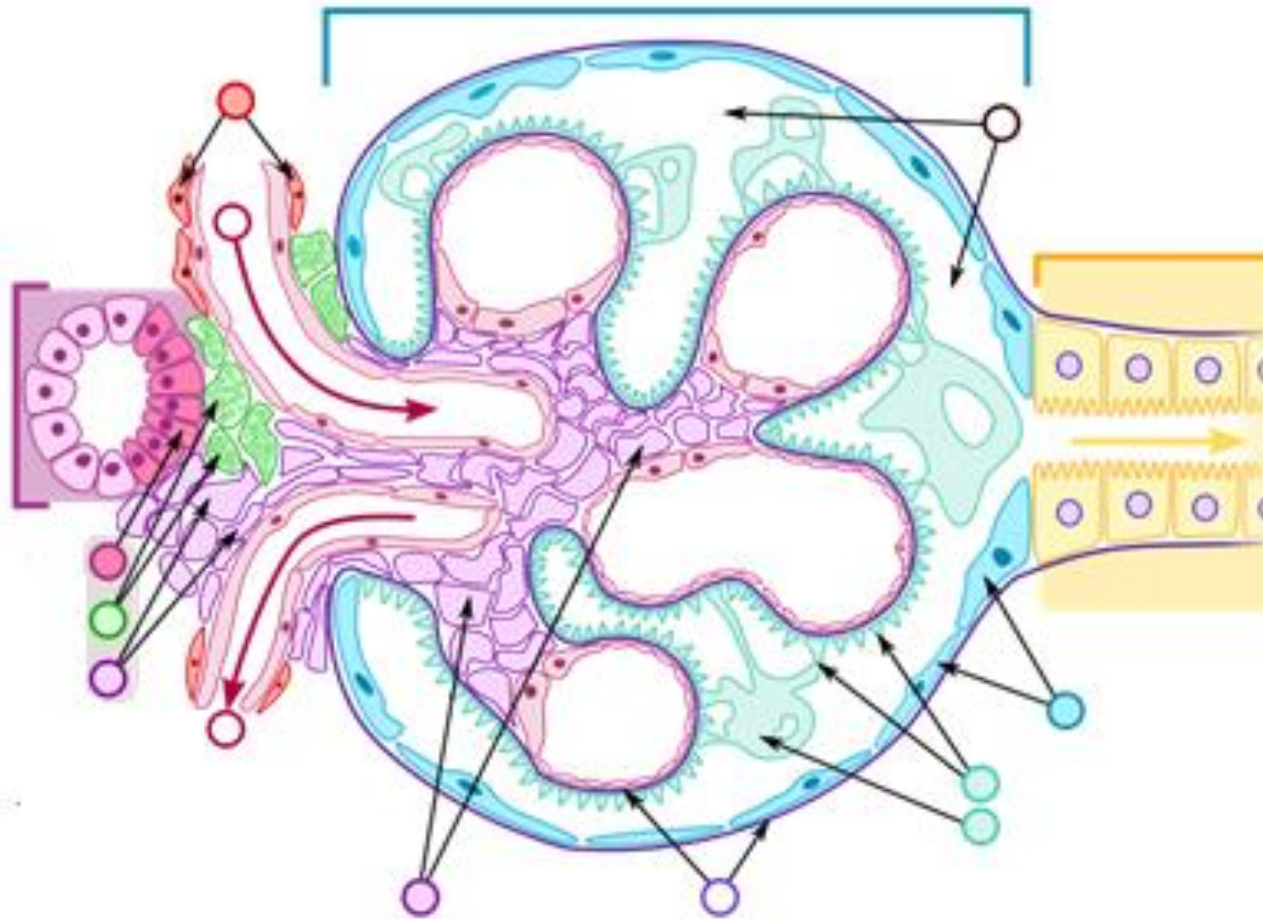
➤ Tubular system:

- Proximal convoluted tubule
 - Proximal straight tubule,
 - Thin descending limb,
 - Thin ascending limb,
 - Distal straight tubule,
 - Distal convoluted tubule.
- } loop of Henle



