

Renal Structure and Function

Sodium Transport

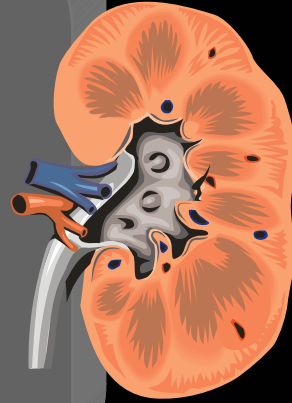
UTSouthwestern STARS Program



Orson W. Moe, M.D.
Department of Internal Medicine
Division of Nephrology

organism

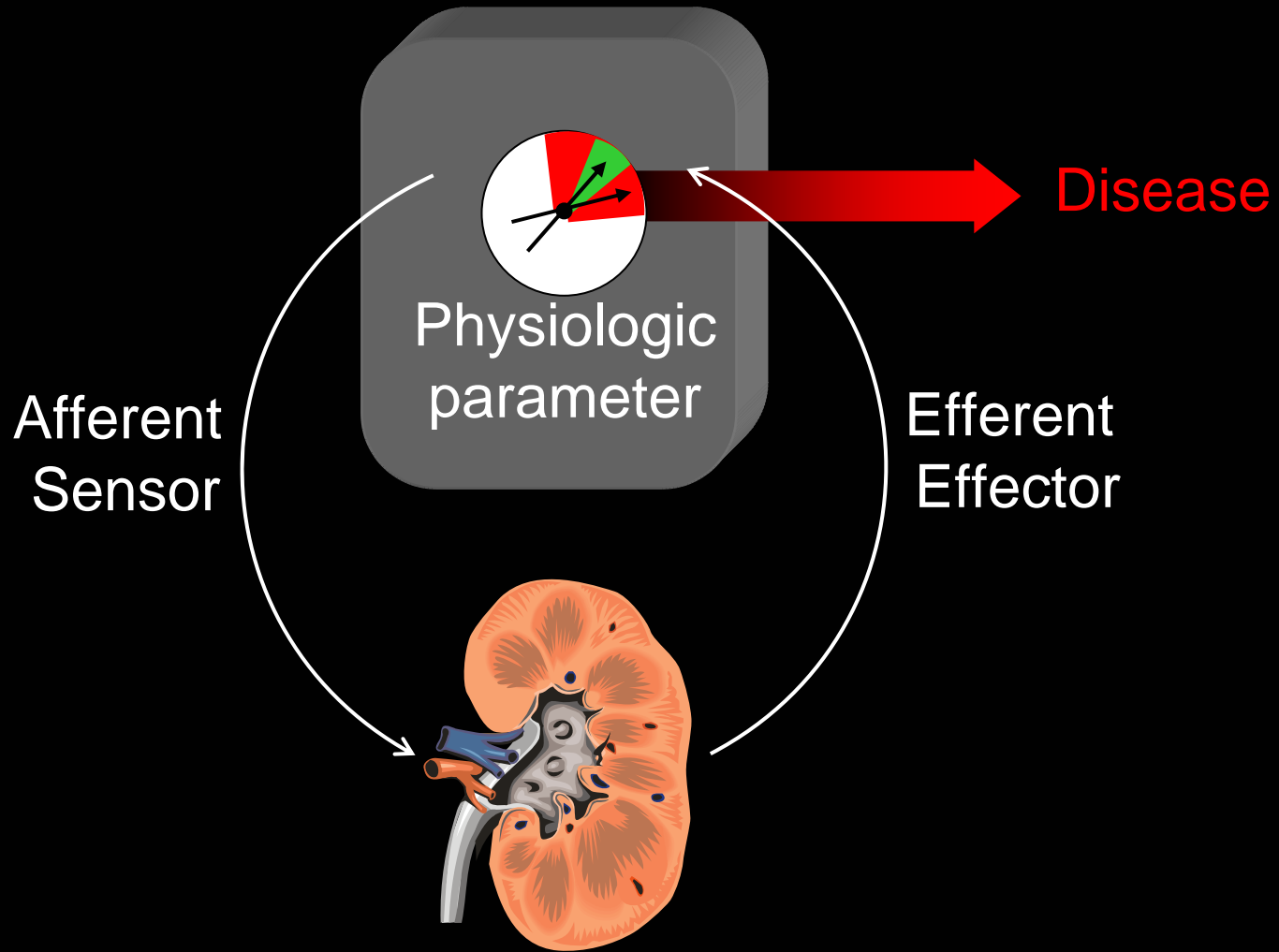
Composition
Quantity



world

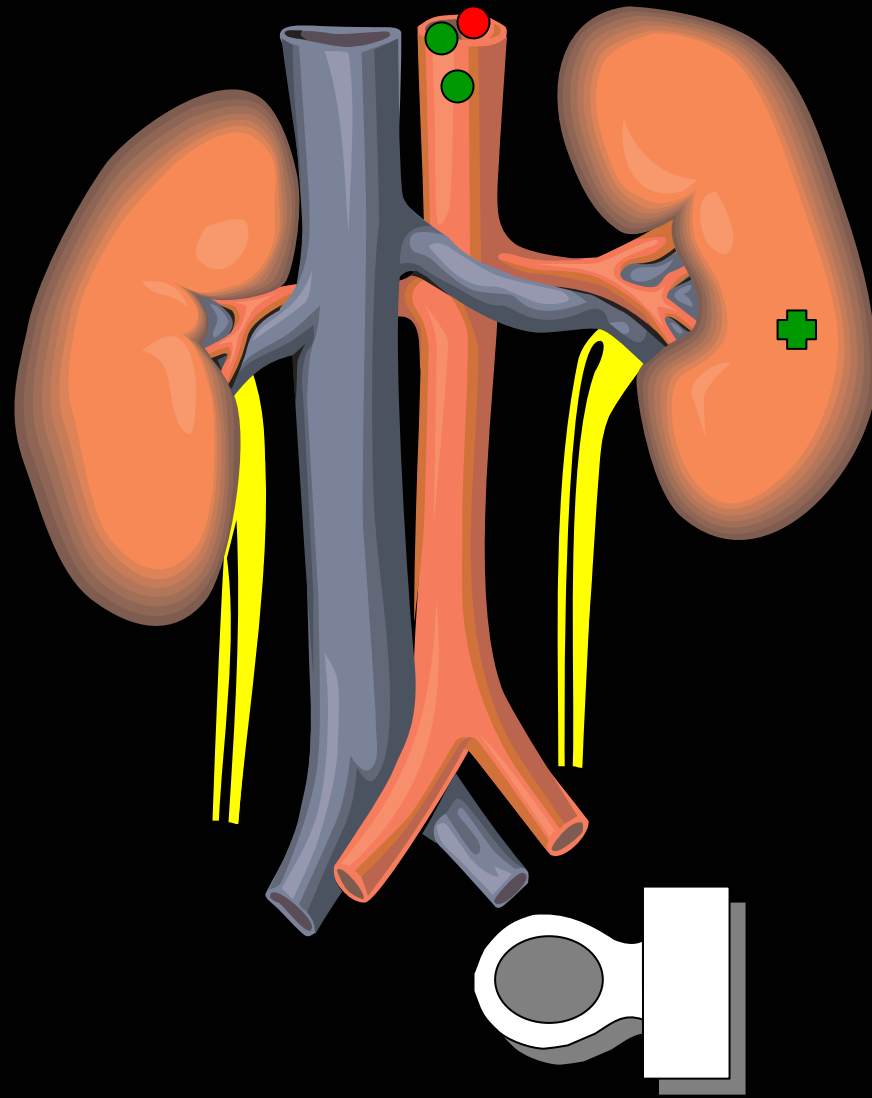


Maintain constancy



Renal Function

- Good stuff
- Bad stuff
- ✚ Endocrine hormone
