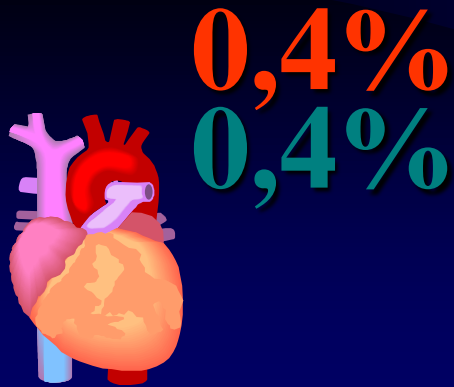
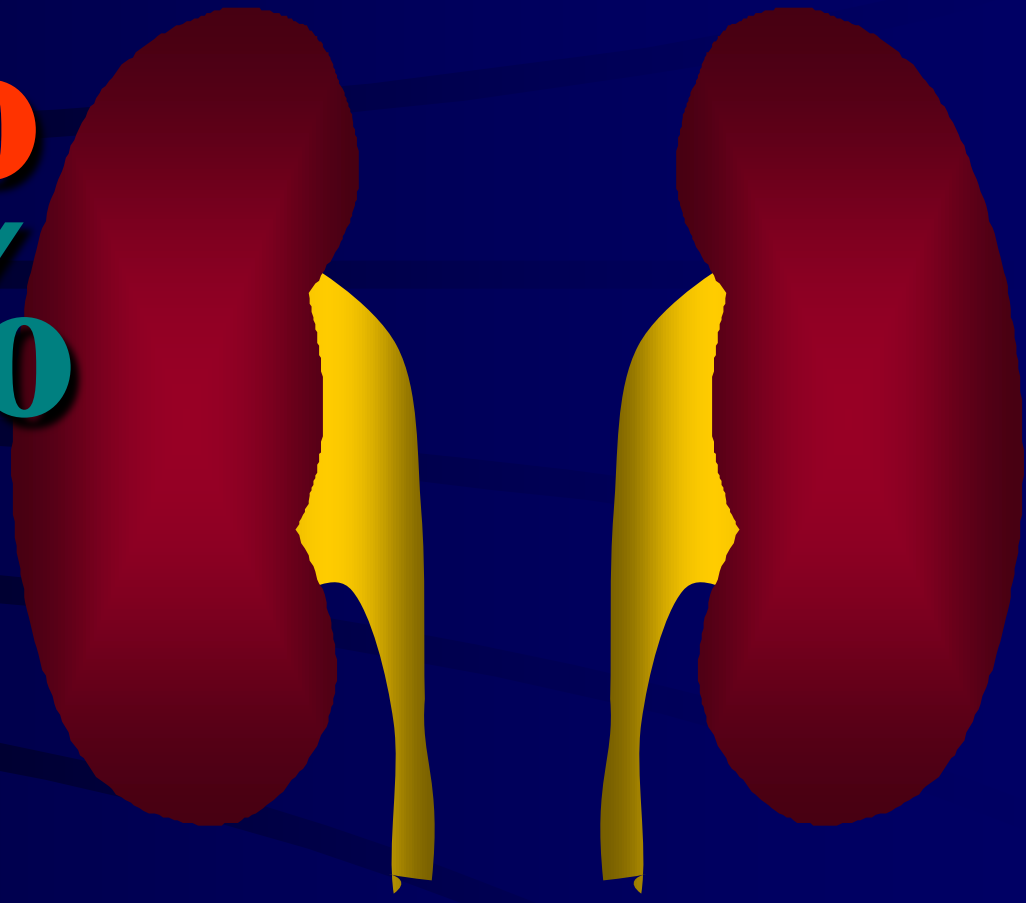
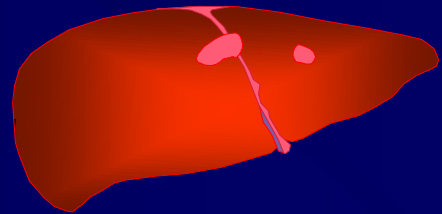


20%
0,4%



0,4%
0,4%

25%
5%



Topics

- General structure of the kidney
- Nephron
 - Plasma filtration in the glomeruli
 - Structure and development of the renal glomerulus
 - Mechanisms regulating filtration
 - Functions and morphology of renal tubules
 - Mechanisms regulating reabsorption

KIDNEY FUNCTION

- The kidneys filter plasma and produce hypertonic final urine.
- Metabolic waste products are excreted in the urine, particularly nitrogen-containing compounds.
- They participate in maintaining electrolyte homeostasis in the blood and interstitial (tissue) fluid.

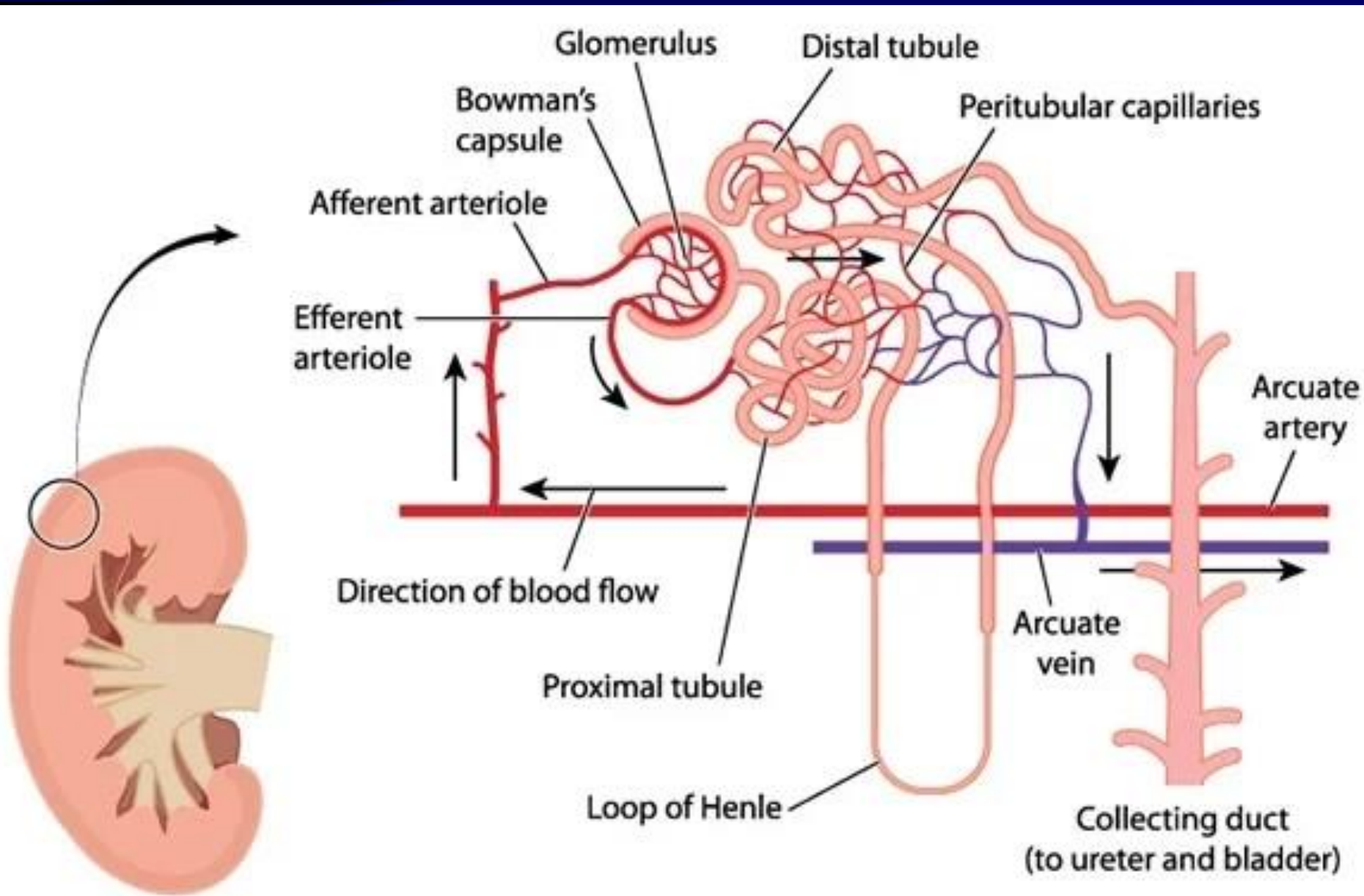
The kidneys synthesize:

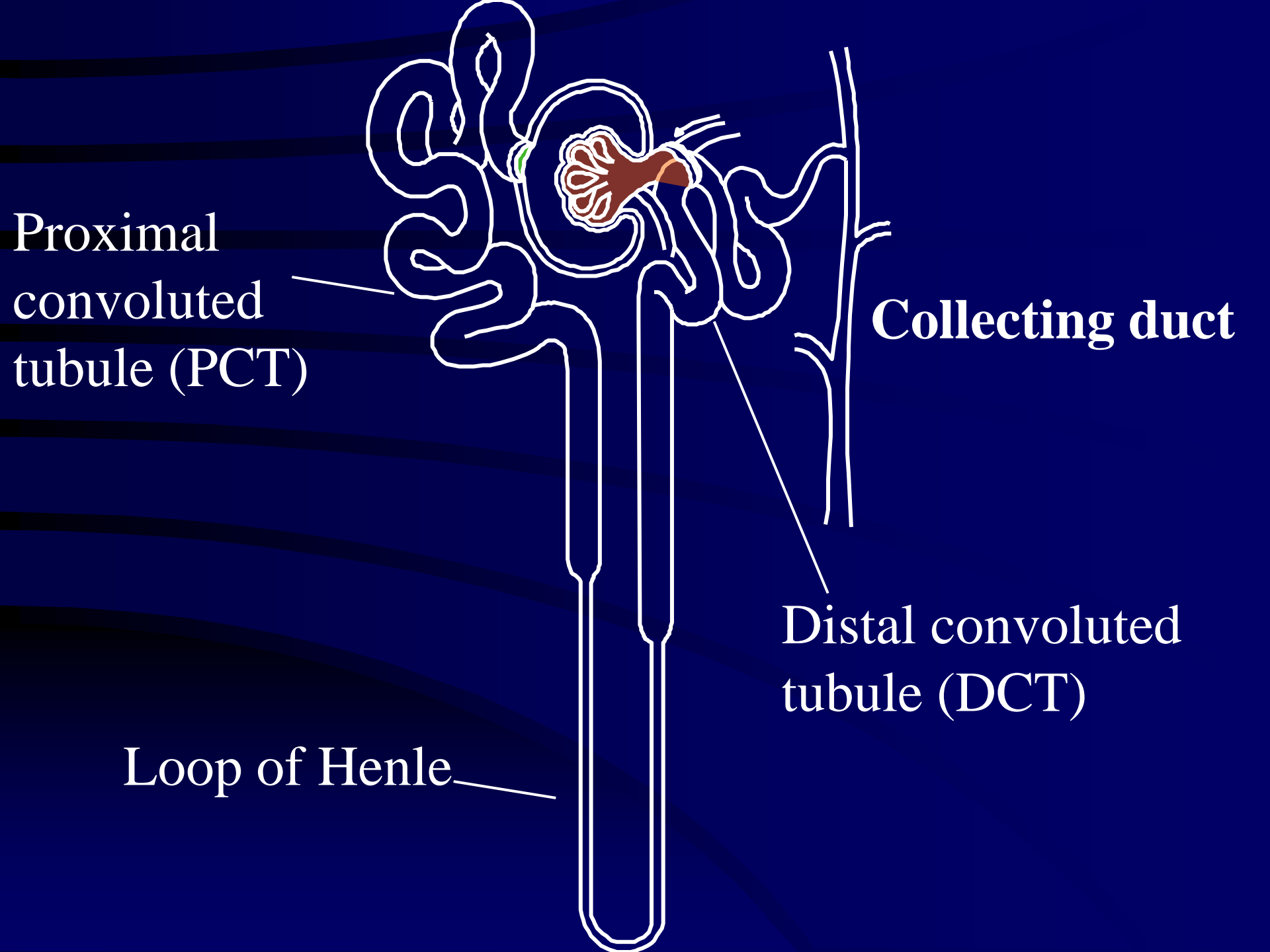
- Renin Erythropoietin
- Active form of vitamin D₃ (1,25-dihydroxycholecalciferol)

Kidney function is regulated by:

- Aldosterone
- Antidiuretic hormone (ADH)
- Atrial natriuretic factor (ANF)
- Parathyroid hormone (PTH)







180 l/day (filtration)

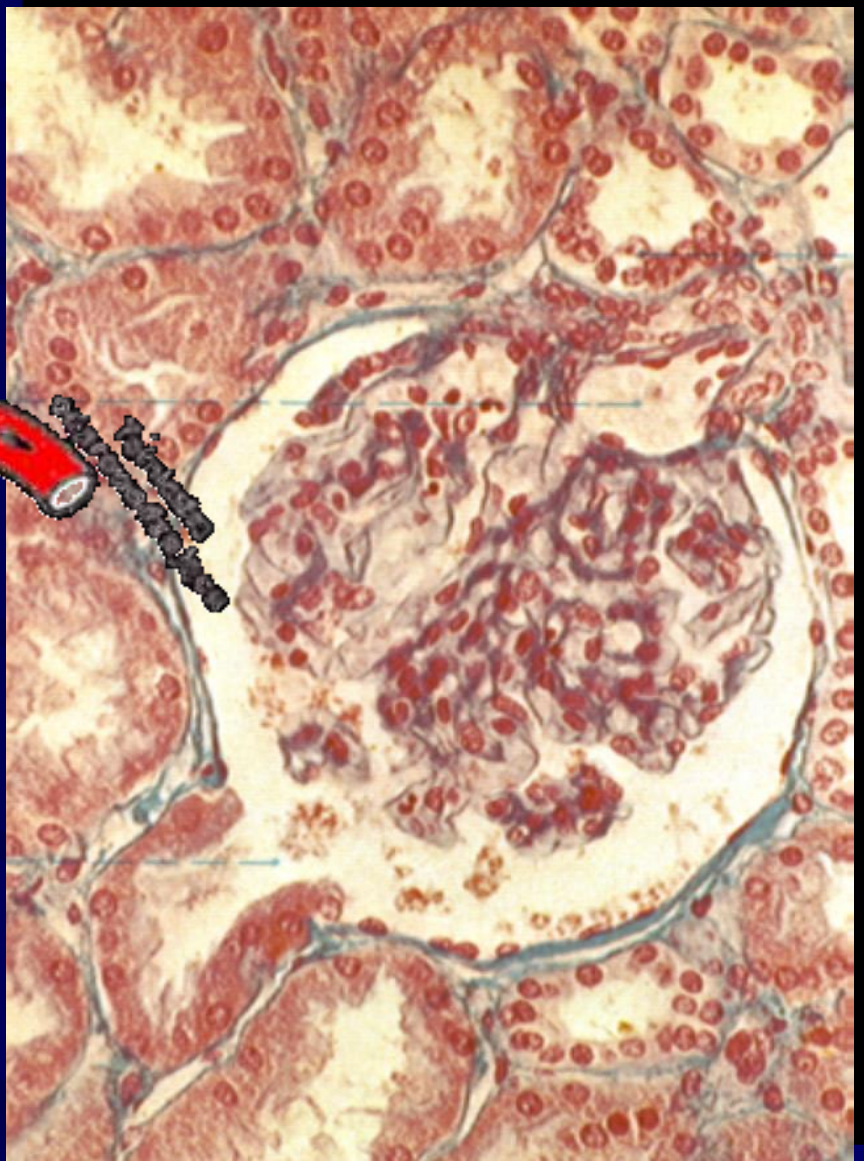
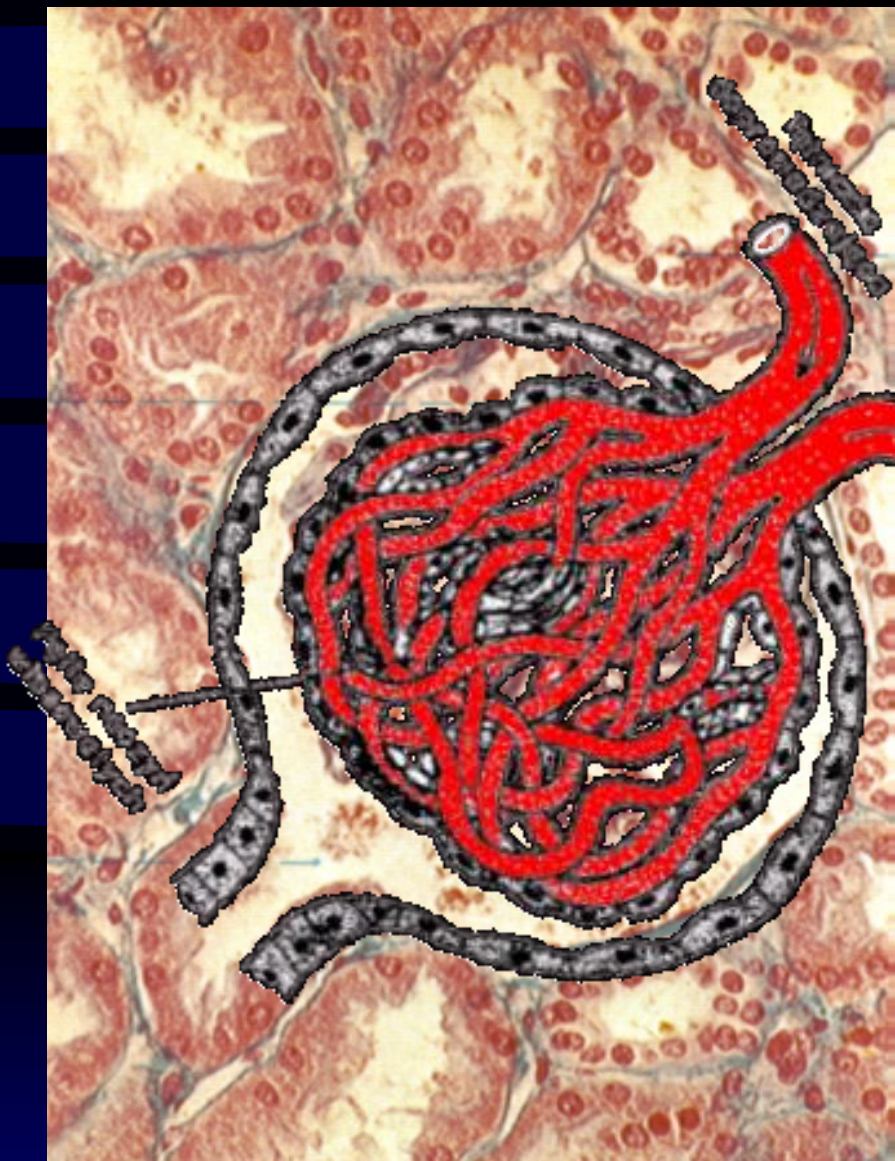