Histological characteristic of the capsule of nephron

Renal corpuscle

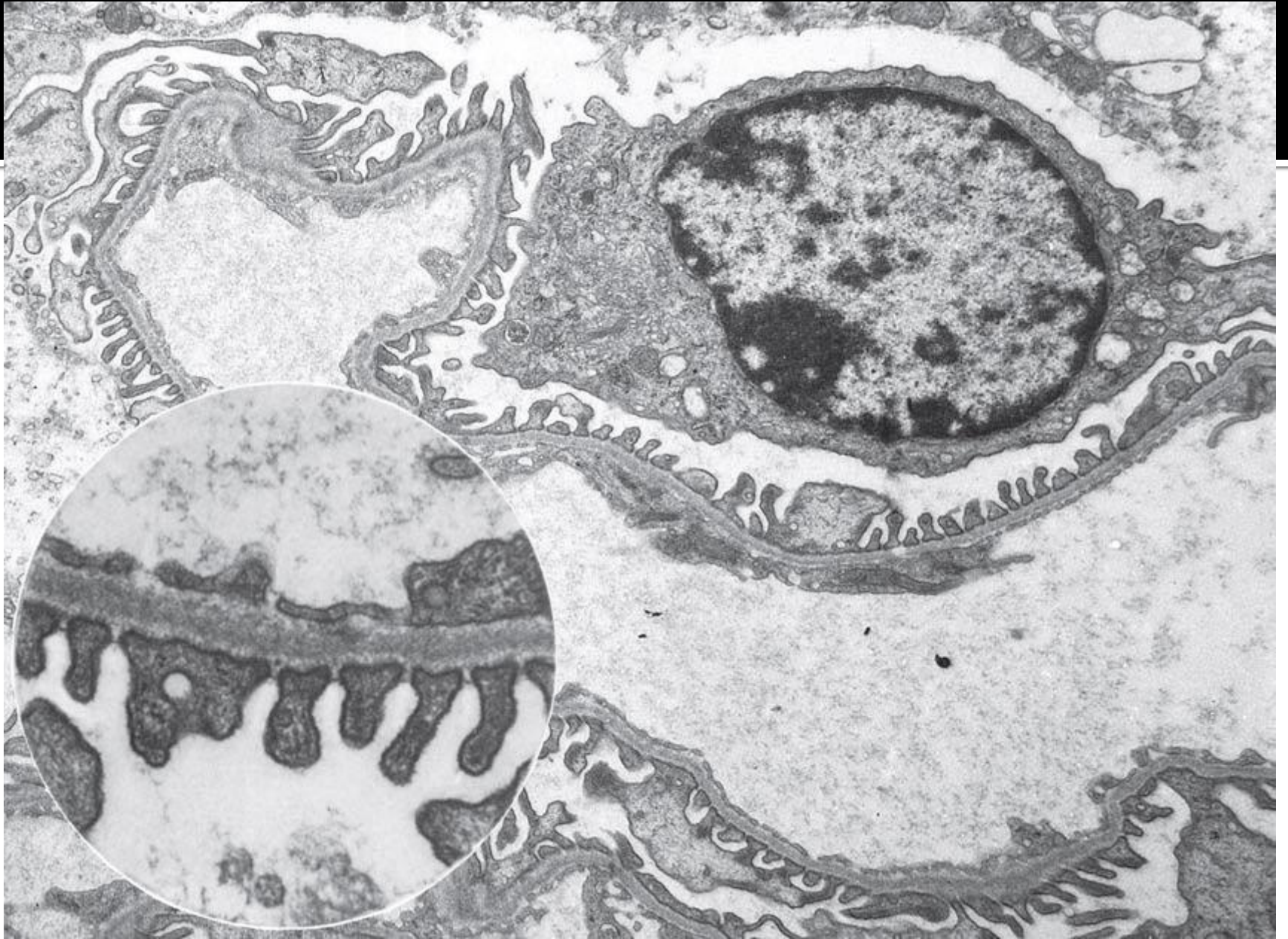


Main process - filtration

Glomerular filtration barrier or filtration apparatus of the kidney consists of:


- endothelial surface layer,
- endothelium of glomerular capillaries,
- underlying glomerular basement membrane,
- visceral layer of Bowman's capsule,
- subpodocyte space.

Result product - **glomerular ultrafiltrate** or primary urine



Histological characteristic of the tubules

Proximal tubules

| Type of the tubule | Type of the epithelium | Function | Cellular mechanizm |
|---|--|---------------------------------|---|
|  <p>Проксимальный извитой каналец</p> | Simple cuboidal microvillar epithelium | Reabsorption of water | Passive transport |
| | | Reabsorption of sugars | Enzymes of the microvillar border |
| | | Reabsorption of elecrolites | Na,K – ATP pumps, SDG of mitochondria of the basal striations |
| | | Reabsorption of proteins | Endocytosis and digestion in lyzosomes |
| | | Secretion of the waste products | |
| Proximal straight tubule | Simple cuboidal microvillar epithelium | | |

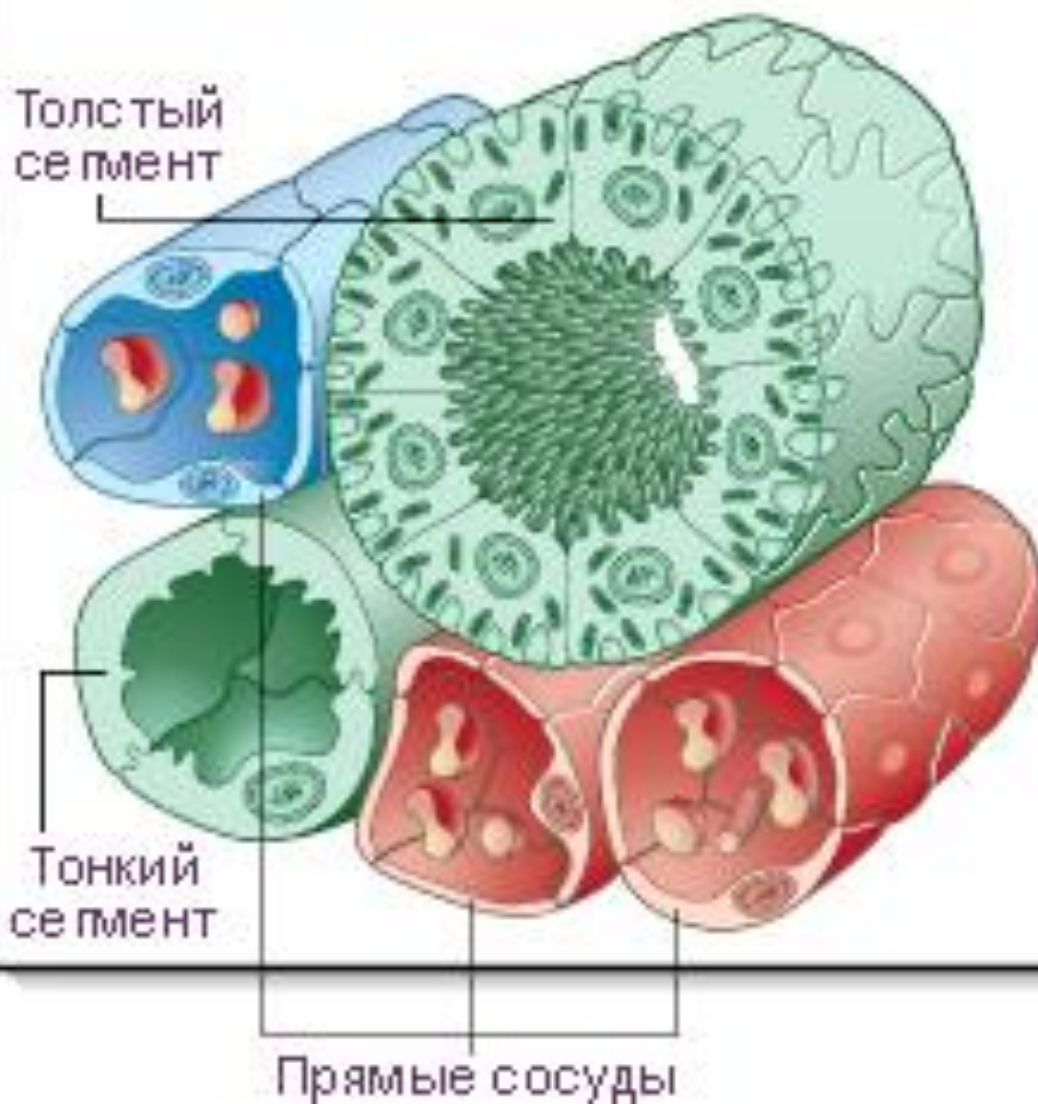
Changes the contence of the primary urine, glucose and protein disappear . 65 % reduction of the volume.