Metabolic substrate

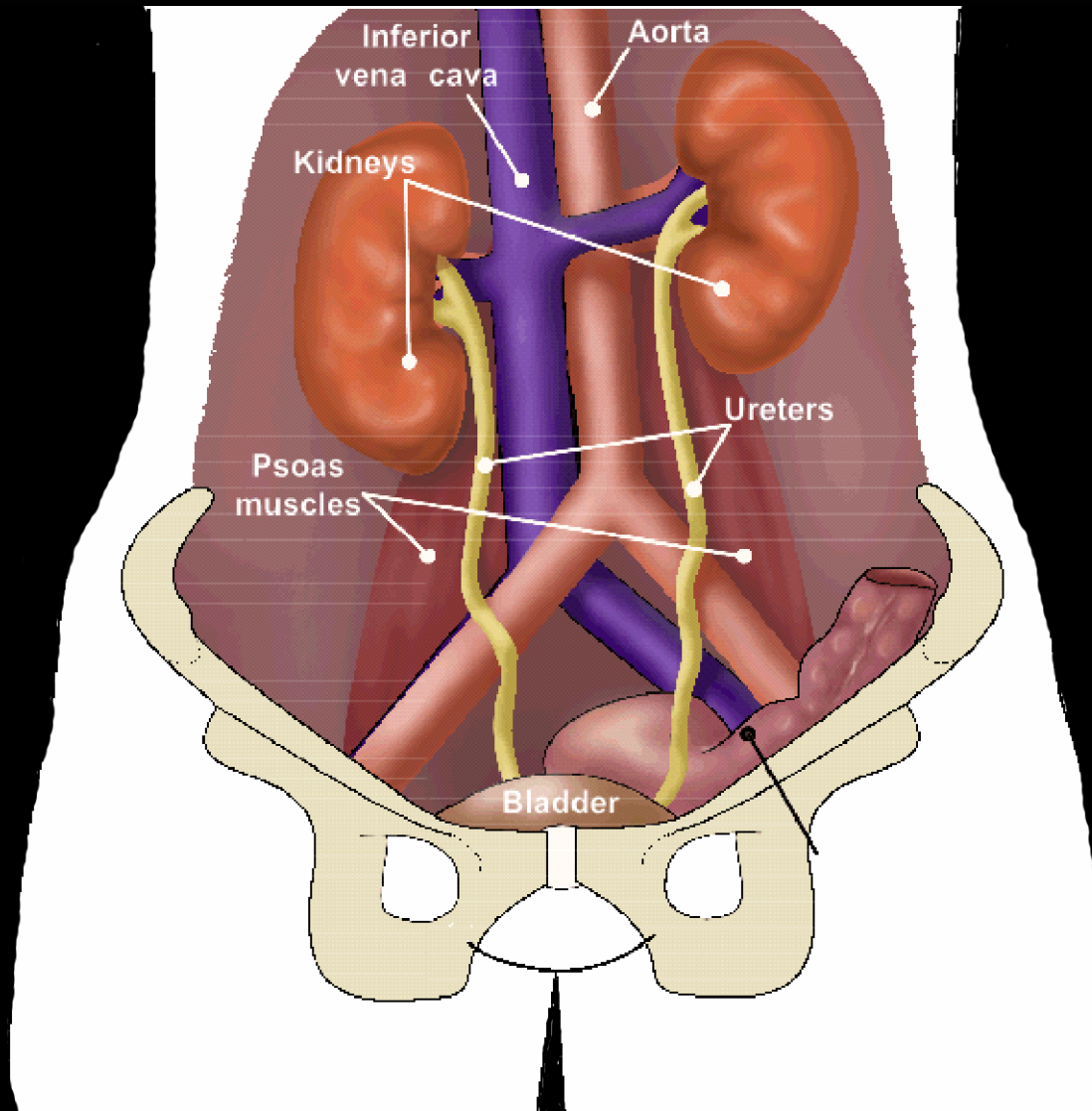


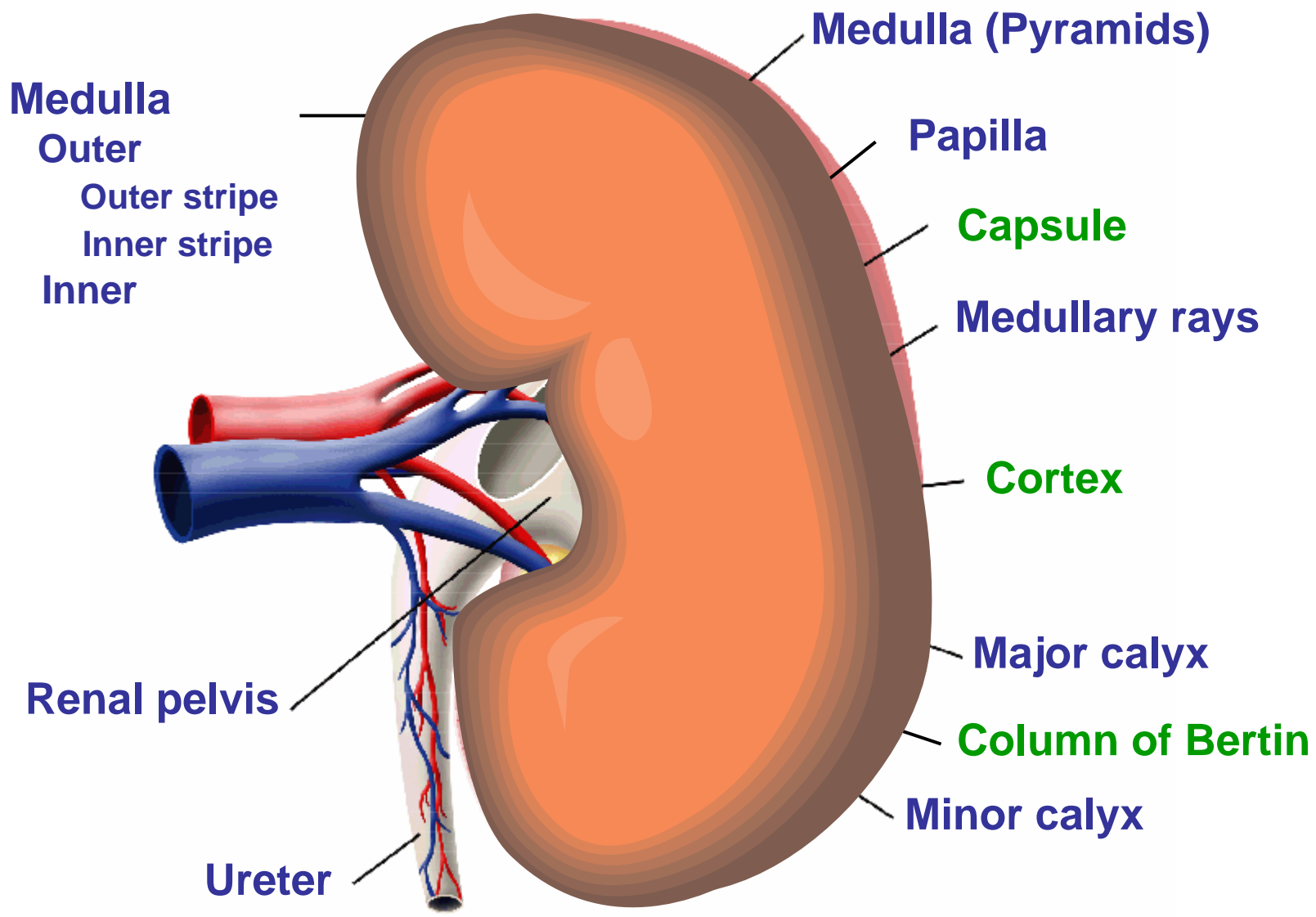
Excretion

Endocrine

Metabolism

Gross anatomy





Medulla (Pyramids)

Medulla

Outer

Outer stripe