1-1,5 l/day

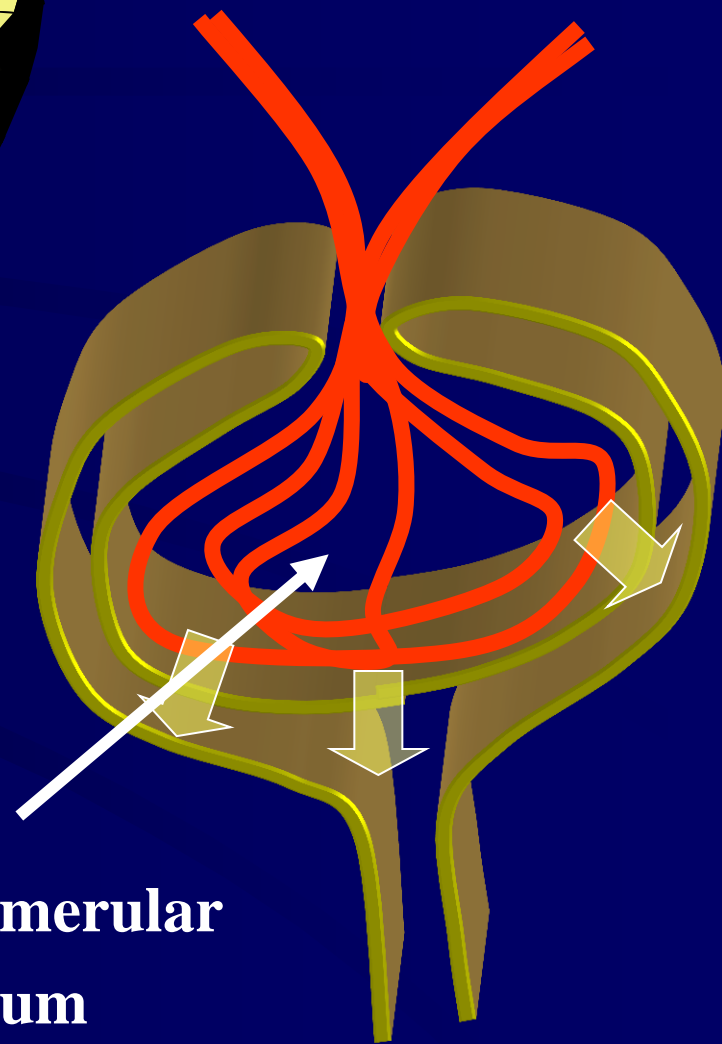
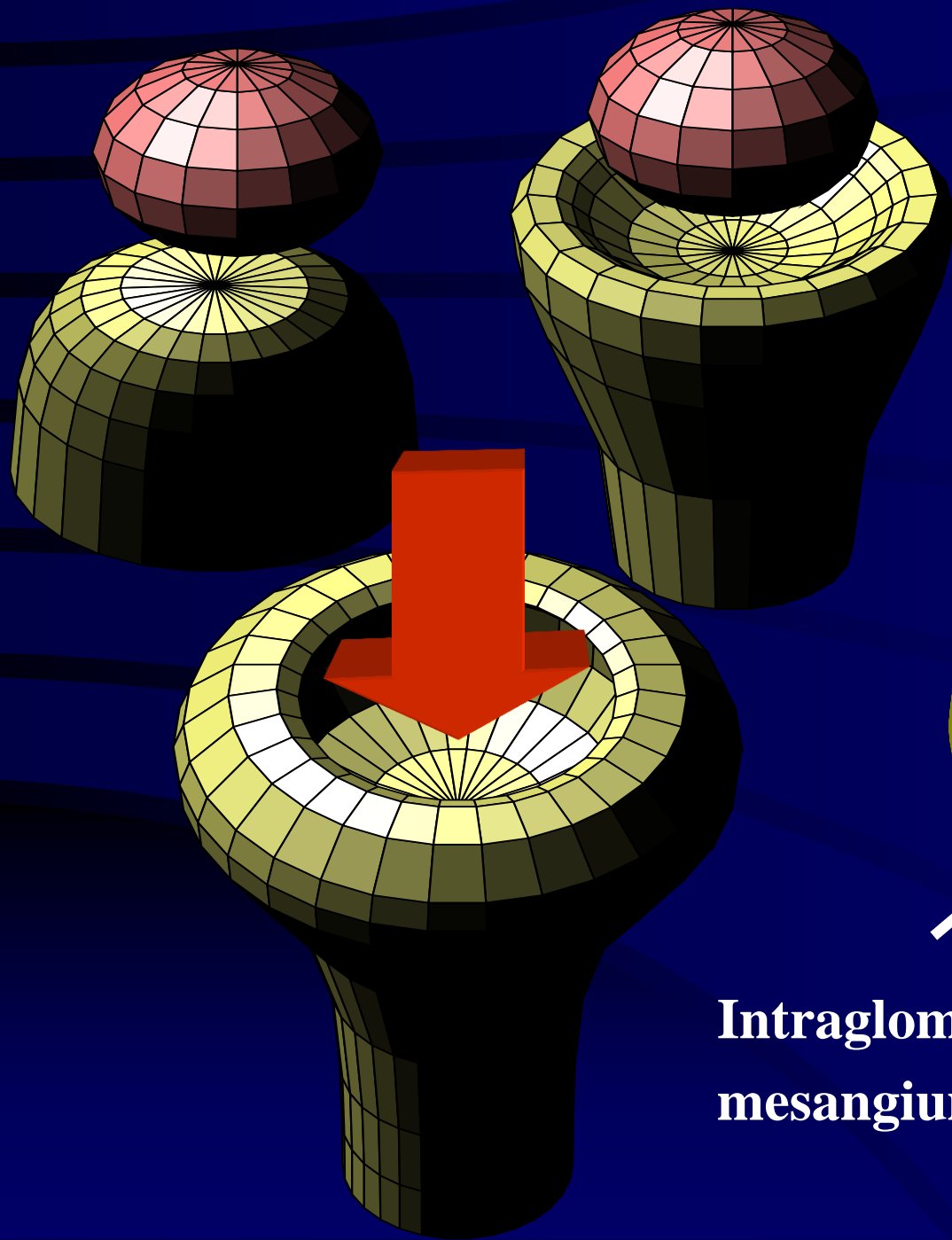


180 l/day

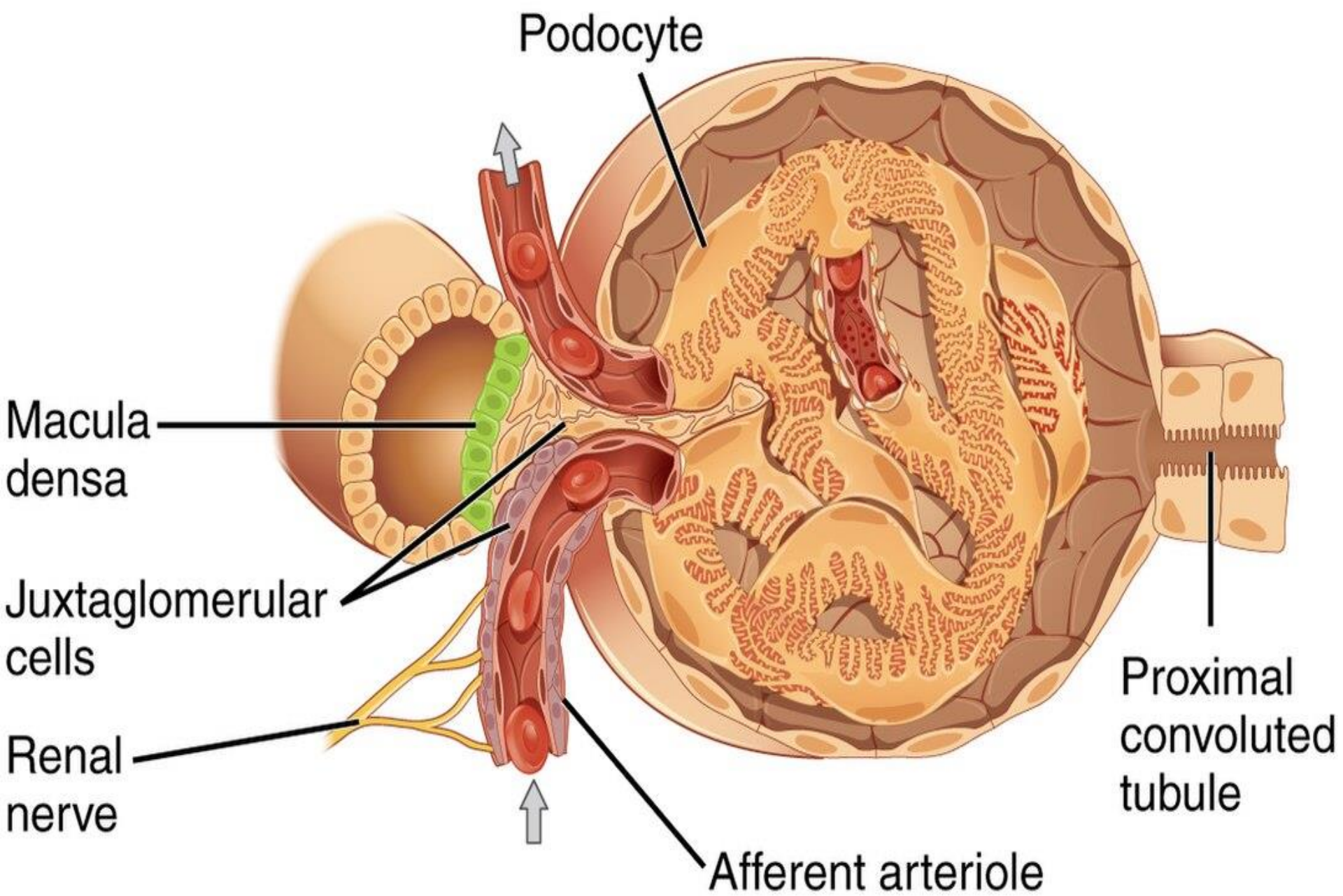




Renal glomerulus



**Intraglomerular
mesangium**



(a)

Macula densa

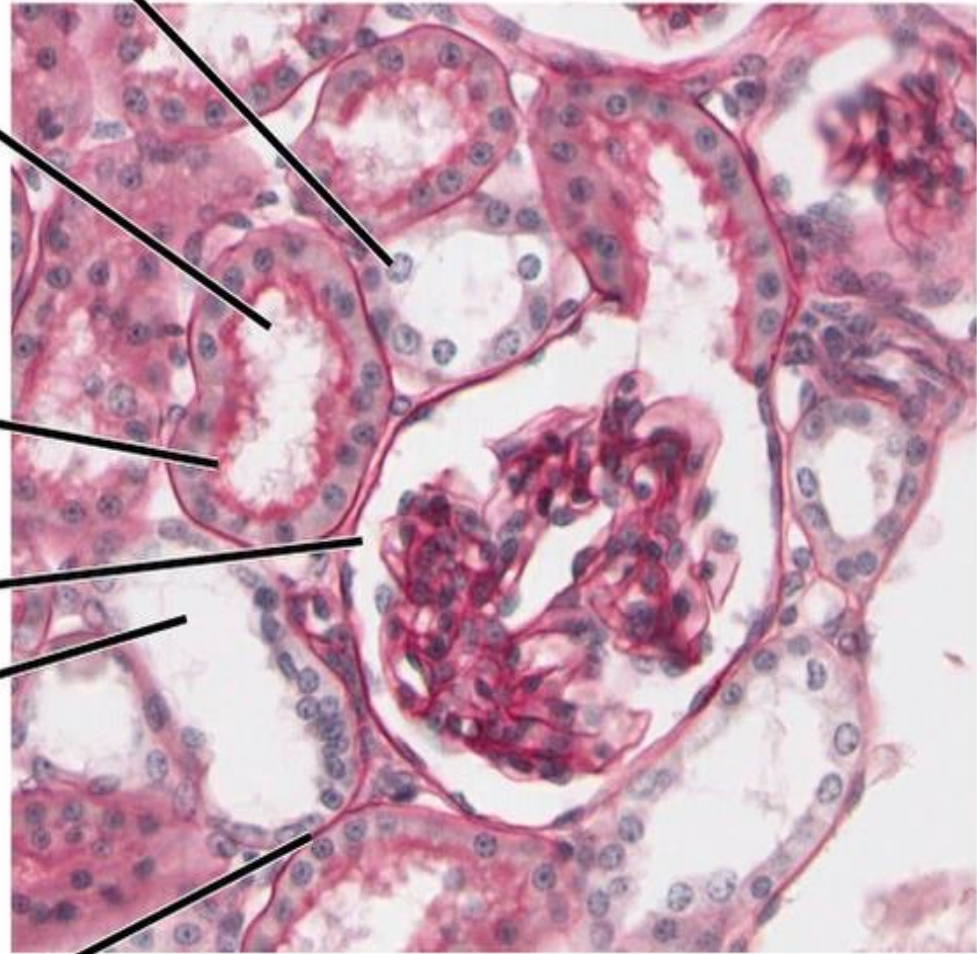
Proximal convoluted tubule

Brush border

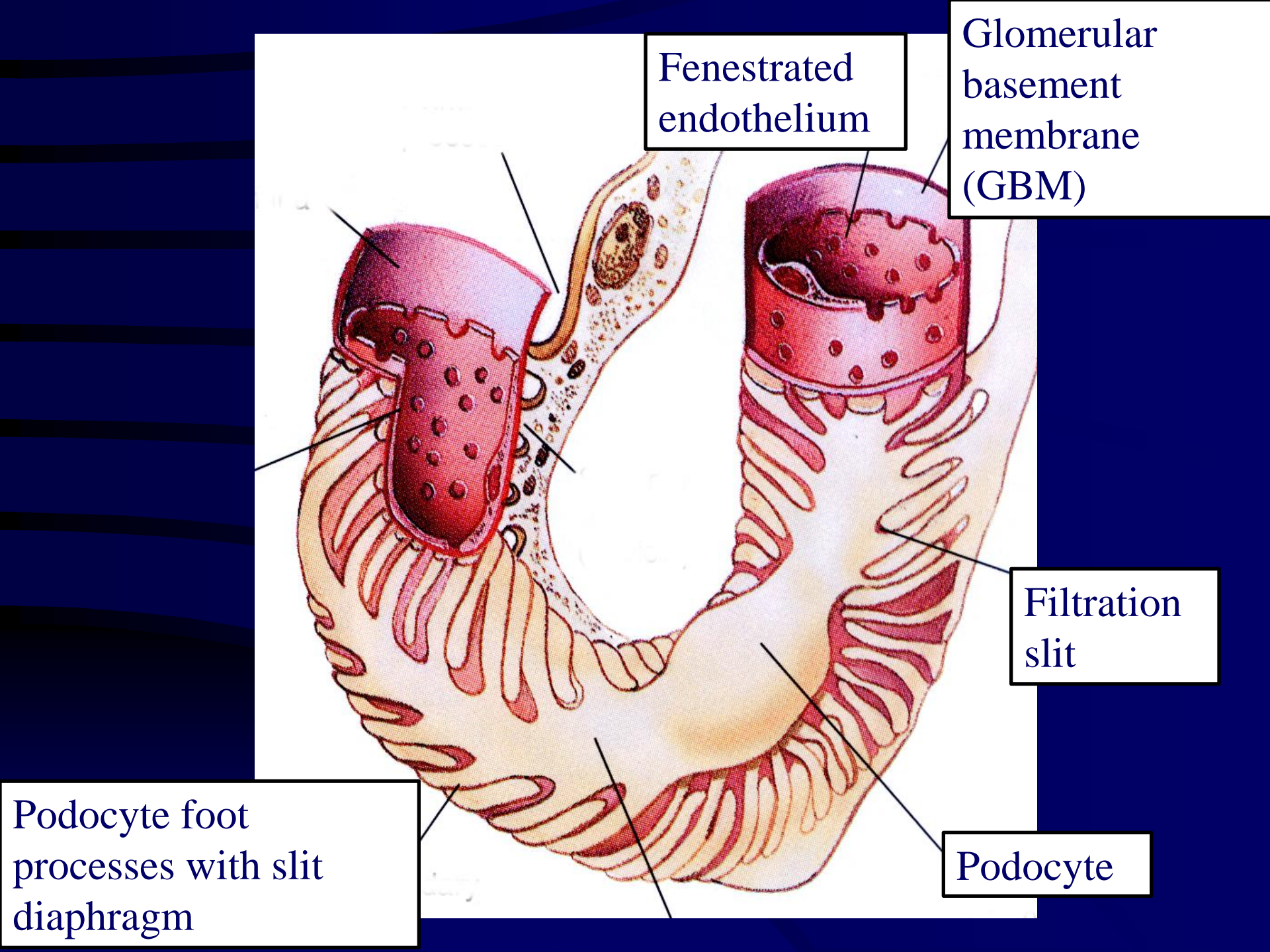
Glomerulus

Distal convoluted tubule

Basement membrane



(b)