Loop of Henle

| Type of the tubule | Type of the epithelium | Function | Cellular mechanizm |
|------------------------|---|------------------------------|---|
| Thin descending limb | Simple squamous epithelium | Reabsorption of water | Passive transport |
| Thin ascending limb | Simple squamous epithelium | Reabsorption of Na and Cl | Passive transport |
| Distal straight tubule | Simple low columnar or cuboidal epithelium with less developed microvilli border, with basal striations | Reabsorption of electrolytes | Na,K – ATP pumps, SDG of mitochondria of the basal striations |

As a result of reapsorption of electrolytes and water the urine becomes hypotonic, and interstitial tissue becomes hyperosmotic. This effect provides the passive transport of water in the thin descending limb and in collecting tubules. All reabsorbed substances move first to the

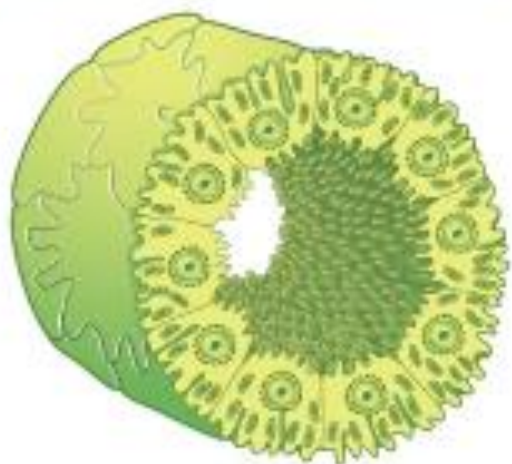
Петля Генле и прямые сосуды



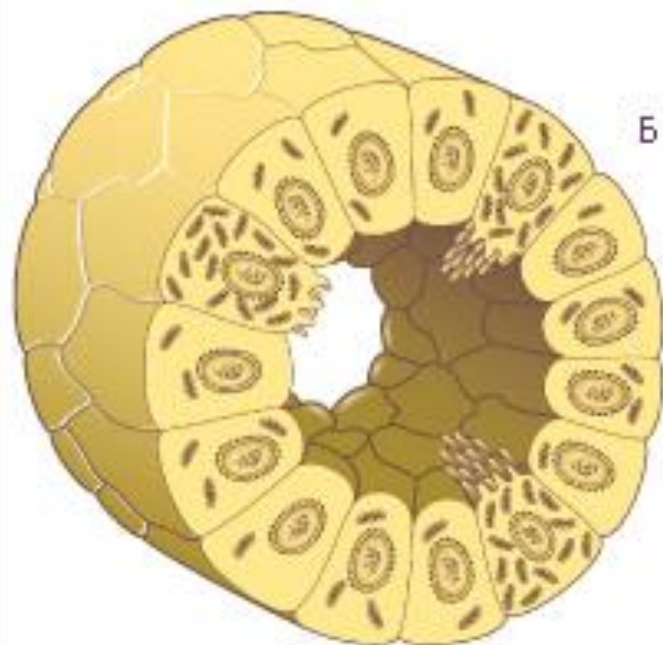
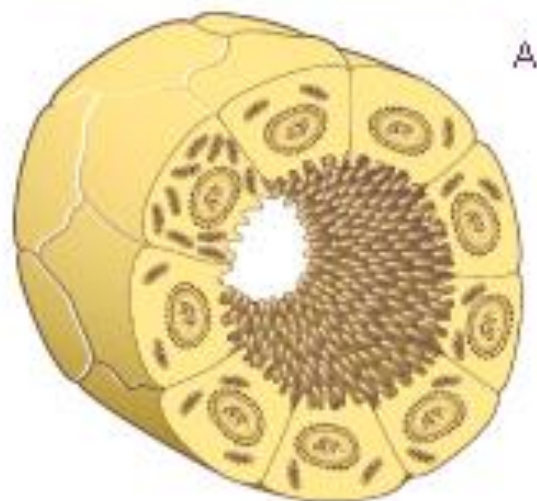
Proximal tubules

| Type of the tubule | Type of the epithelium | Function | Cellular mechanizm |
|--------------------------|--|--|---|
| Distal convoluted tubule | Simple cuboidal microvillar epithelium | Reabsorption of electrolytes, bicarbonate ions Secretion of hydrogen ions and of ammonium | Na,K – ATP pumps, + influence of the aldosterone |
| Collecting tubule | Simple squamous or cuboidal epithelium: Light cells | Reabsorption of water | Antidiuretic hormone (ADH)–regulated water channels, aquaporin-2 (AQP-2) |
| | Dark cells | Secretion bicarbonate ions hydrogen ions | ATP-dependent pumps and releases HCO_3^- , $\text{Cl}^-/\text{HCO}_3^-$ exchangers |