Fenestrated endothelium

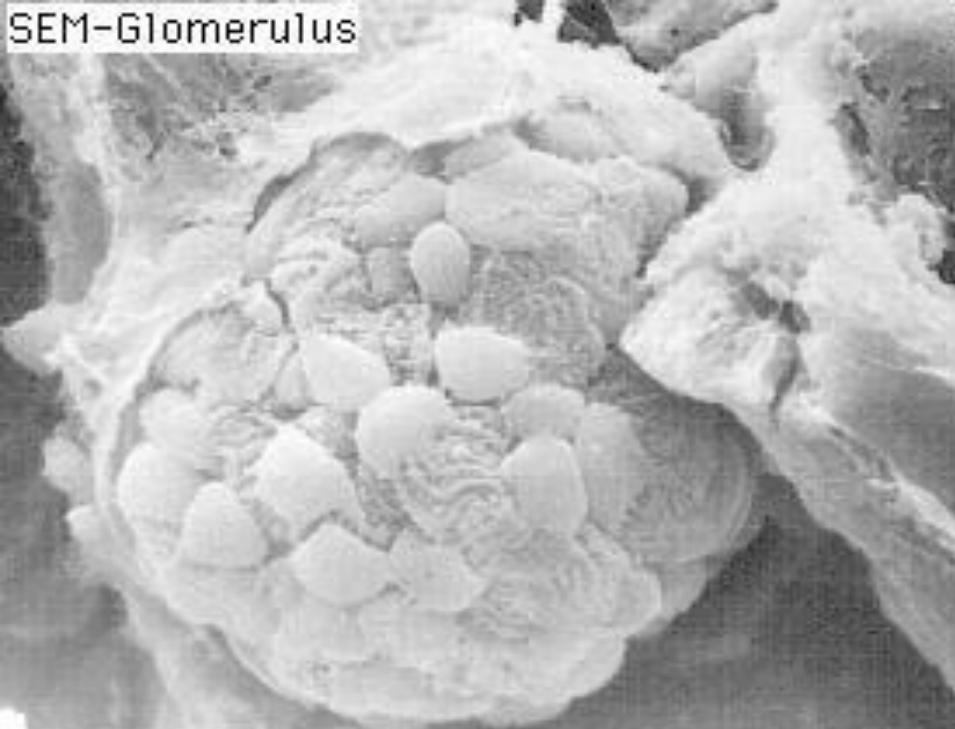
Glomerular basement membrane (GBM)