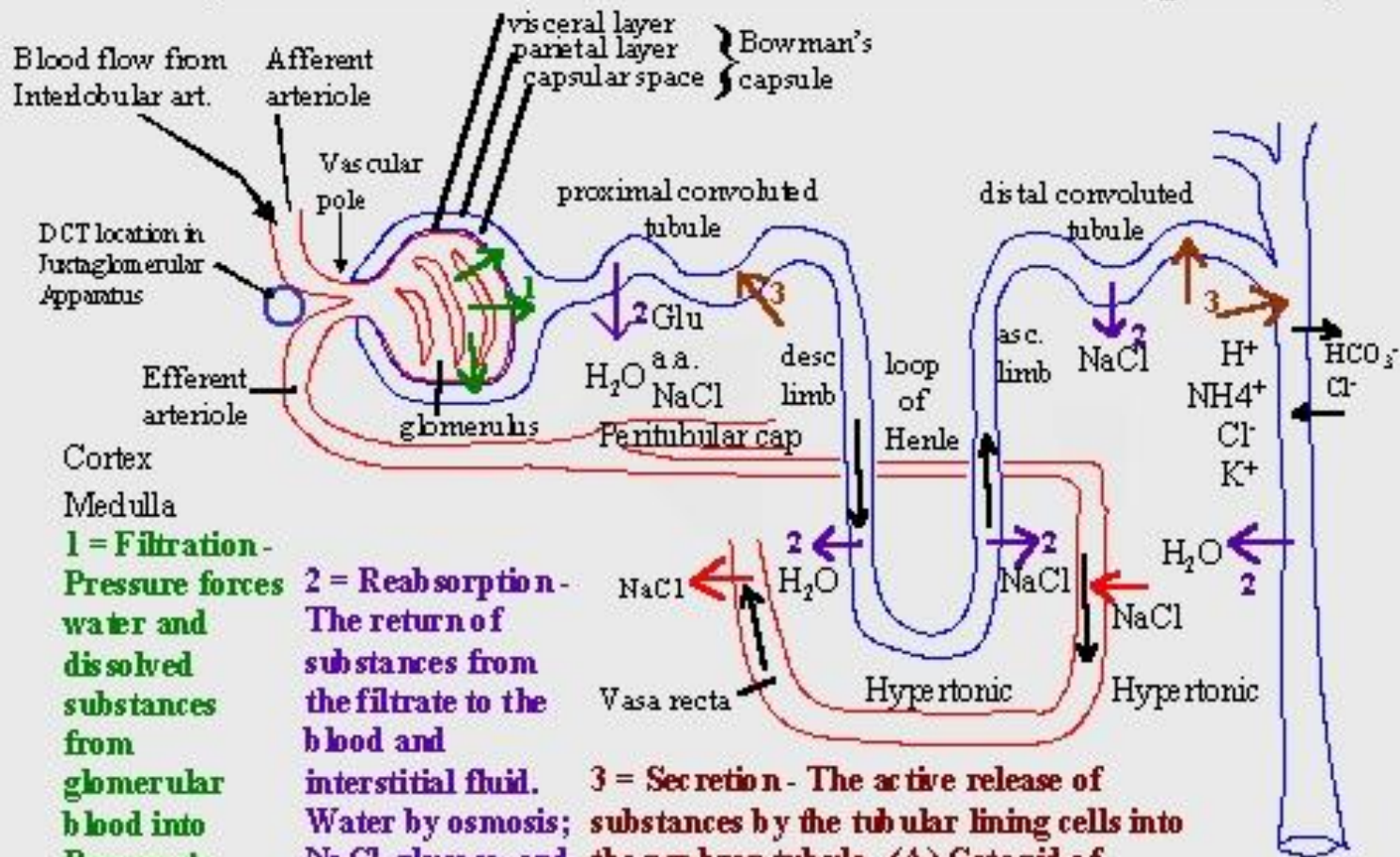
Дистальный извитой каналец



Собирающая трубочка



Structure and Function of the Nephron



Cortex
Medulla
1 = Filtration -
Pressure forces
water and
dissolved
substances
from
glomerular
blood into
Bowman's
capsule.
Amounts to 125
ml/min.

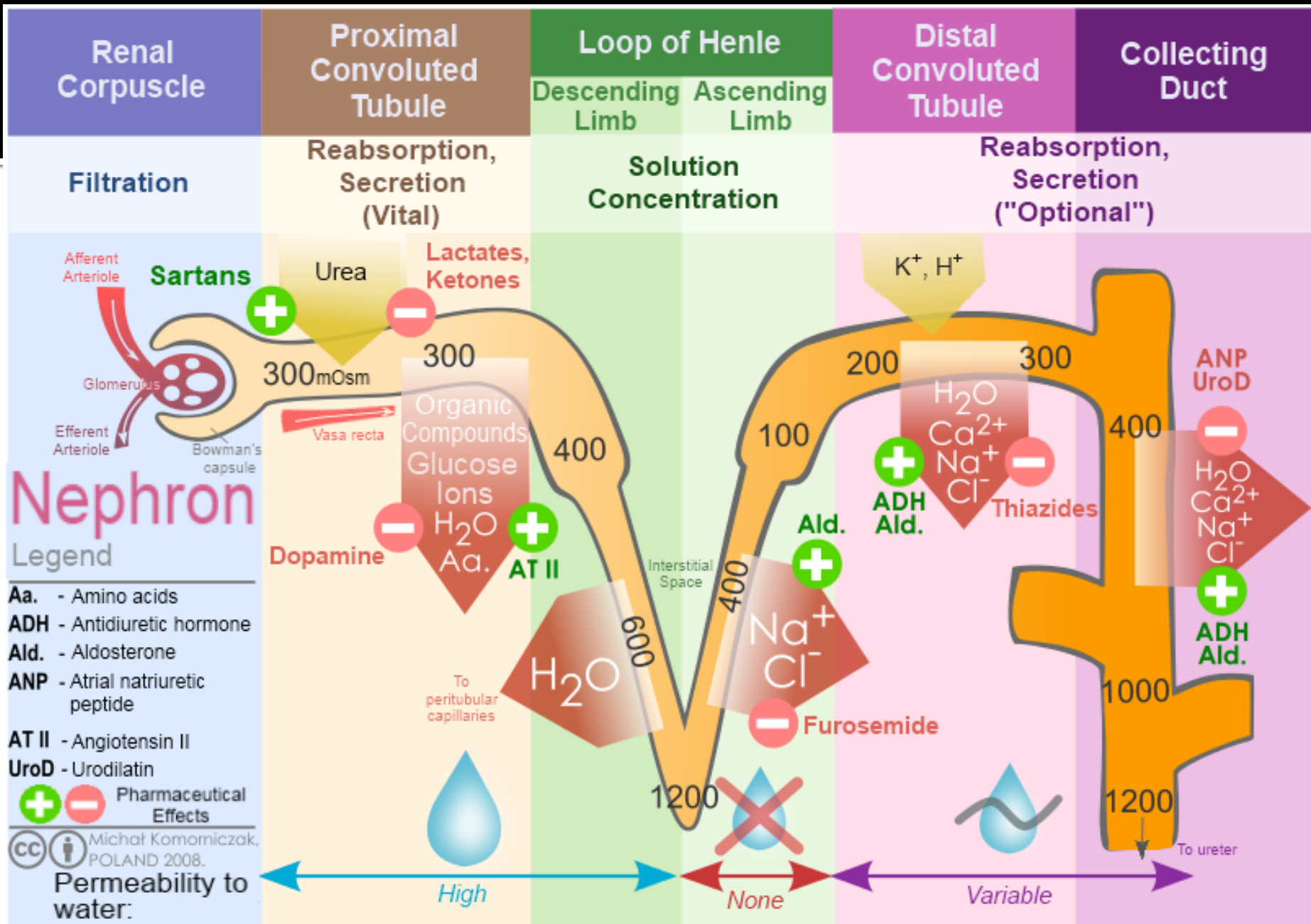
2 = Reabsorption -
The return of
substances from
the filtrate to the
blood and
interstitial fluid.
Water by osmosis;
NaCl, glucose, and
amino acids by
active transport

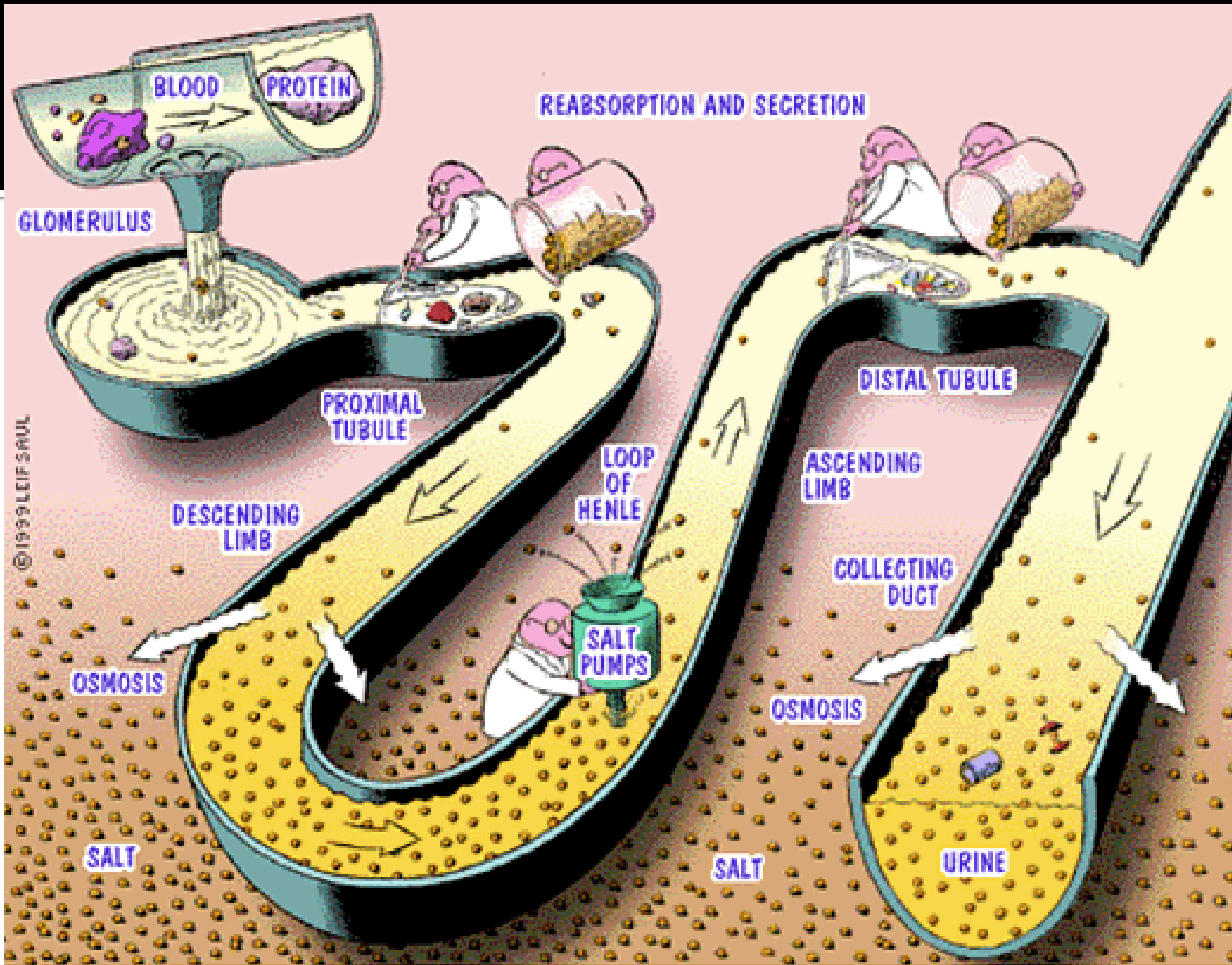
3 = Secretion - The active release of
substances by the tubular lining cells into
the nephron tubule. (A) Gets rid of
toxins and residues, (B) electrolyte
balance, mostly releasing K^+ , (C) acid
base balance by releasing H^+ , NH_4^+ .