Filtration slit

Podocyte

Podocyte foot processes with slit diaphragm

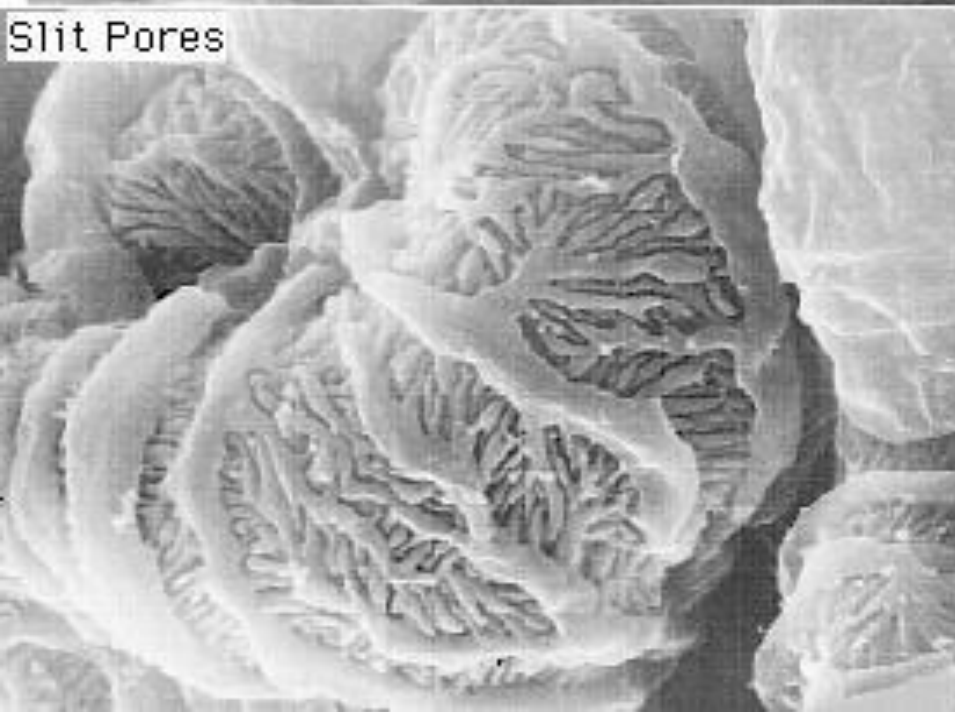
SEM-Glomerulus



SEM-Podocytes

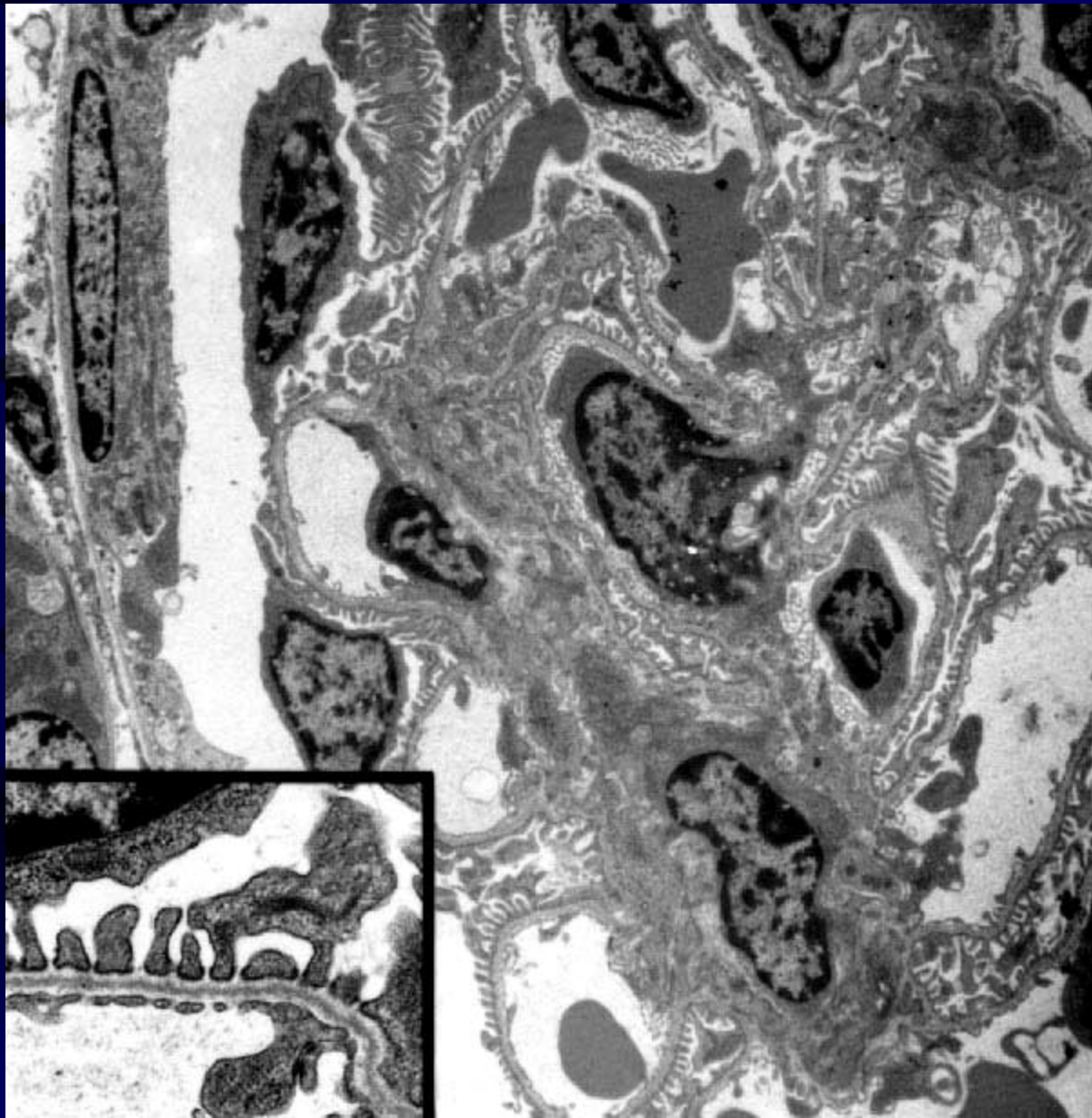


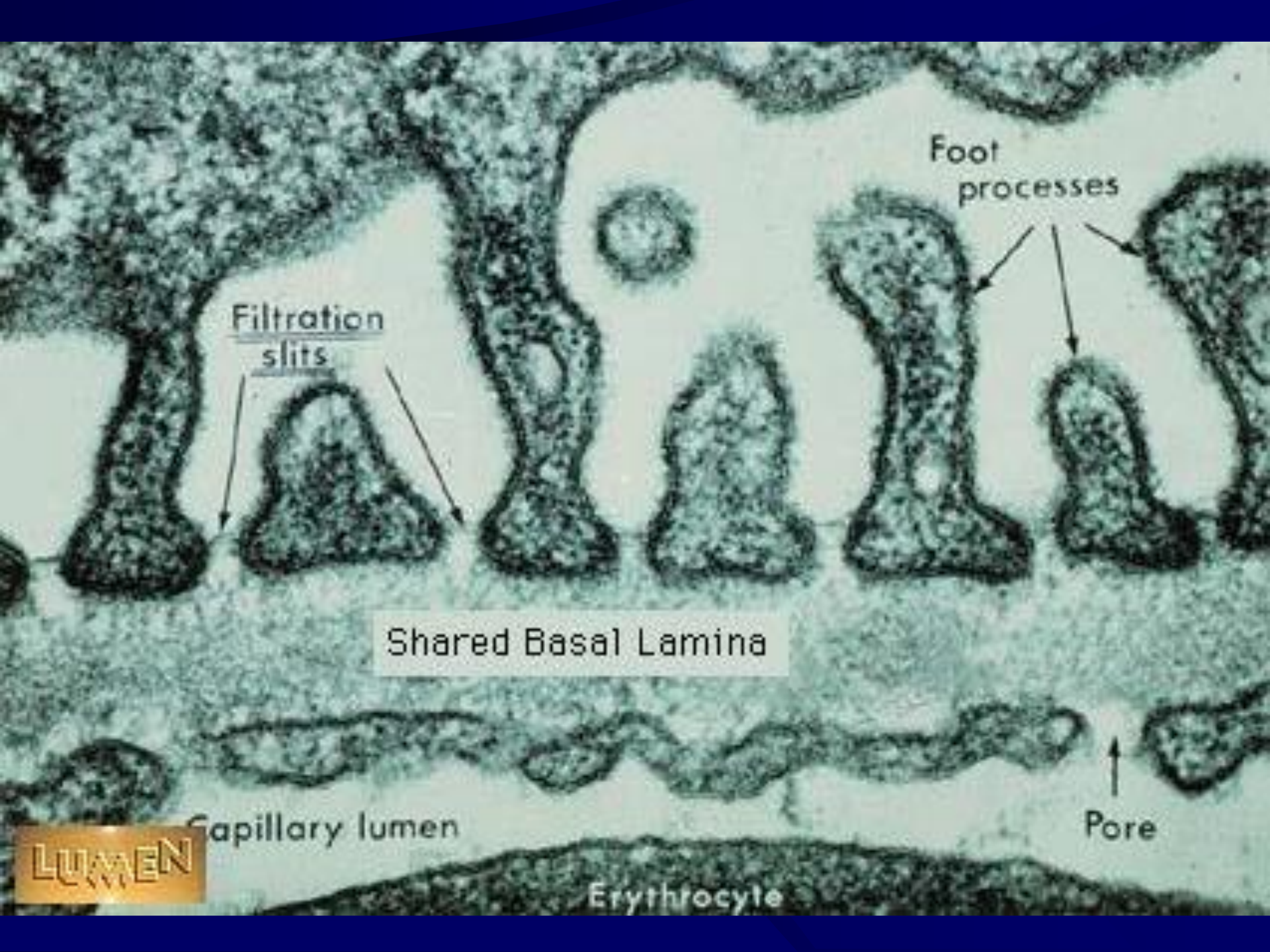
Slit Pores



Primary & Secondary Processes







Foot processes

Filtration slits

Shared Basal Lamina

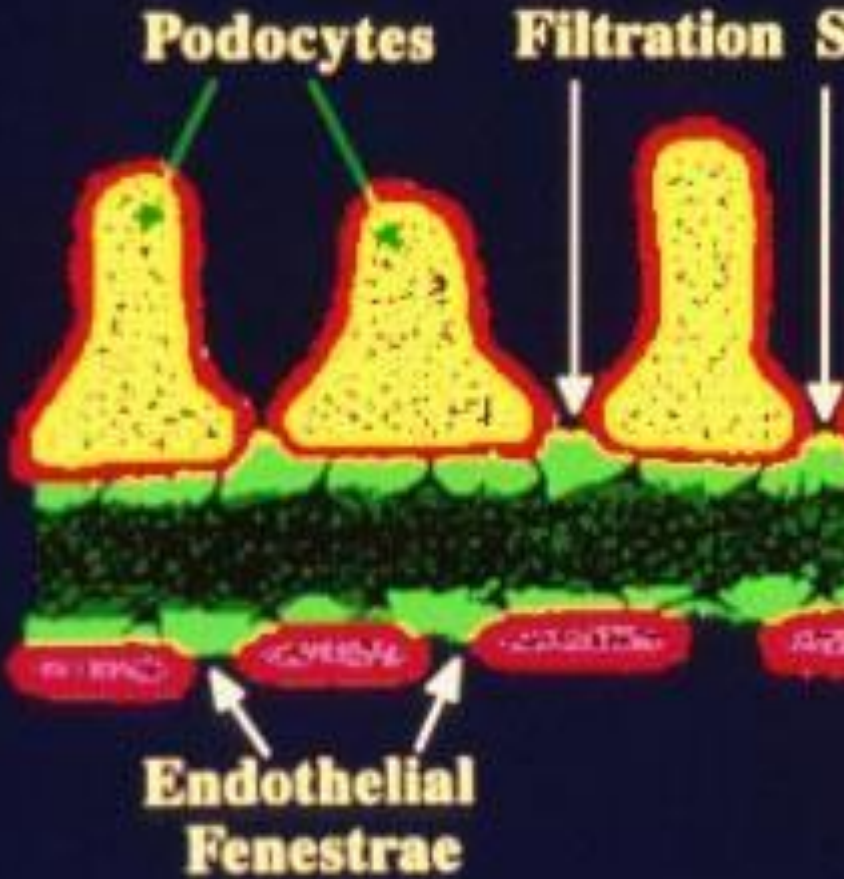
Capillary lumen

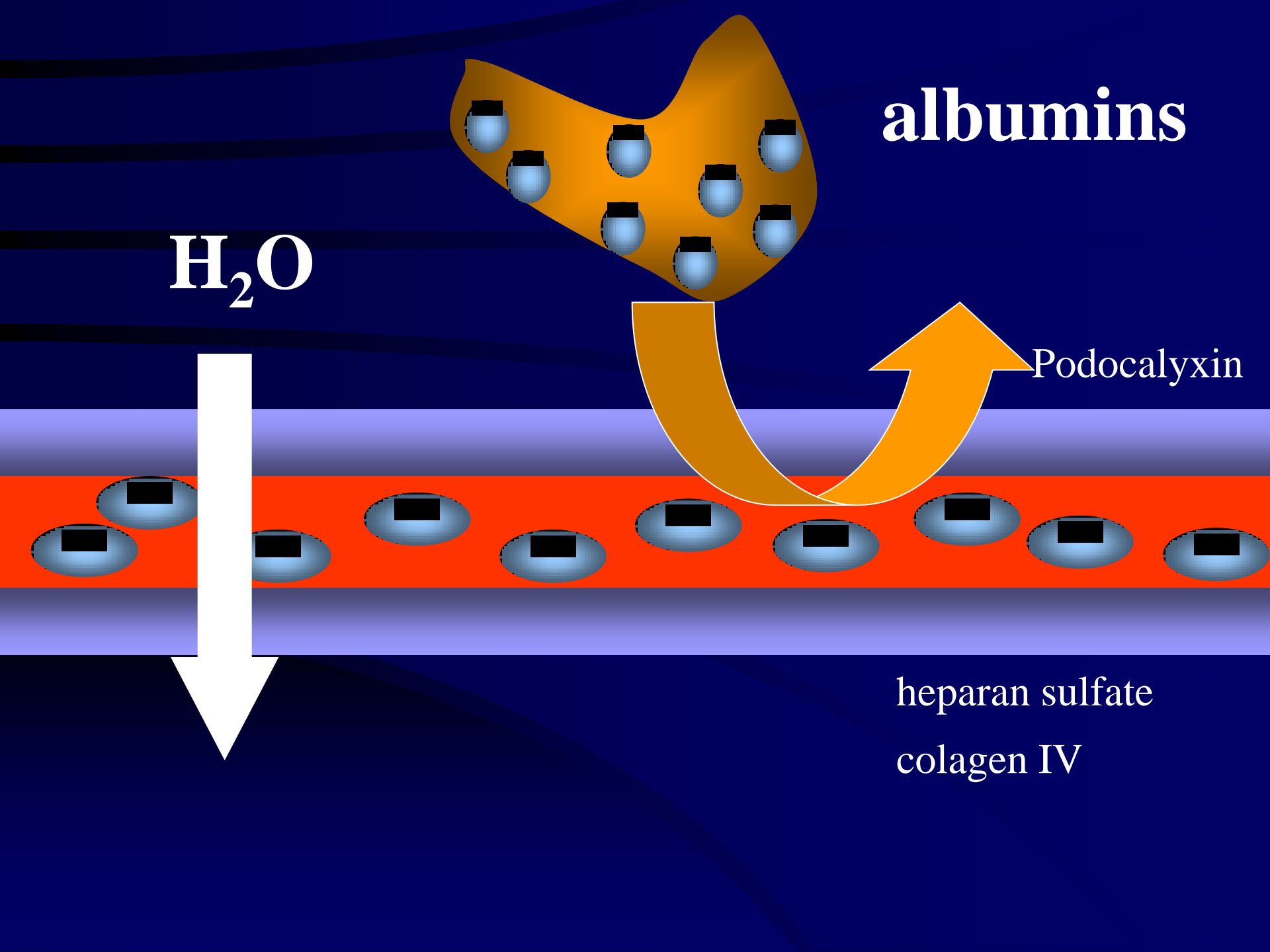
Pore

Erythrocyte

LUMEN

Glomerular Filtration



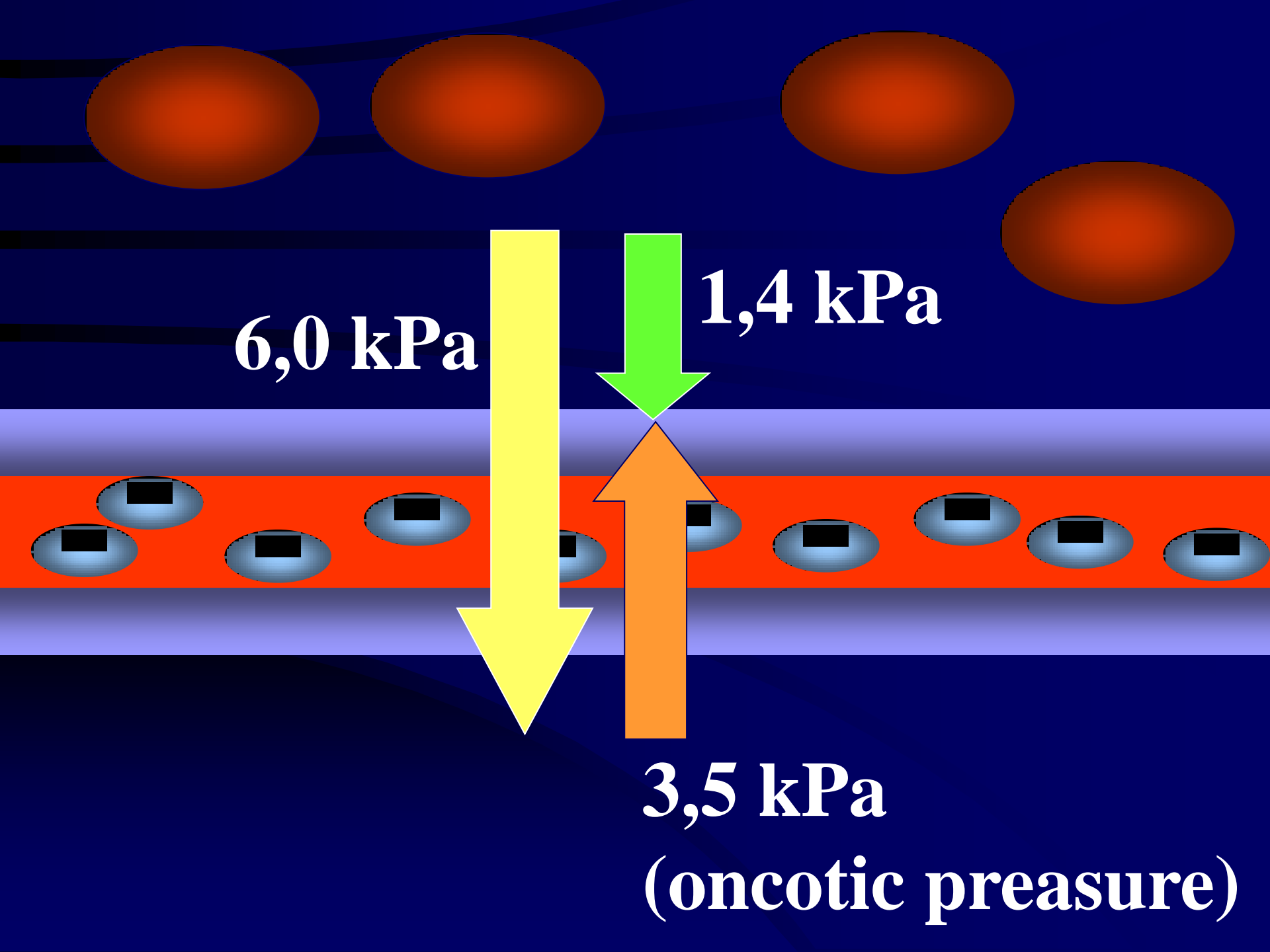


albumins

H_2O

Podocalyxin

heparan sulfate
collagen IV



6,0 kPa

1,4 kPa

3,5 kPa

(oncotic pressure)

A detailed diagram of a nephron's glomerulus and Bowman's capsule. On the left, a cross-section of a blood vessel shows various components: large purple leukocytes, smaller purple platelets, and red erythrocytes. In the center, a cluster of capillaries (the glomerulus) is shown. On the right, the Bowman's capsule is depicted as a series of interconnected sacs. Green arrows point from the glomerulus into the capsule, indicating the flow of filtrate. Labels with leader lines identify the blood components and the process of glomerular filtration. A text box on the right lists the contents of the filtrate.

Leukocytes

Large plasma proteins

Platelets

Erythrocytes

Glomerular Filtration

**After Filtration
(Glomerular Filtrate)**

The filtrate contains:

Water

Glucose

Amino acids

**Ions (Na^+ , K^+ , Cl^- ,
 HCO_3^-)**

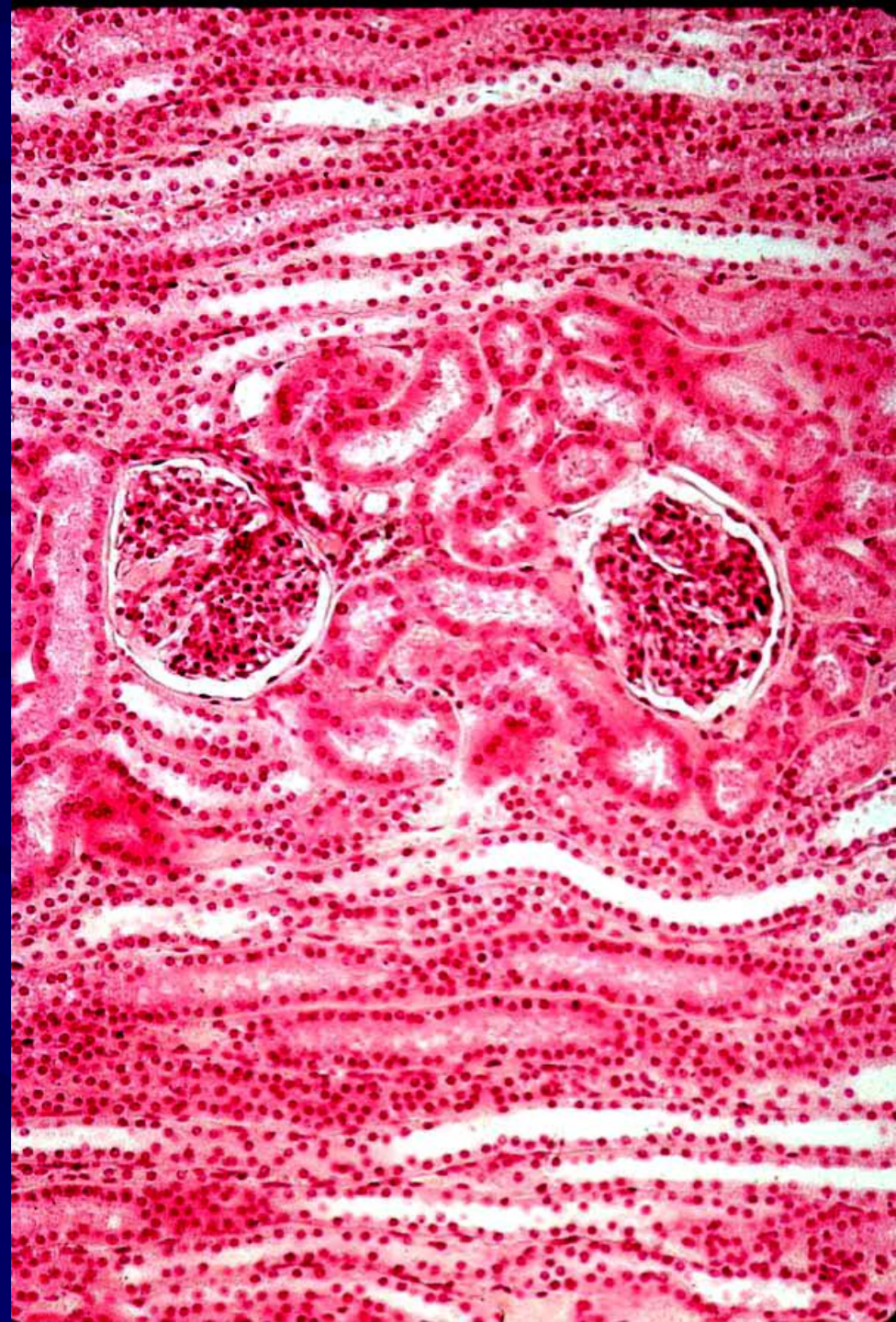
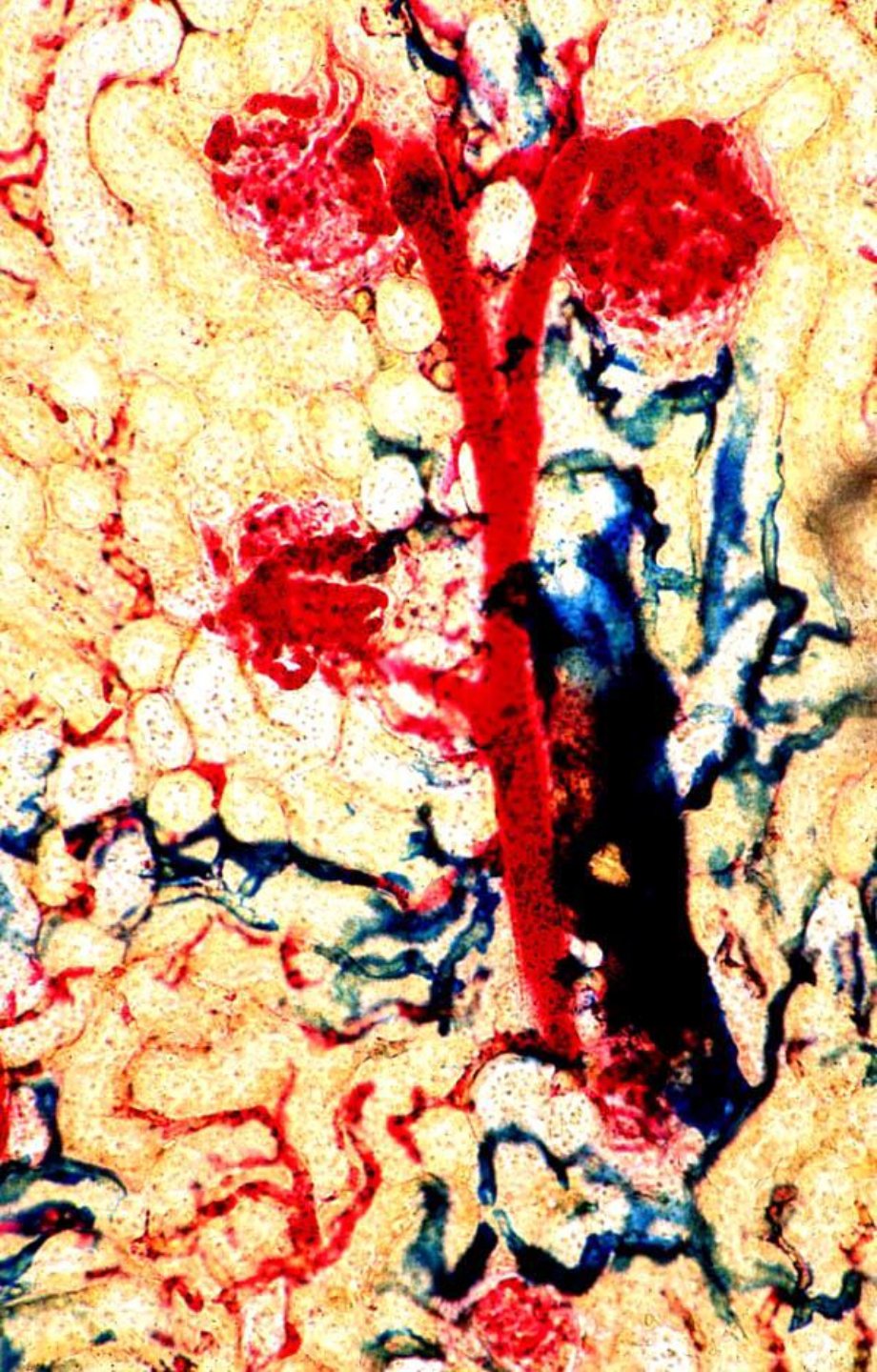
Urea

Creatinine

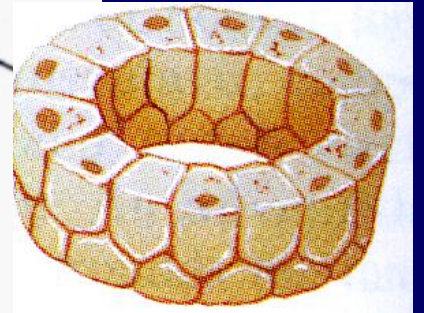
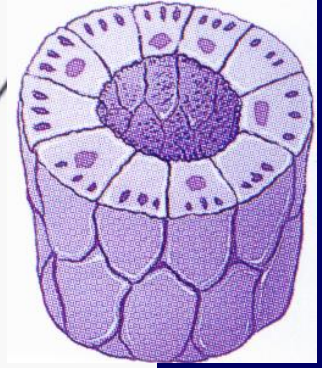
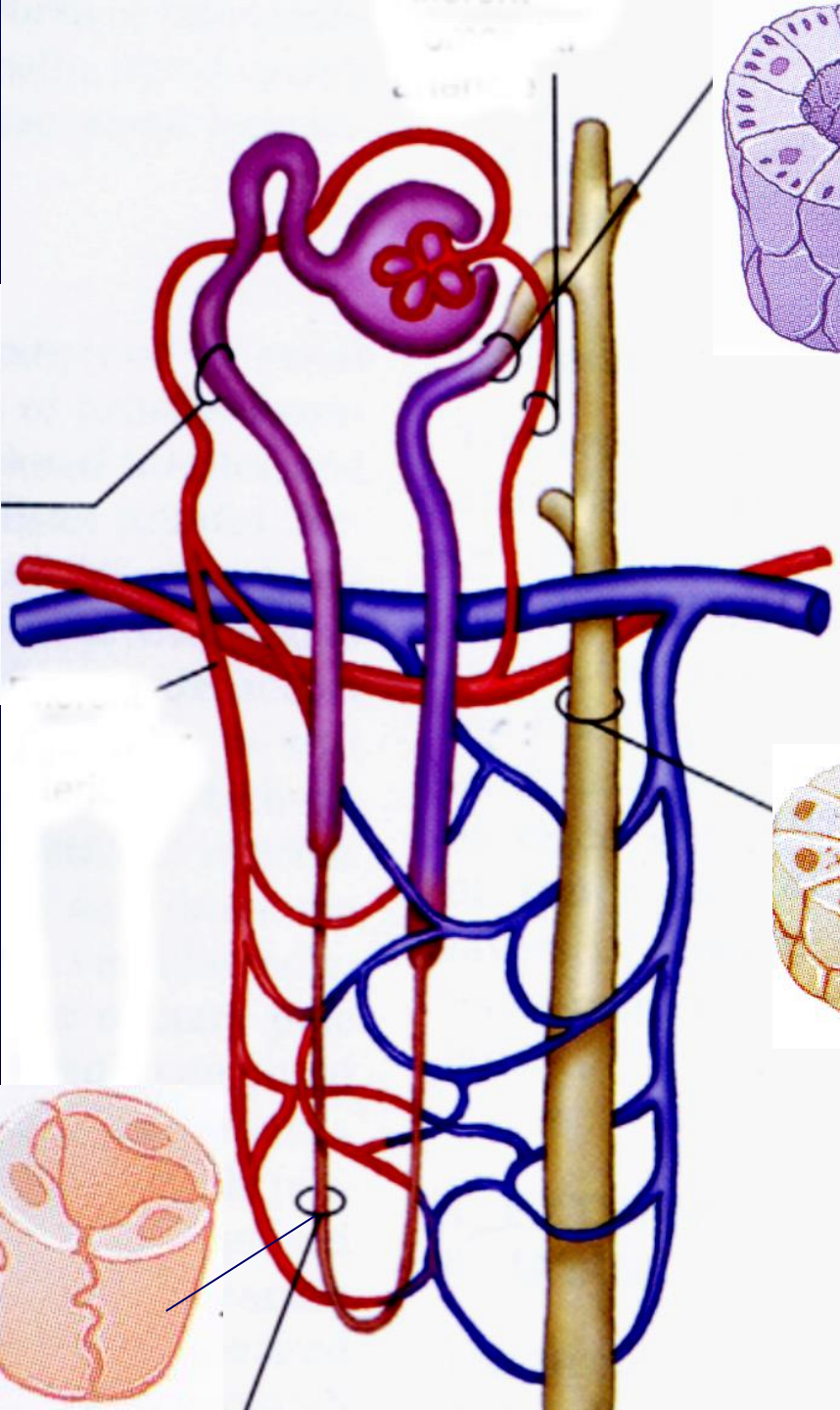
Many hormones