Countercurrent exchange system

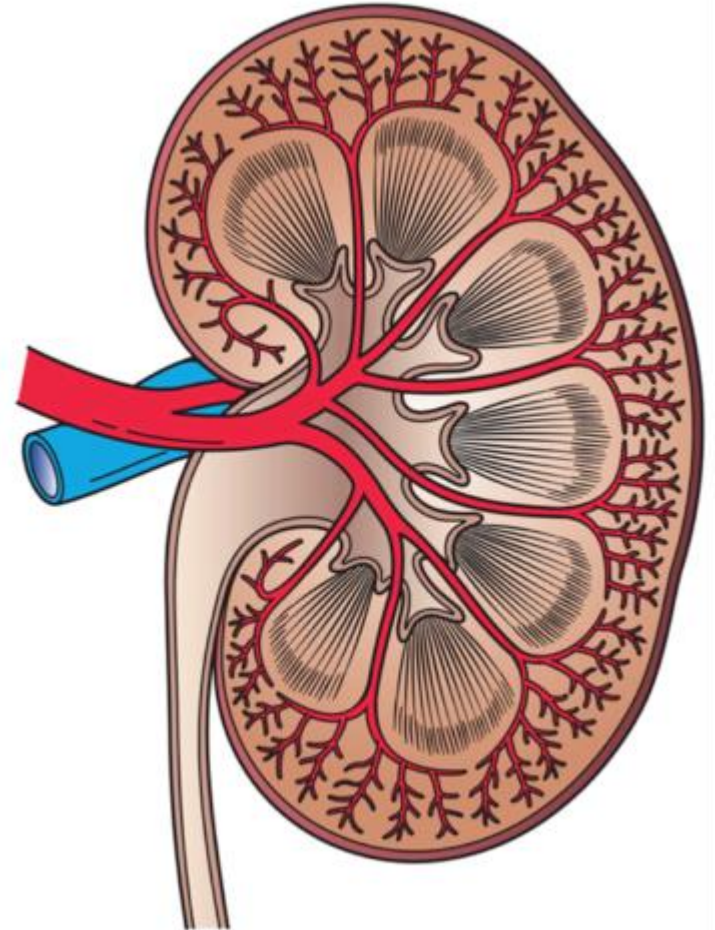
The term **countercurrent multiplier system** indicates a system where liquid moves in a loop followed by a long length of movement in opposite directions with an intermediate zone. The tube leading to the loop passively building up a gradient of solvent concentration while the returning tube has a constant small pumping action all along it, so that a gradual intensification of the concentration is created towards the loop.

The ability to excrete hyperosmotic urine depends on the **countercurrent multiplier system**.





Blood supply.



Blood supply.

The color seen in the cut surface of the unfixed kidney reflects the distribution of blood in the organ:

- 90% to 95% of the blood passing through the kidney is in the cortex (reddish color in unfixed organ);
- 5% to 10% is in the medulla (more pale in unfixed organ).

Blood supply.

a. renalis

(a branch of aorta enters the hilum of the kidney)



interlobar a.

(passes between medullar pyramids up to the border between cortex and medulla)



arcuate a.

(branches on the border between cortex and medulla)



interlobular a.



upper intralobular aa.



intralobular a.



lower intralobular aa.

give afferent arterioles of
the cortical and
intermediate nephrons

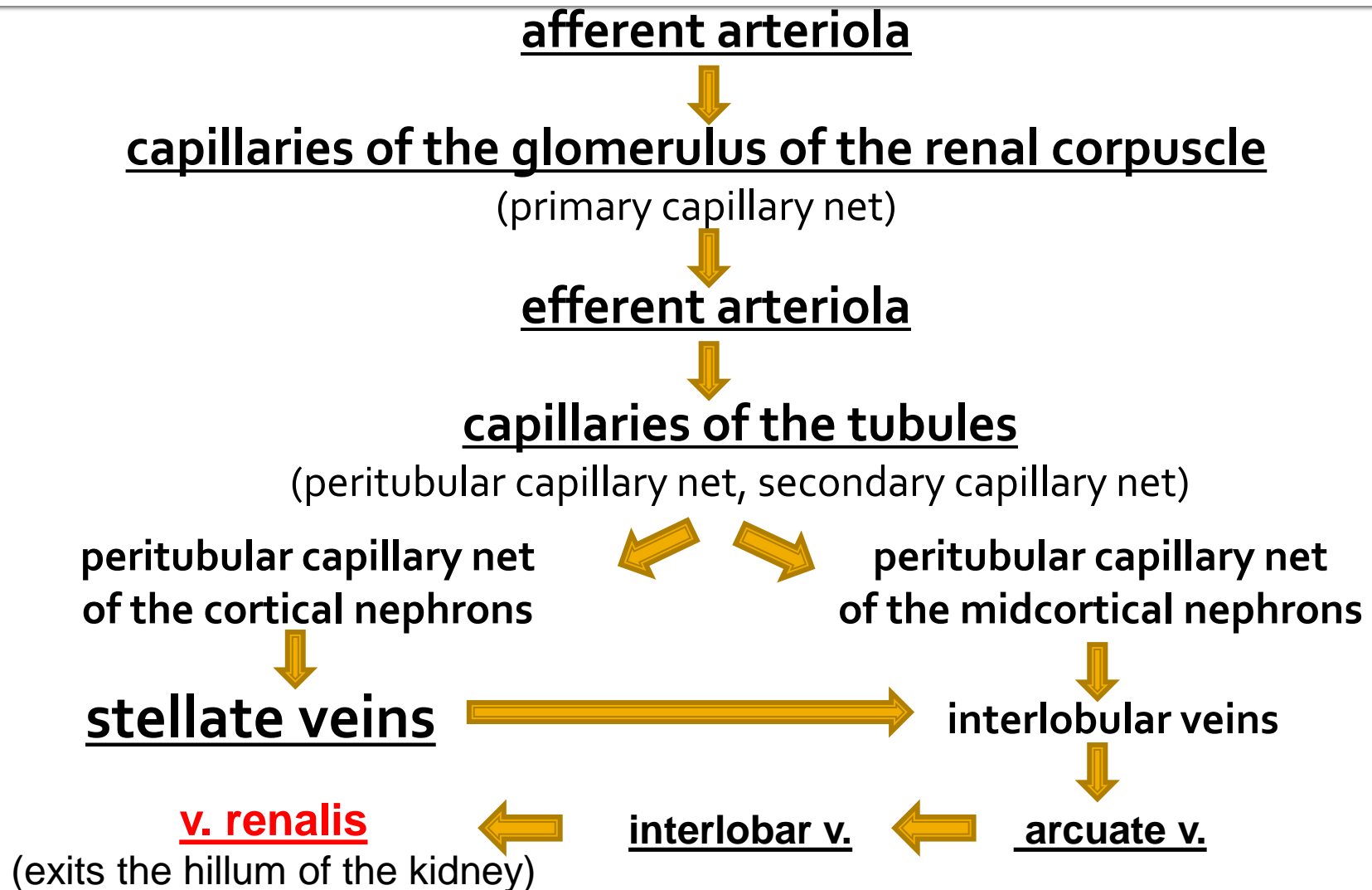
Cortical blood circulation!

give afferent arterioles of the
juxtamedullar nephrons

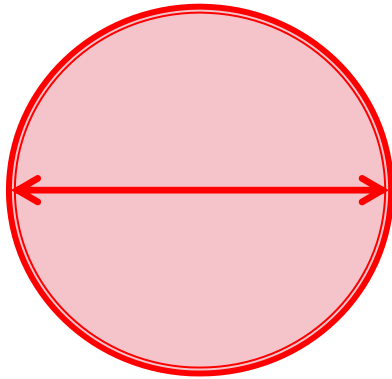
Juxtamedullar blood circulation!

Cortical blood supply

(of the cortical and intermediate nephrons)

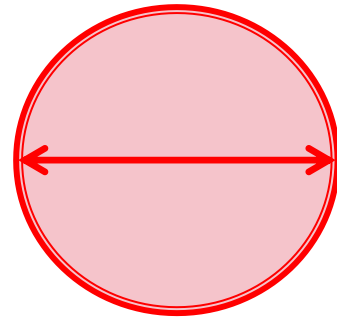


∅ of afferent arteriole



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∅ of efferent arteriole



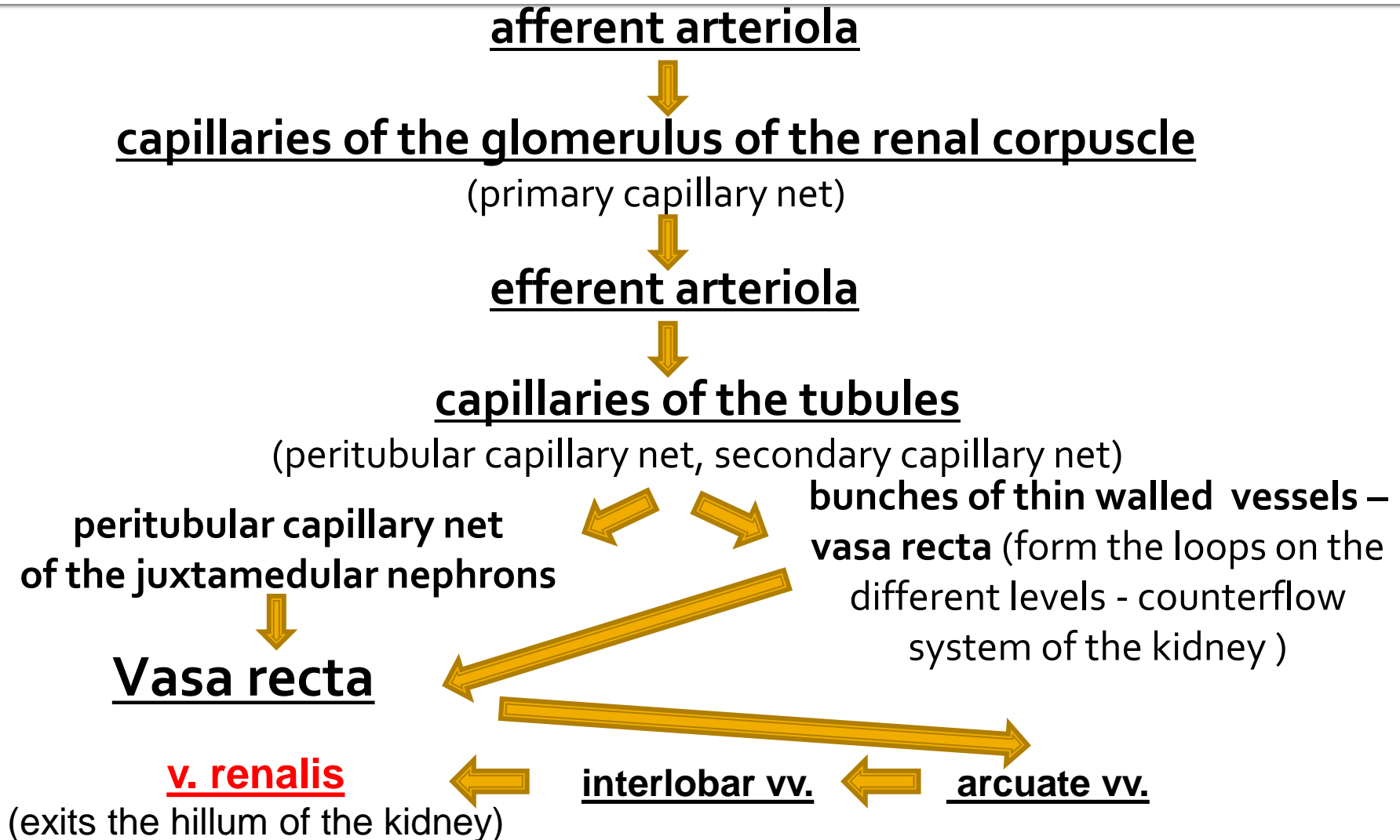
Conclusion: blood pressure stays high (50 mm Hg) for effective blood filtration

Conclusion:

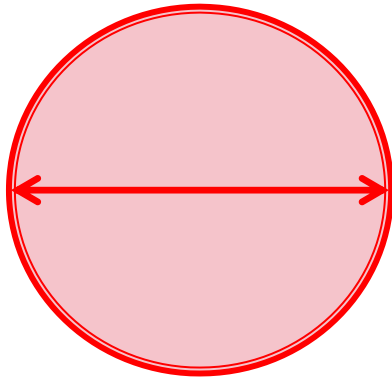
- Cortical and midcortical nephrons take an active part in the process of the formation of the urine.