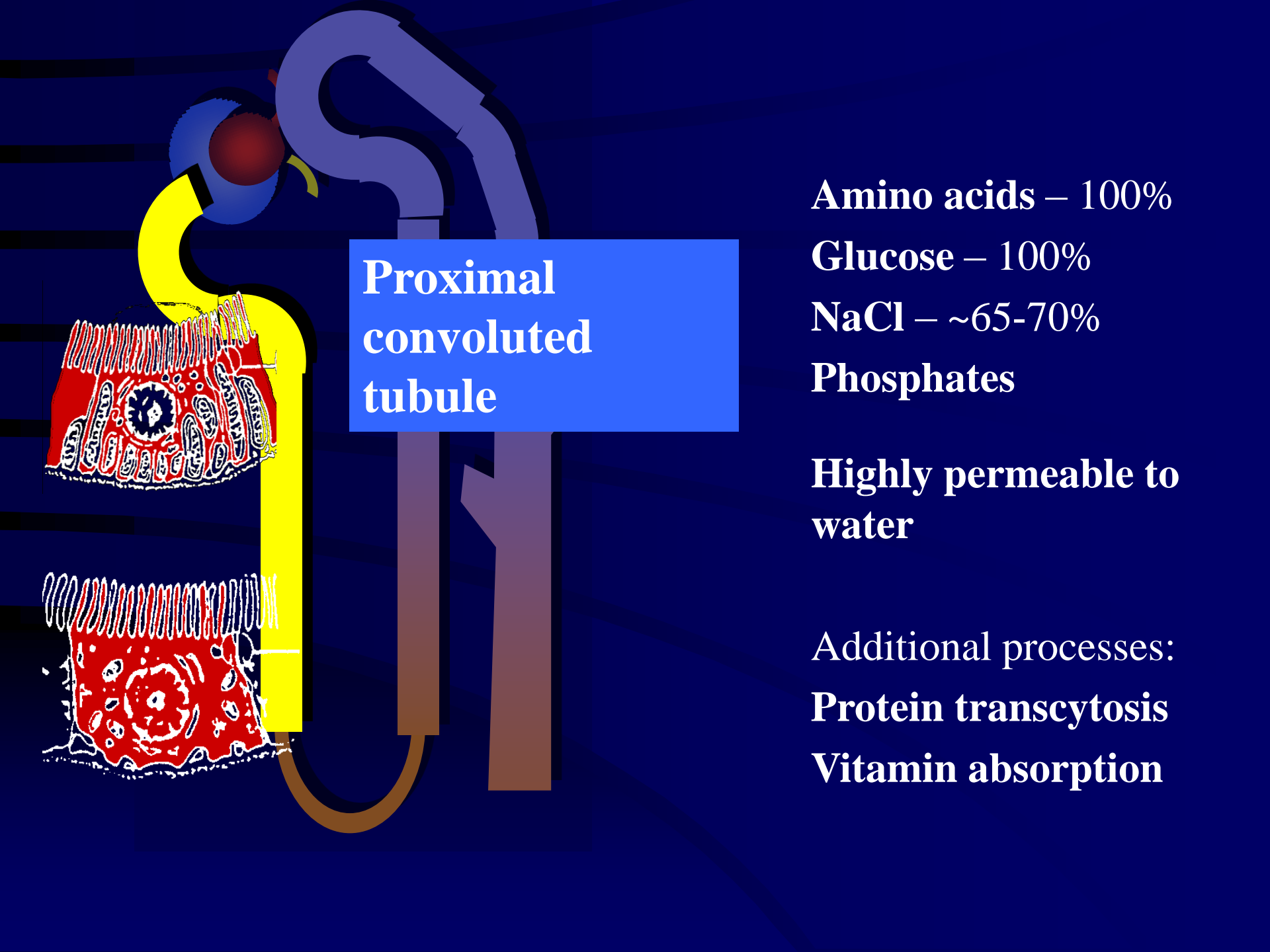
Vitamins B and C

**Very small amounts of
proteins**







A diagram of a nephron, the functional unit of the kidney. The proximal convoluted tubule is highlighted in yellow. Two cross-sections of the tubule are shown, illustrating the brush border (microvilli) on the apical surface and the basal membrane with various organelles. A blue box with white text is positioned over the yellow tubule.

**Proximal
convoluted
tubule**

Amino acids – 100%

Glucose – 100%

NaCl – ~65-70%

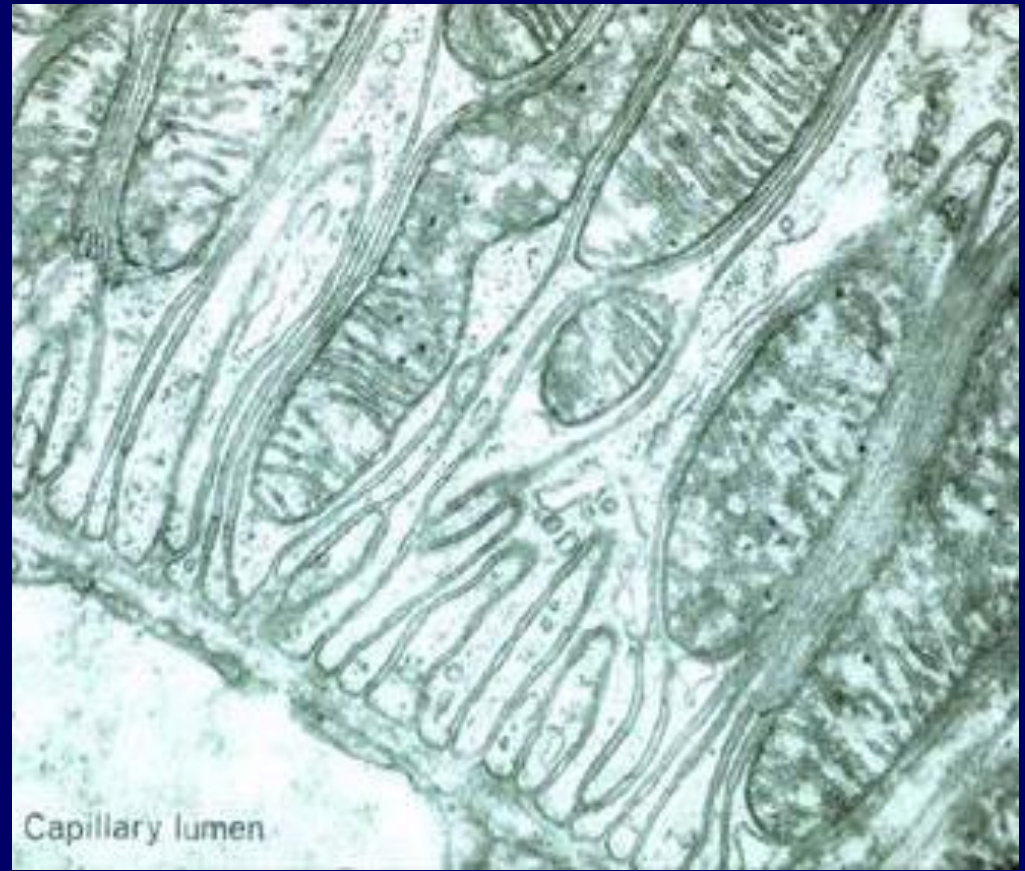
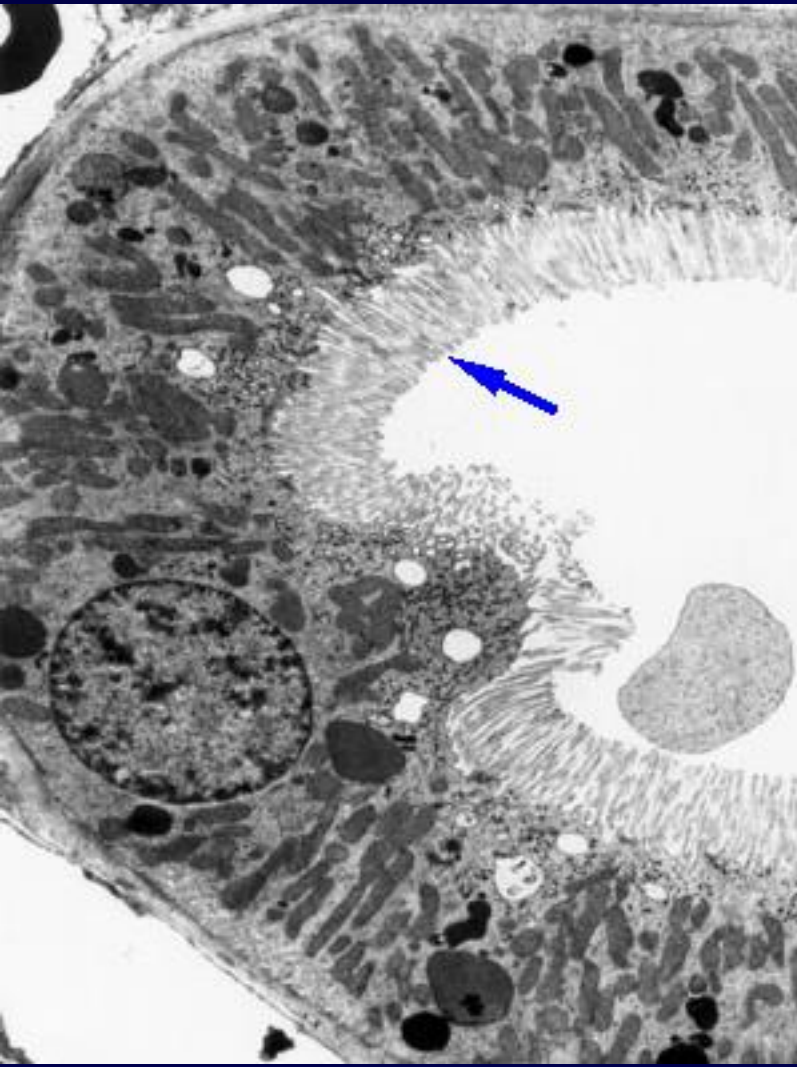
Phosphates

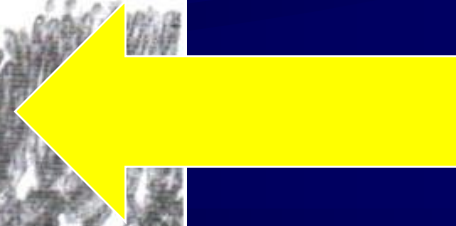
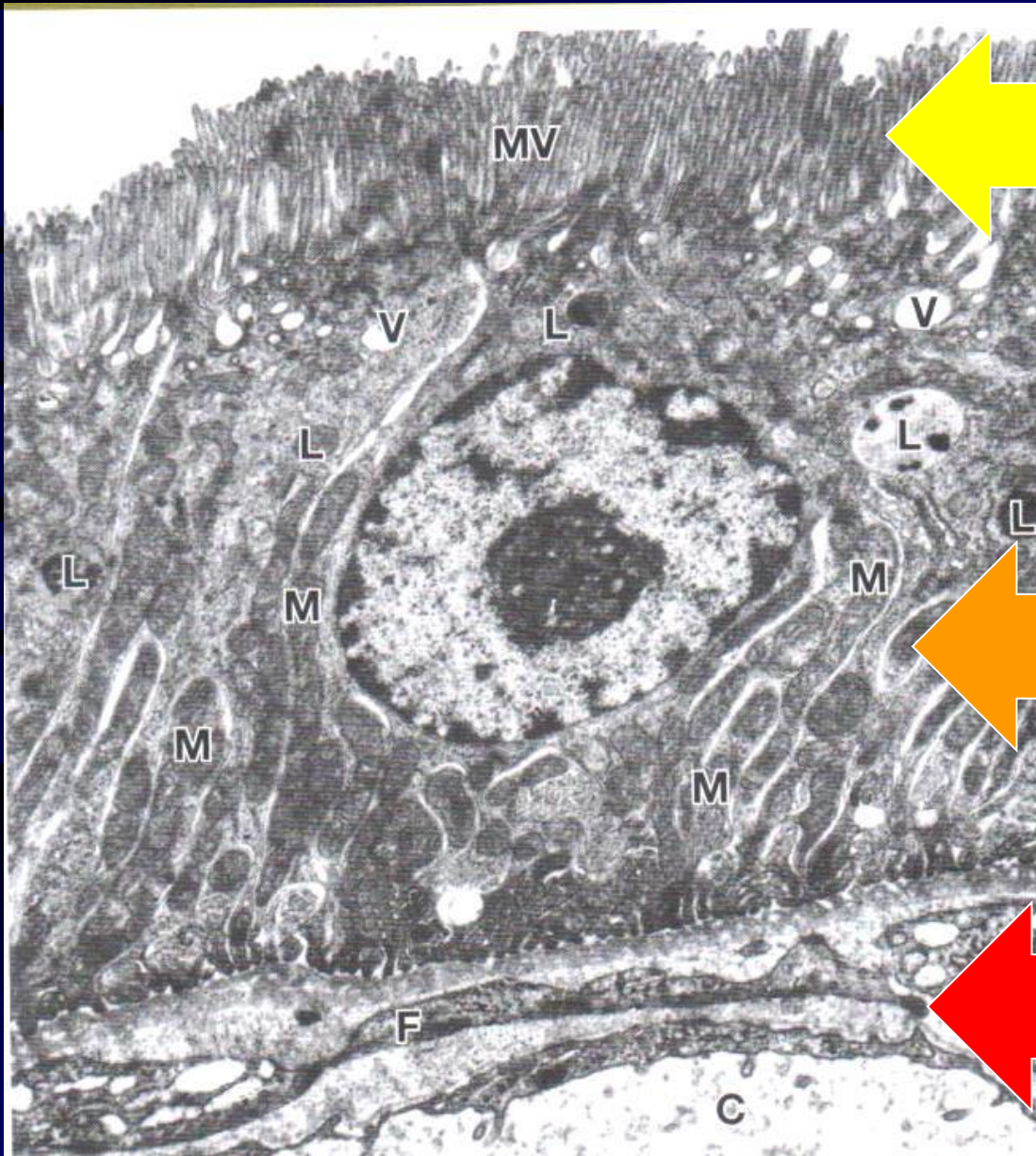
**Highly permeable to
water**

Additional processes:

Protein transcytosis

Vitamin absorption

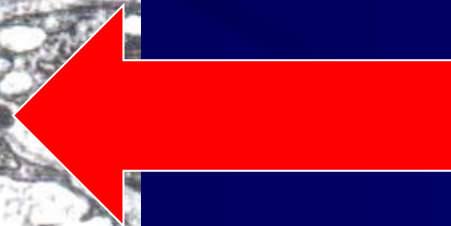




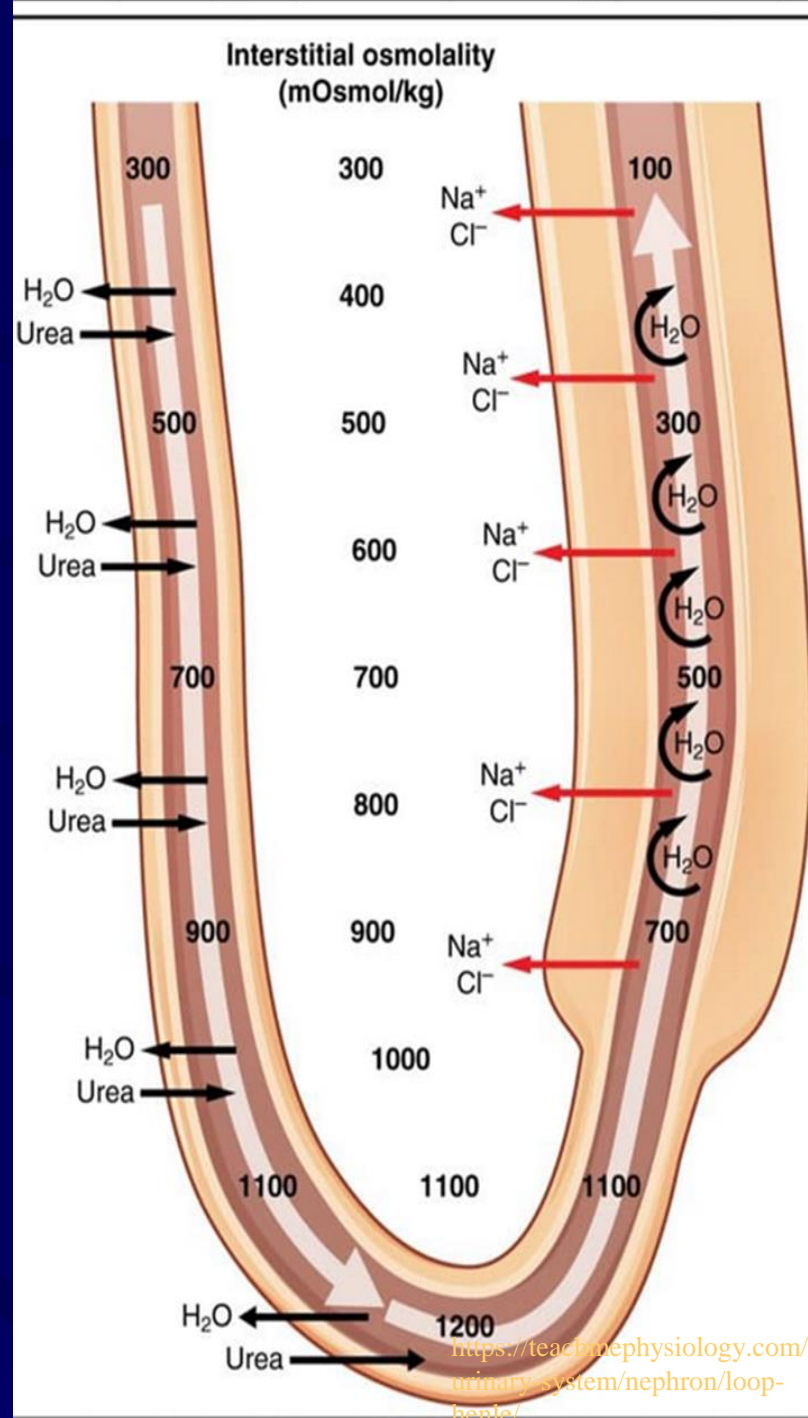
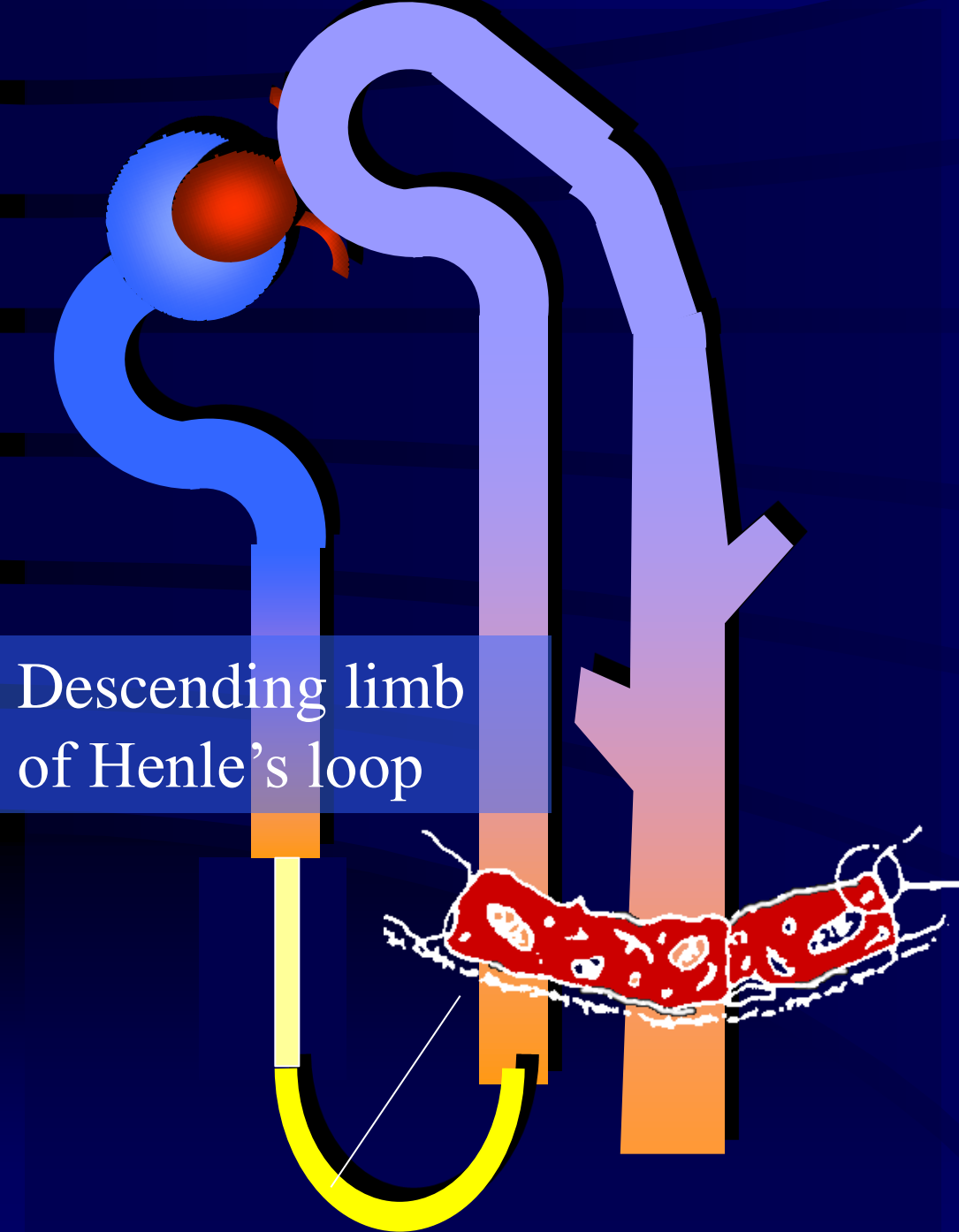
Microvilli



Mitochondria



Endothelial cells



- Active reabsorption of Na^+ , K^+ and Cl^- (NKCC transporter)

- Impermeable to water

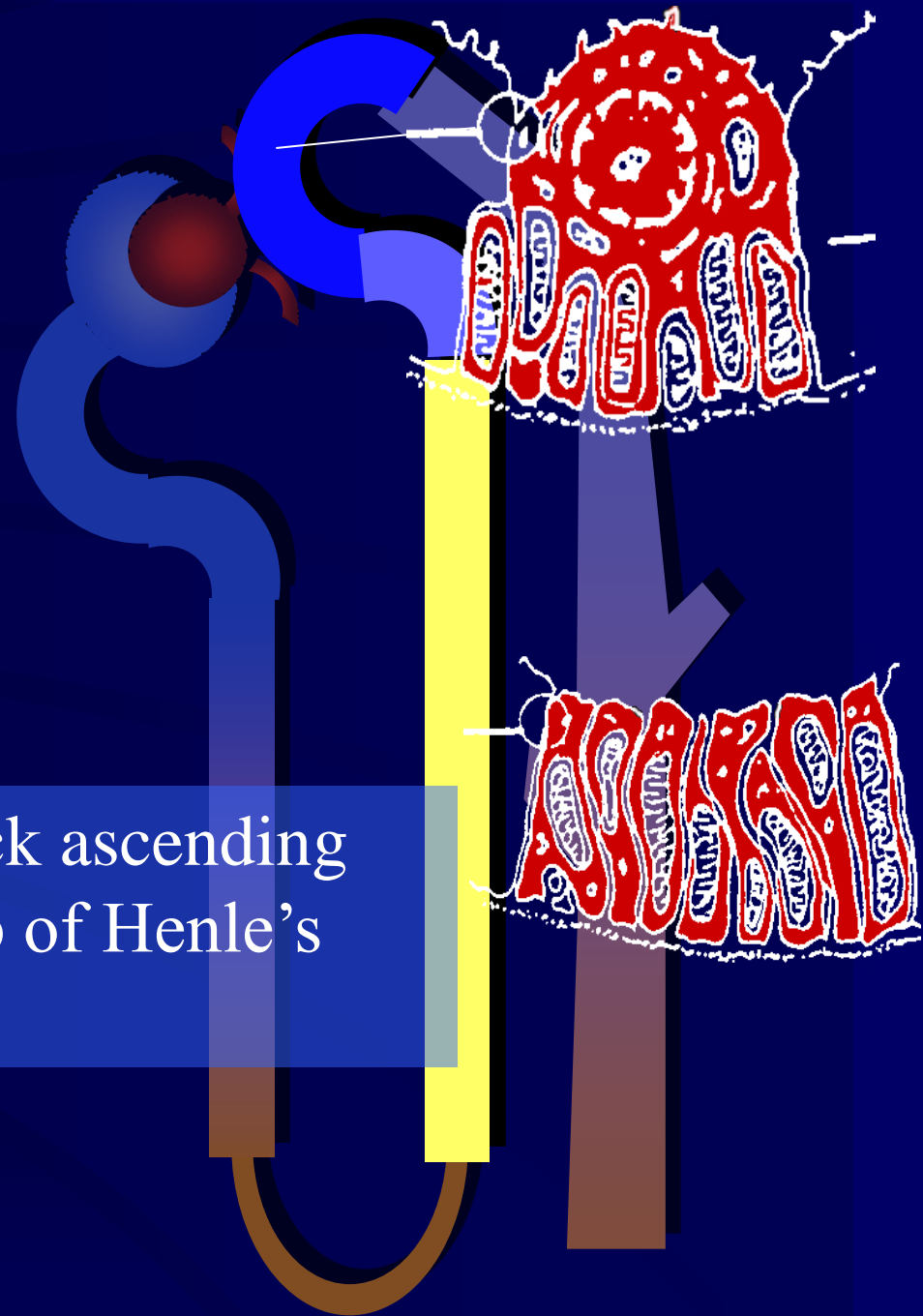
- Important for **countercurrent multiplication** and **formation of the medullary osmotic gradient.**

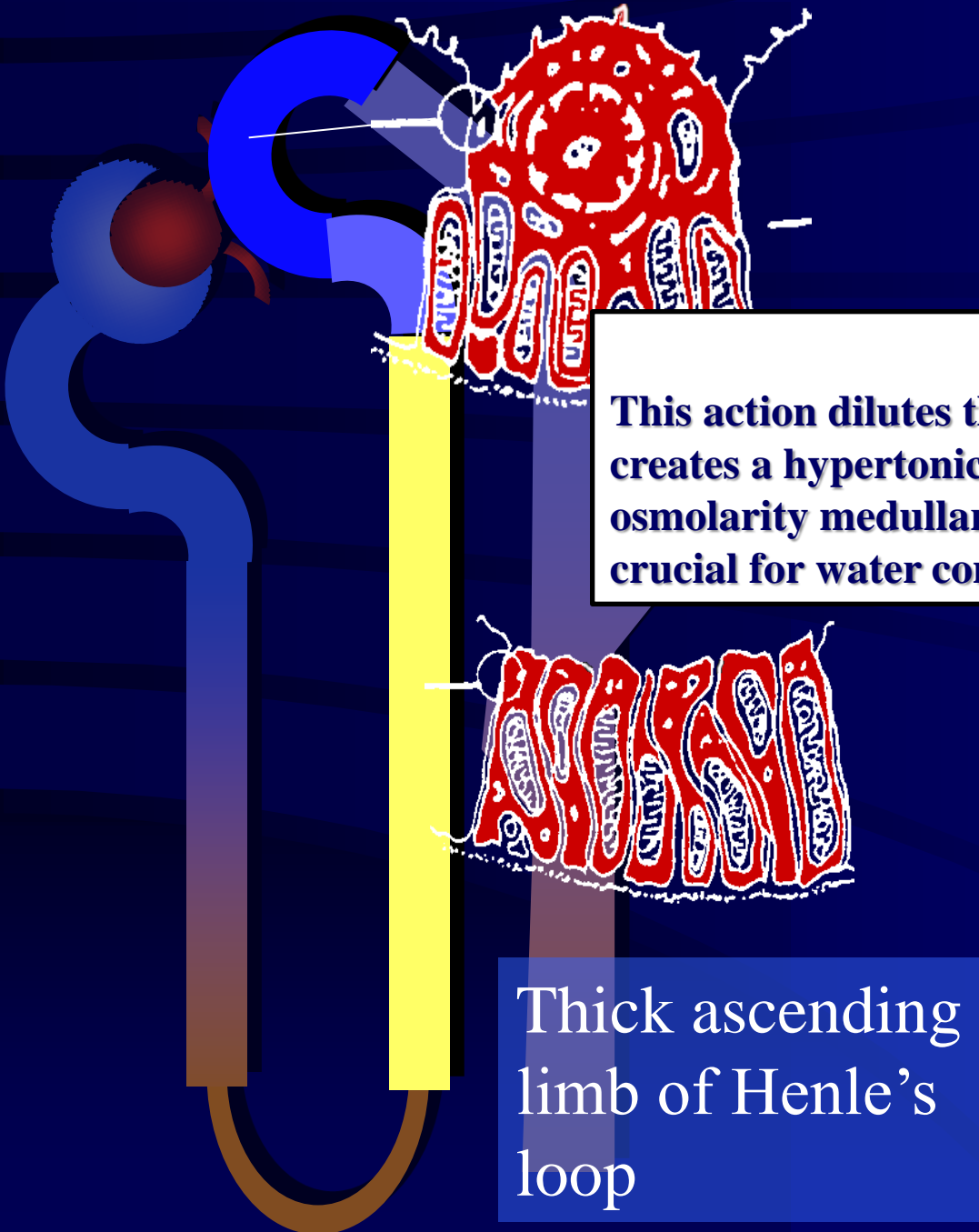
Loop diuretics (furosemide) strong natriuresis

- loss of Ca^{2+} and Mg^{2+}

- collapse of medullary gradient

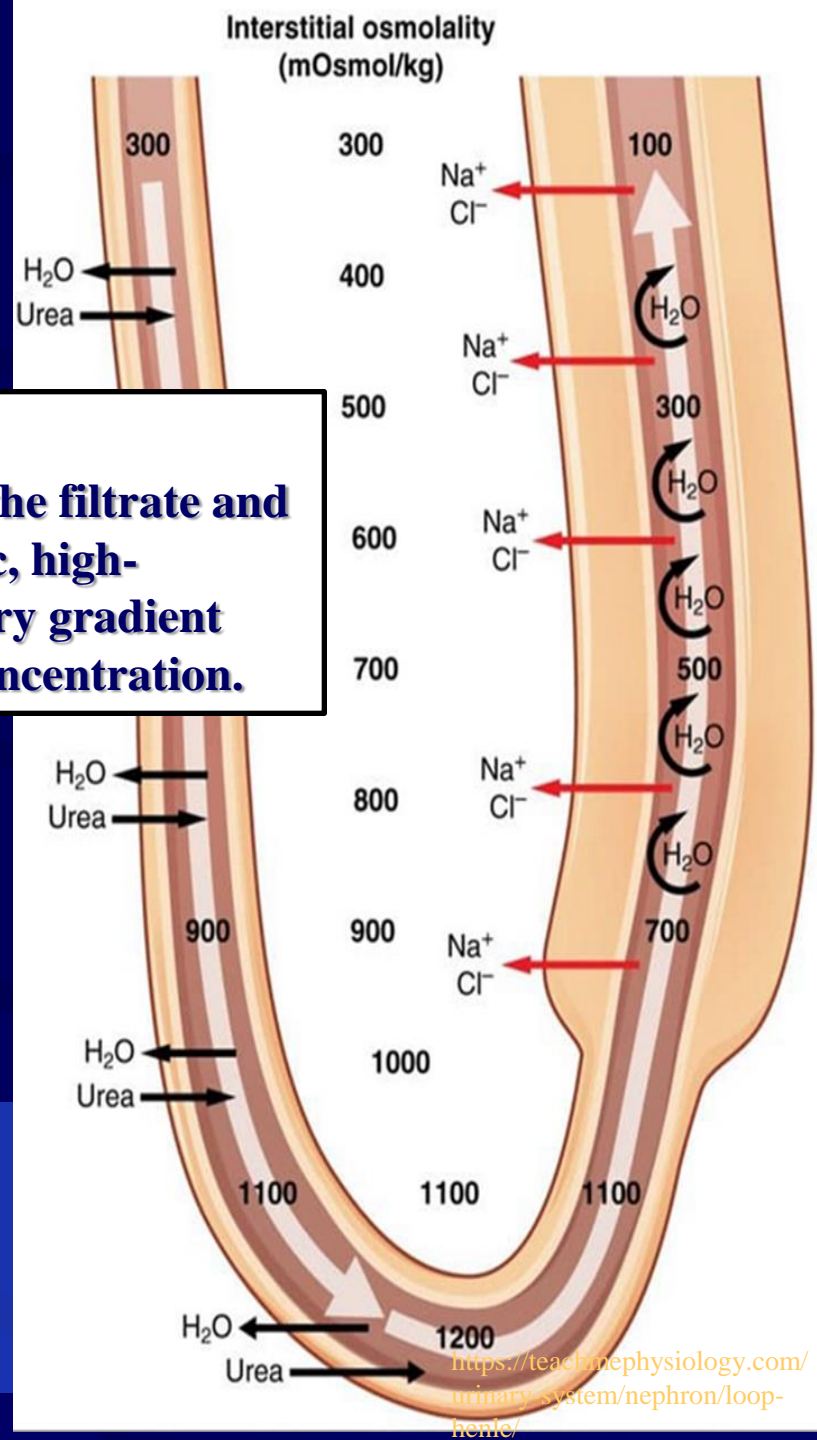
Thick ascending limb of Henle's loop





This action dilutes the filtrate and creates a hypertonic, high-osmolarity medullary gradient crucial for water concentration.

Thick ascending limb of Henle's loop



Distal convoluted tubule (DCT)

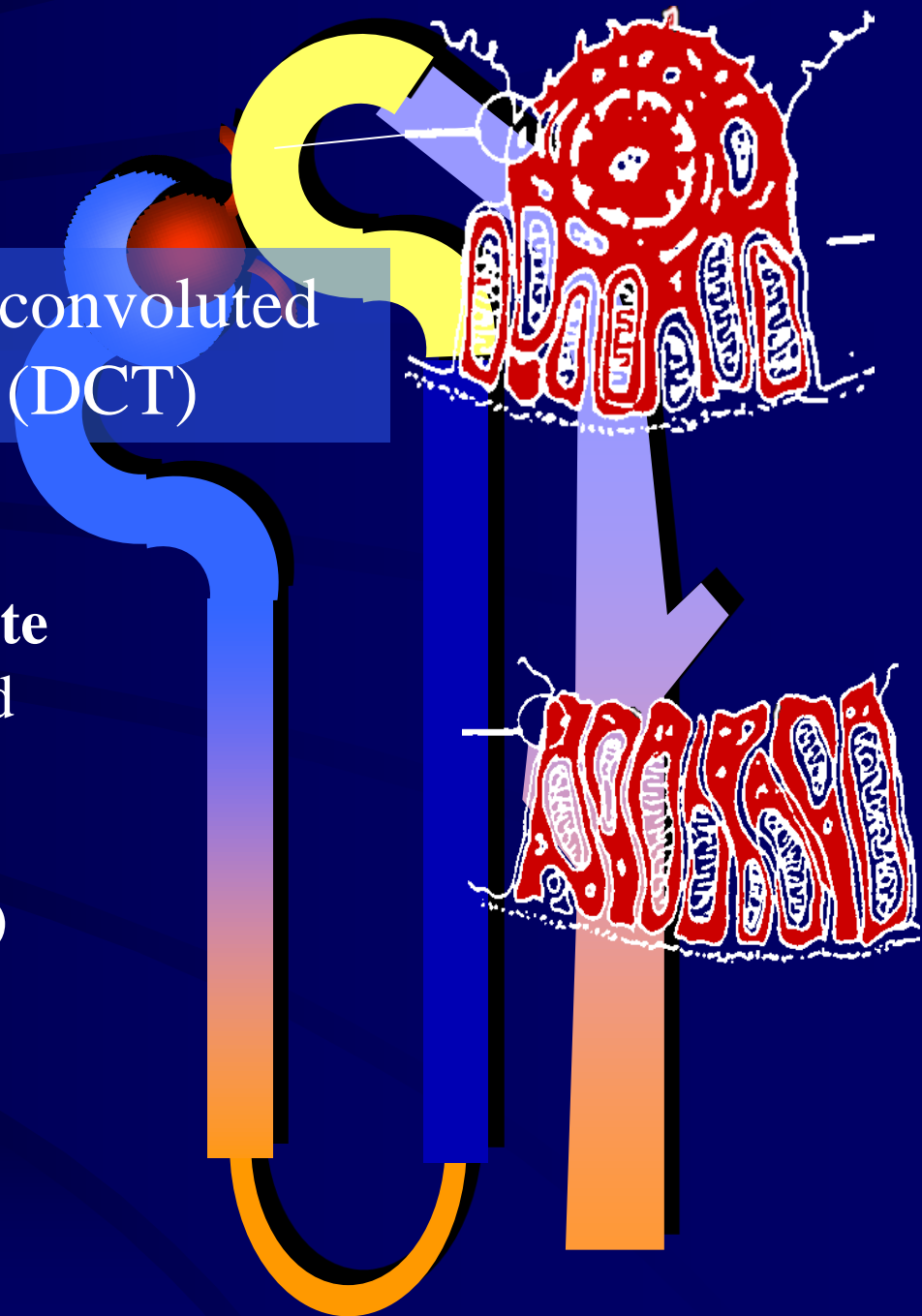
Precise regulation of electrolyte balance, especially calcium and sodium.