Juxtamedullar blood supply

(of the juxtamedullar nephrons)

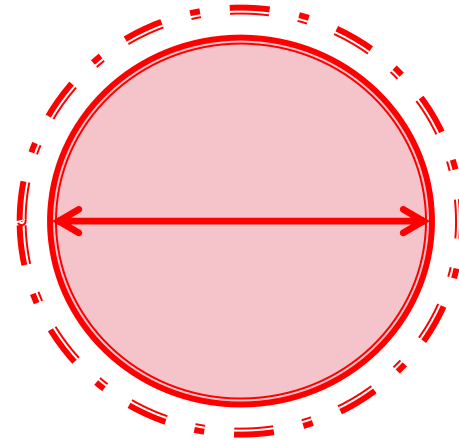


∅ of afferent arteriole

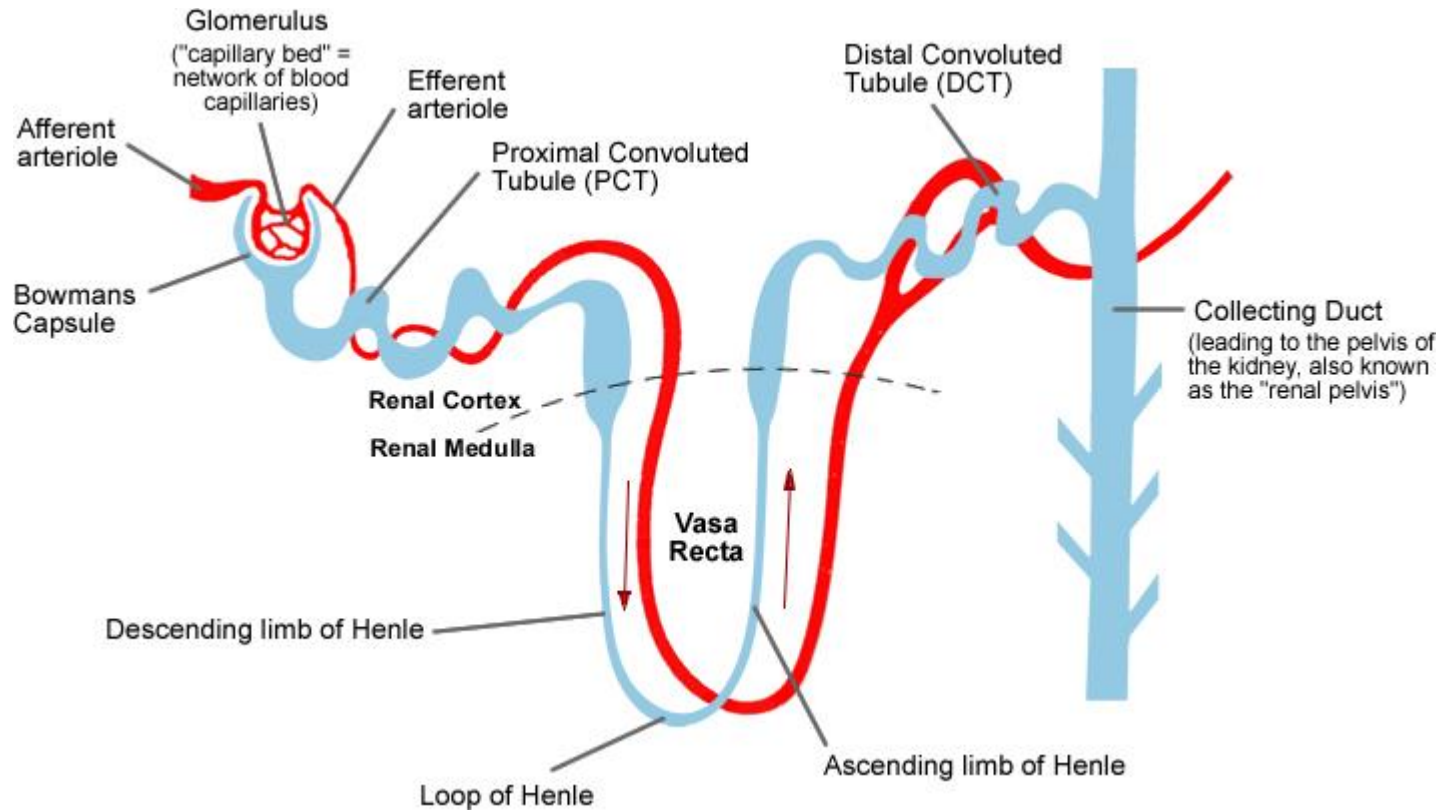


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∅ of efferent arteriole



Conclusion: blood pressure is lower than in cortical glomeruli



Vasa recta represent the vascular part of the **countercurrent exchange system** that regulates the concentration of the urine.

Conclusion:

- Juxtamedullar nephrons take not so active part in the in the process of the formation of the urine.
- Juxtamedullar vascular system works as a shunt – a short bypass for the blood in conditions of high blood filling during hard physical work.

Vascular system of kidney is a dynamic system that provides adequate blood filtration and formation of urine both in usual conditions, and in the conditions of the intensive work.

Clinical correlation: work of the kidneys is closely interconnected with work of the cardiovascular system as the speed of glomerular filtration is in the direct dependence from the systemic blood pressure.

СПАСИБО ЗА ВНИМАНИЕ!

THANK YOU FOR ATTENTION!