Primary transporter:

NCC (Na⁺-Cl⁻ cotransporter) symport

PTH, aldosterone

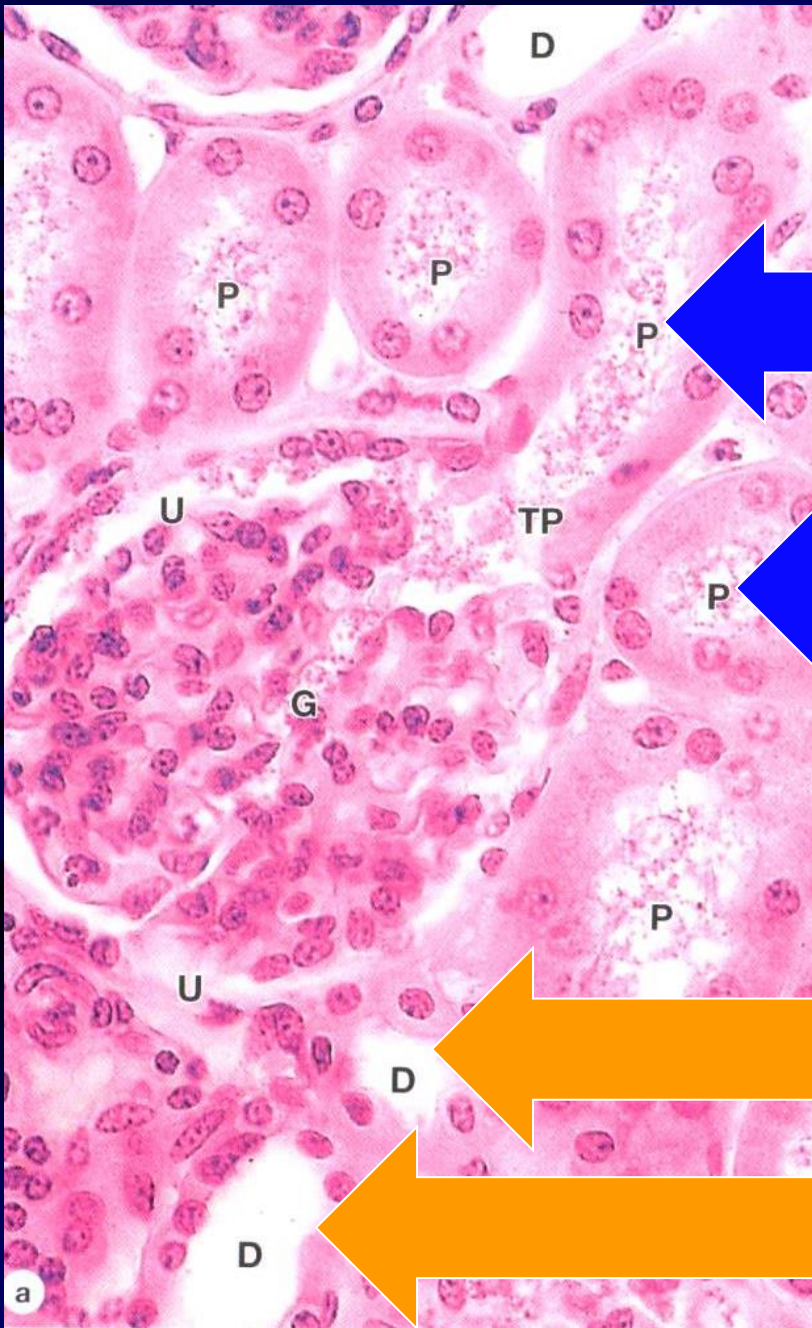
Thiazide diuretics



Thick Ascending Limb of the Loop of Henle (TAL) creates the **medullary osmotic gradient**, whereas the distal convoluted tubule (DCT) performs **hormone-regulated fine control of electrolyte balance**.

Thick Ascending Limb of the Loop of Henle (TAL) reabsorbs
~25% of the filtered sodium load

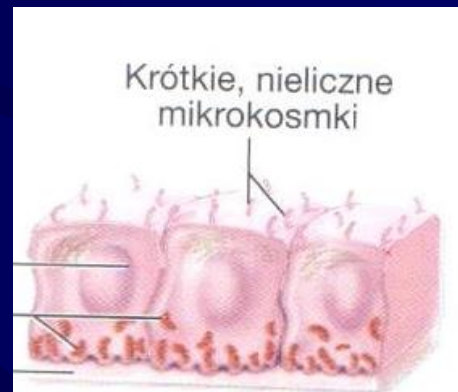
The DCT reabsorbs 5%–10% of the filtered sodium load



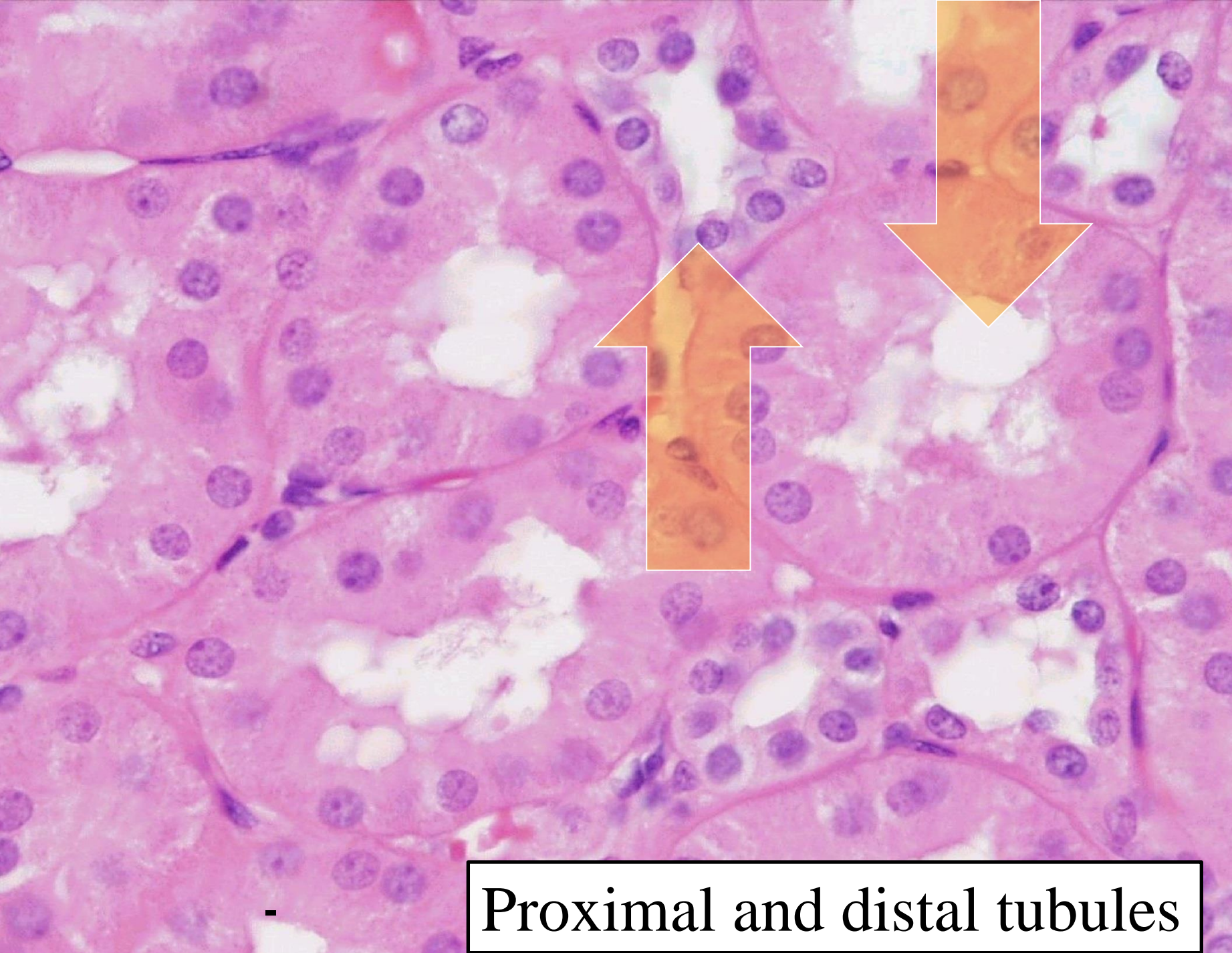
Microvilli



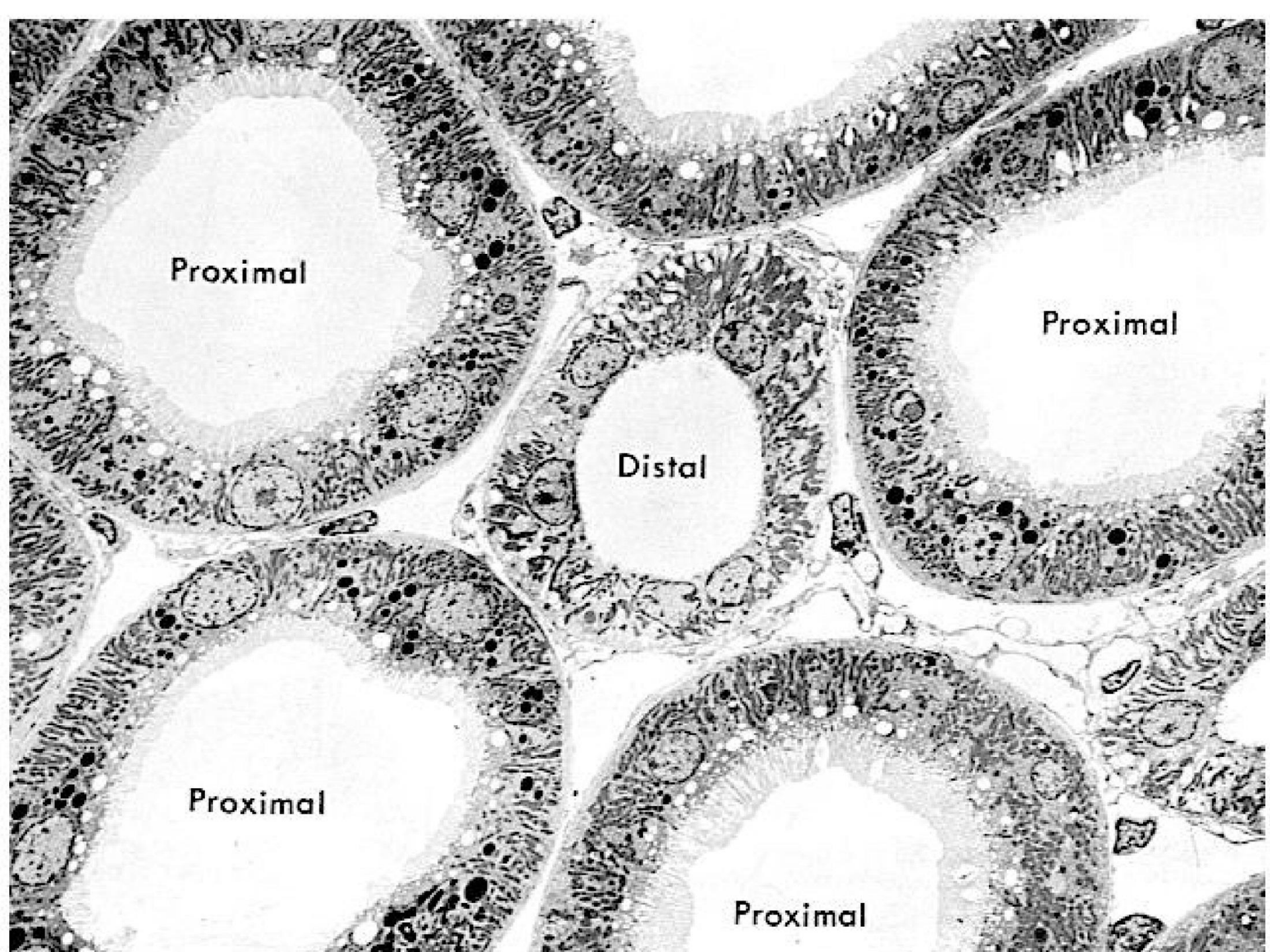
Proximal convoluted tube



Distal convoluted tube



- Proximal and distal tubules



Proximal

Proximal

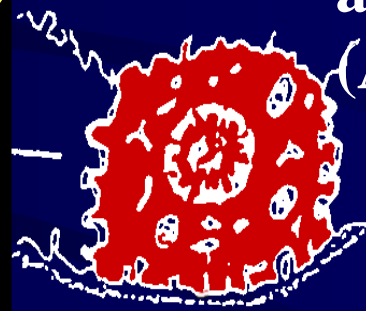
Distal

Proximal

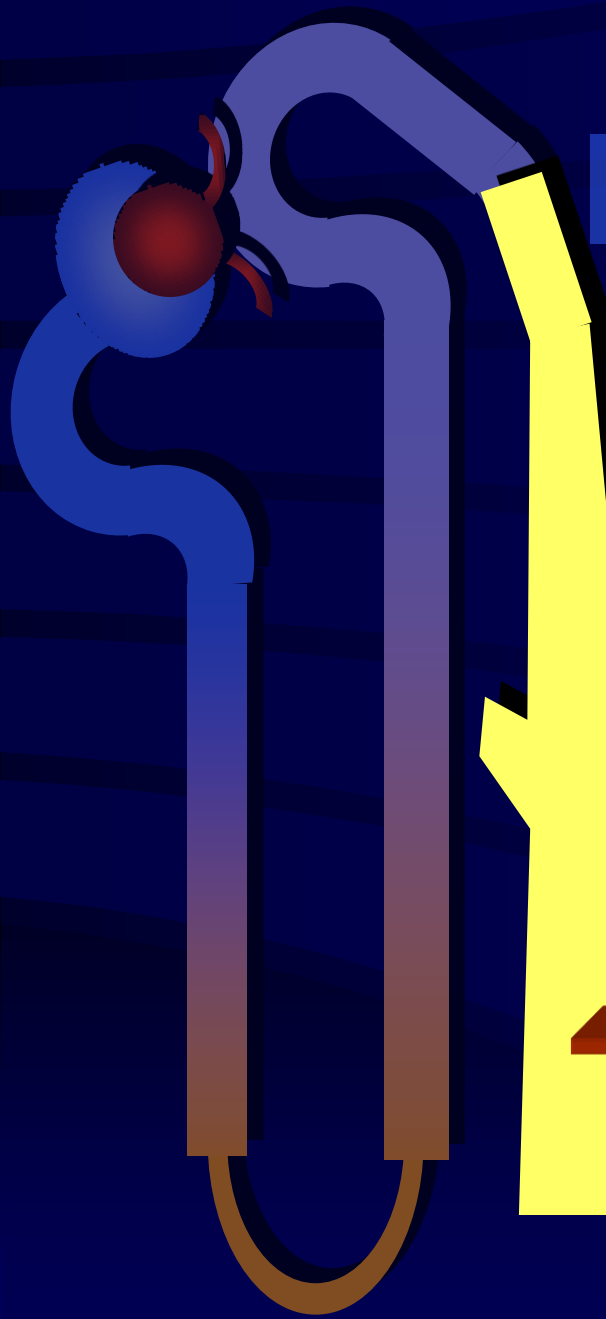
Proximal

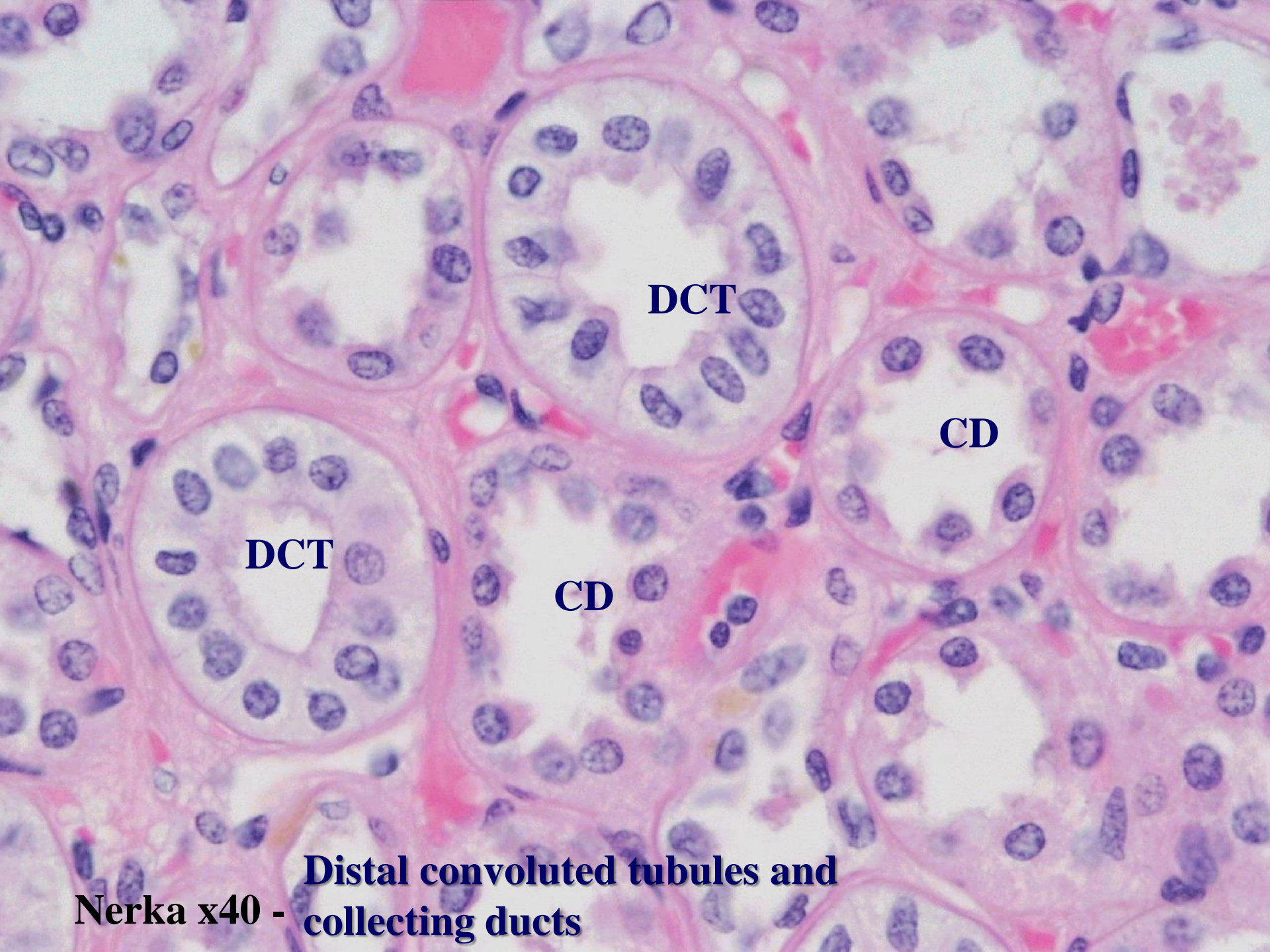
Collecting duct

**Water permeability
regulated by
antidiuretic hormone
(ADH)**



aquaporin-2 channels





DCT

CD

DCT

CD

Nerka x40 - Distal convoluted tubules and collecting ducts

Segment	Epithelium	Lumen
PCT	cuboidal + brush border	fuzzy
Thin loop	squamous	very thin
DCT	cuboidal	clear
Collecting duct	cuboidal → columnar	wide

Renal medulla



thick ascending limb of Henle

collecting ducts

↓ O₂

Peritubular interstitial fibroblast-like cells of the kidney cortex and outer medulla.



↑ **ERYTHROPOETIN (EPO)**

D₃

25-HYDROXYCALCIFEROL

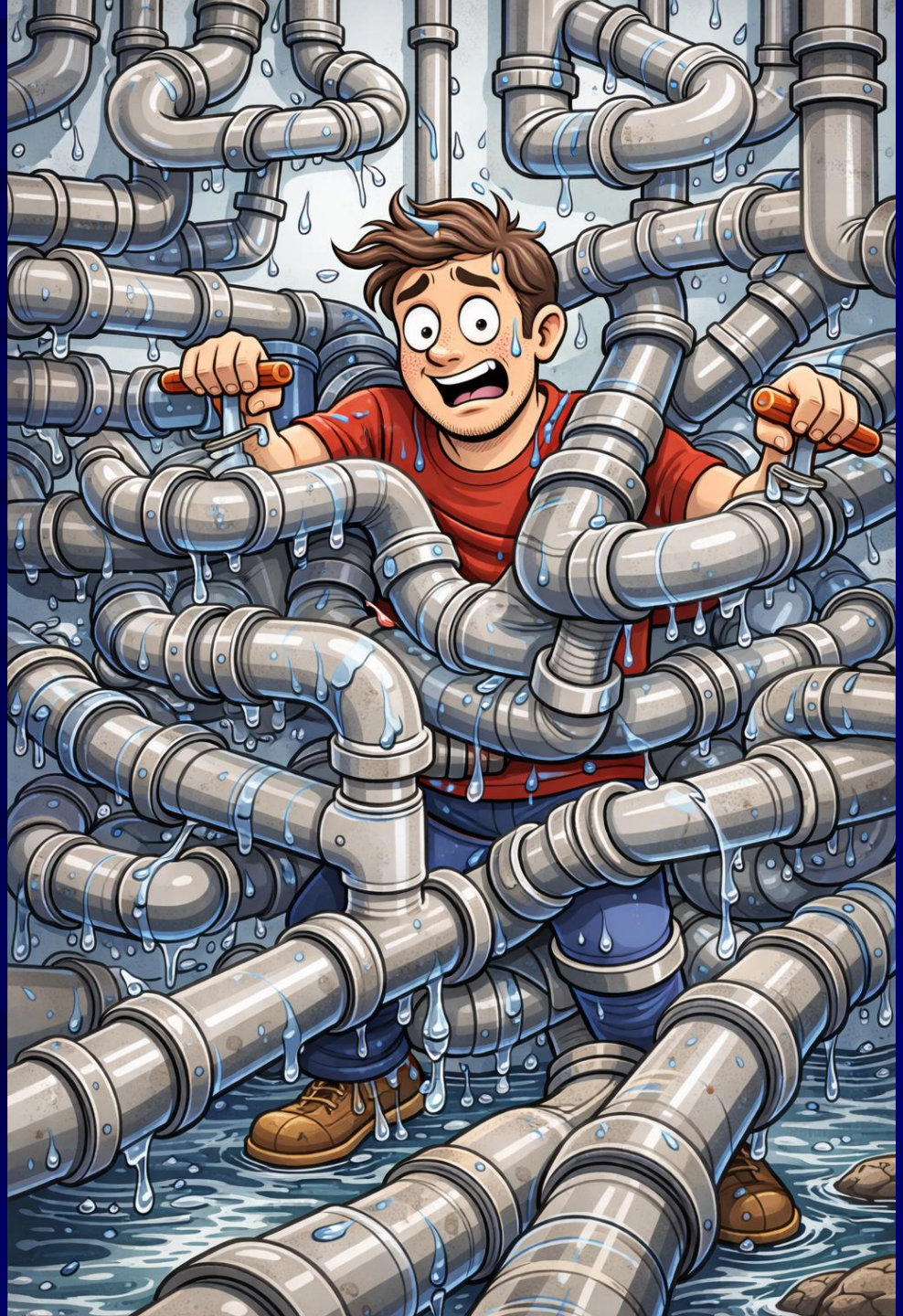


1-25-HYDROXYCALCIFEROL

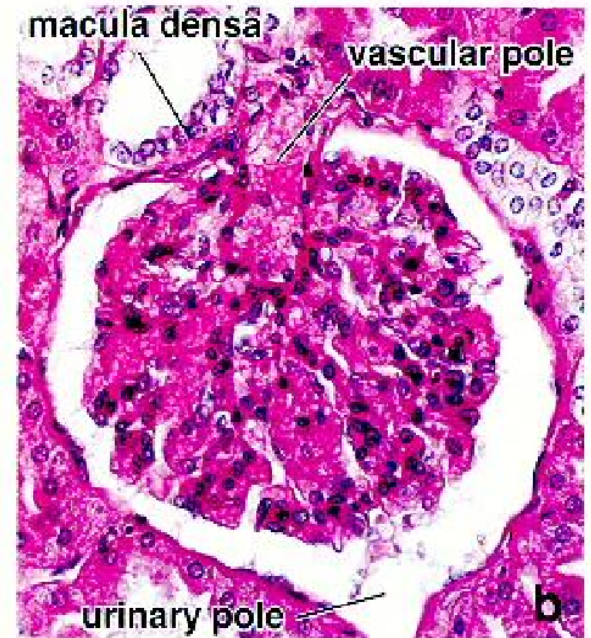
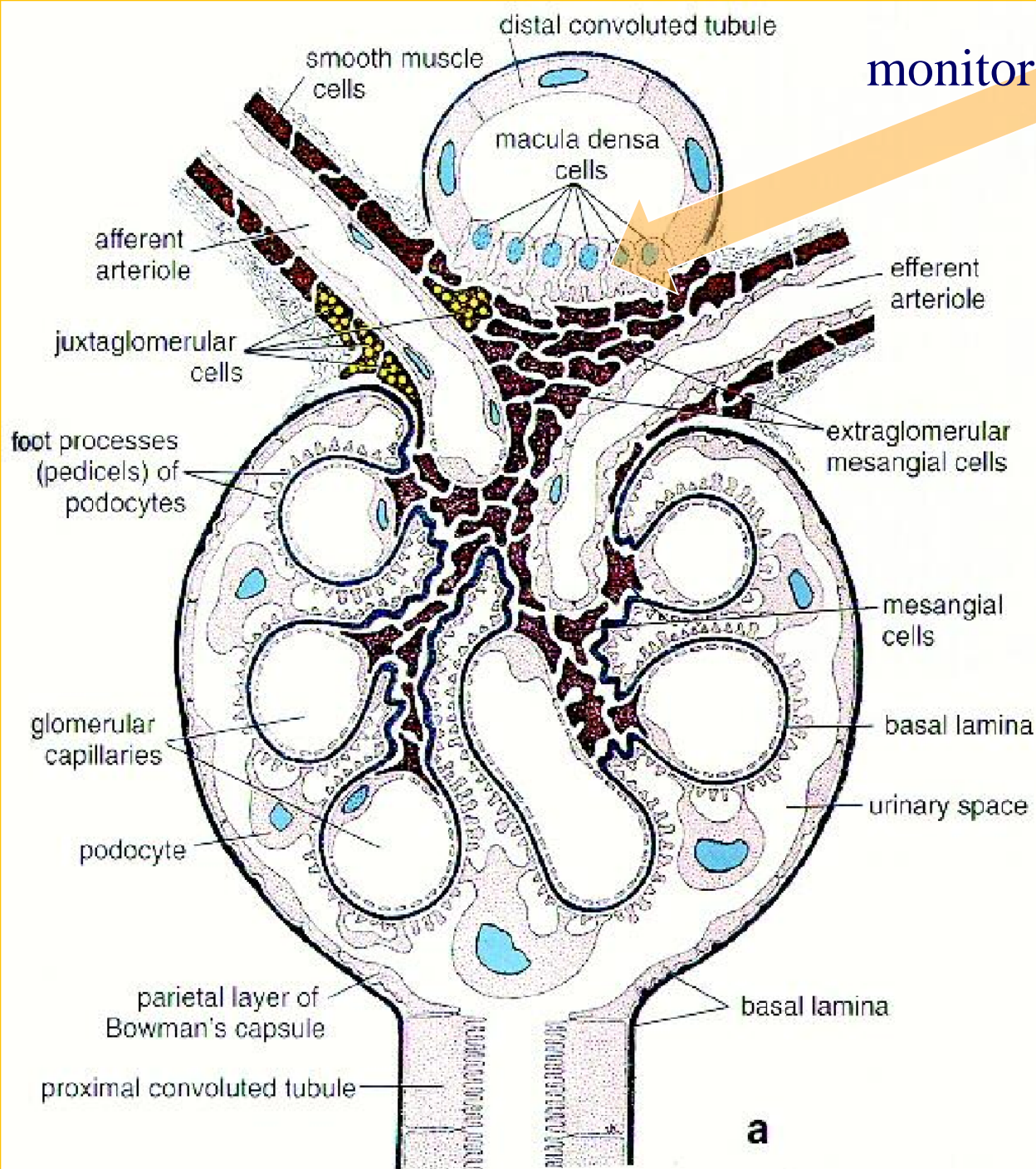


phosphate reabsorption ↓

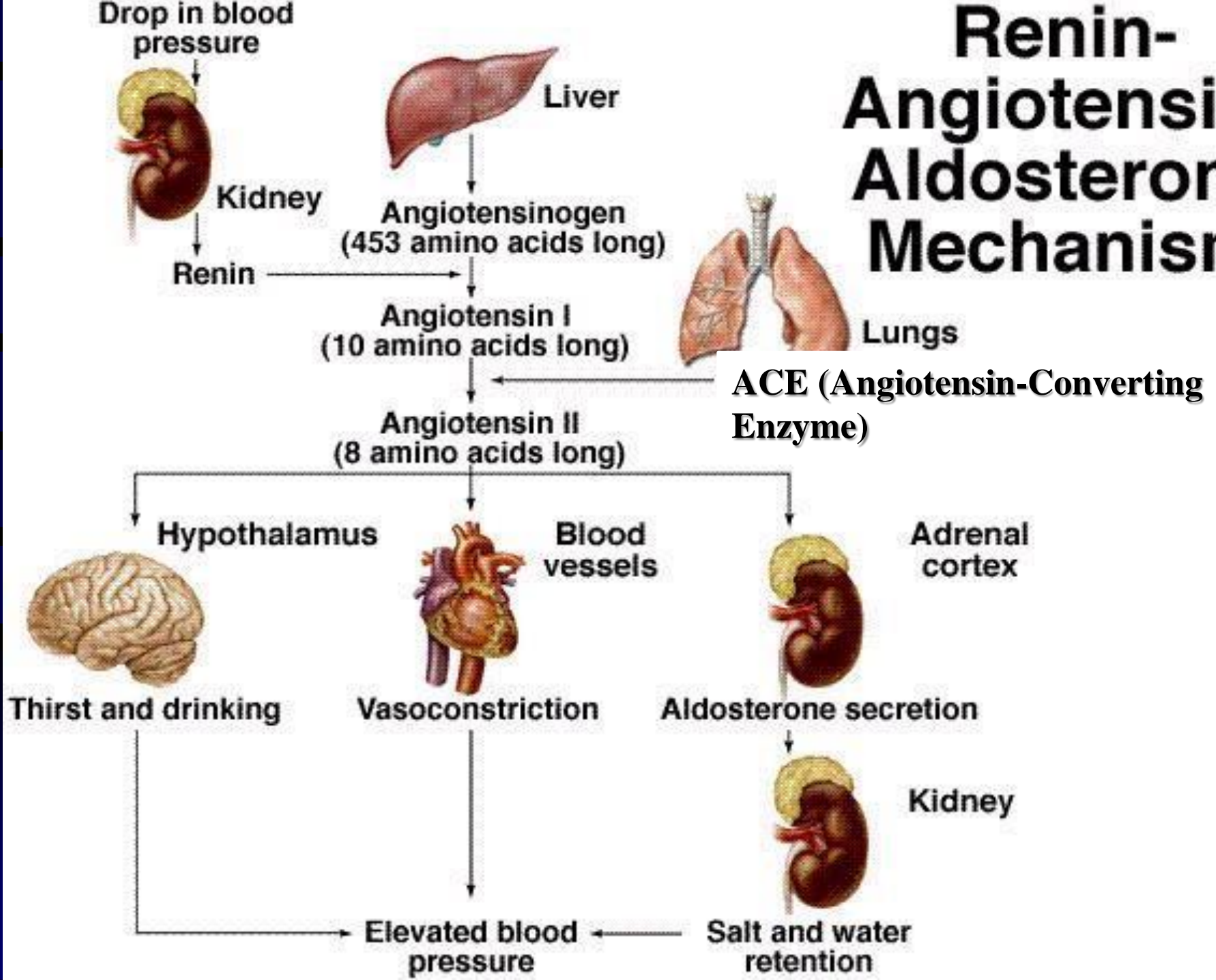
Controlling flow



monitor the osmolality



Renin-Angiotensin-Aldosterone Mechanism



Hormones can be excreted in urine, but usually in the form of metabolites or conjugated compounds produced during their breakdown in the body.

- Elimination of steroid hormones from blood



Renal Corpuscles :

Primary urine (glomerular filtrate) = plasma without cells and macromolecules.

Proximal Convoluted :

- Glucose and amino acids – reabsorbed completely
- NaCl – about 80% reabsorbed
- Potassium – active transport
- Water – passive movement following ions
- Proteins and vitamins – transcytosis

Proximal Convoluted Tubule (PCT)

= main tubule = proximal tubule

Convoluted part – cortex

Straight part – medulla

Simple cuboidal epithelium (4–5 cells)

Ion-pumping cells

(microvilli, basal striations)

High alkaline phosphatase activity

Nephron loop = Loop of Henle

Descending limb and ascending limb

Descending limb – simple squamous epithelium

(thin descending limb and part of the ascending limb)

Ascending limb – simple cuboidal epithelium

ion-transporting epithelial cells

Juxtamedullary nephrons – long descending limb

Cortical nephrons – shortened descending limb

Loop of Henle :

countercurrent multiplier

Ascending limb impermeable to water actively transports Cl^- ions into the medullary interstitium Na^+ follows Cl^-

Descending limb highly permeable to water and ions

Result formation of a hypertonic gradient in the renal medulla
the deepest medullary layers are the most hypertonic

Fluid leaving the loop slightly hypotonic

Distal Convoluted Tubule (DCT)

= distal tubule

Simple cuboidal epithelium (~10 cells)

Near the renal corpuscle:

simple columnar epithelium → macula densa

Collecting Tubules

Receive filtrate from distal tubules

Run in medullary rays

Open at the surface of the renal papillae (area cribrosa)

Epithelium:

simple cuboidal epithelium

Terminal segments called papillary ducts (ducts of Bellini)

(increase in diameter)

simple columnar epithelium

Distal Convoluted Tubules

Regulation by aldosterone:

- reabsorption of sodium ions (Na^+) from tubular fluid into the blood
- secretion of hydrogen ions (H^+) and ammonium ions (NH_4^+) into the tubular lumen
- regulation of the body's acid–base balance

Collecting Ducts Regulated by antidiuretic hormone (ADH):

- become permeable to water but not to ions
- water moves into the hypertonic interstitium of the renal medulla

Blood flow in the vasa recta:

- descending vessels carry blood into the deep medulla where it becomes hypertonic
- ascending vessels return toward the cortex and absorb water from the collecting ducts

Result: restoration of isotonic blood

This mechanism forms the countercurrent exchange system.

Diabetes Insipidus

Lack of ADH → collecting ducts become impermeable to water.
Result: inability to concentrate urine production of large volumes of dilute urine