Inner stripe

Inner

Papilla

Capsule

Medullary rays

Cortex

Major calyx

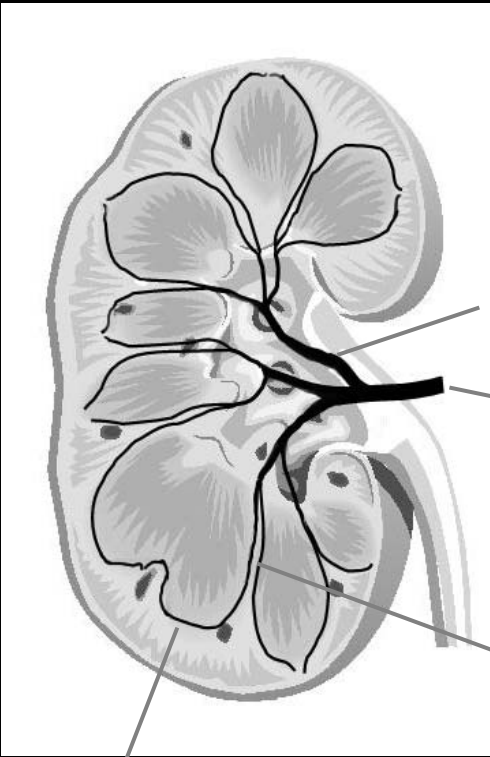
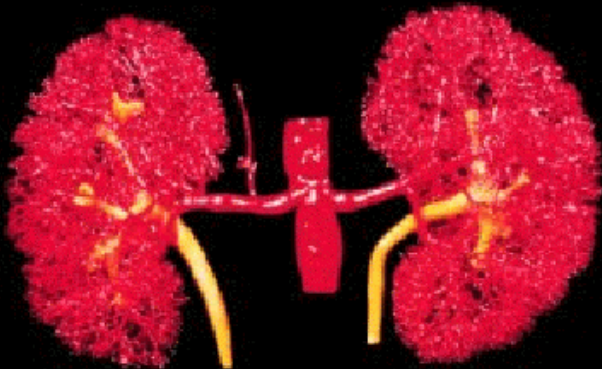
Column of Bertin

Minor calyx

Renal pelvis

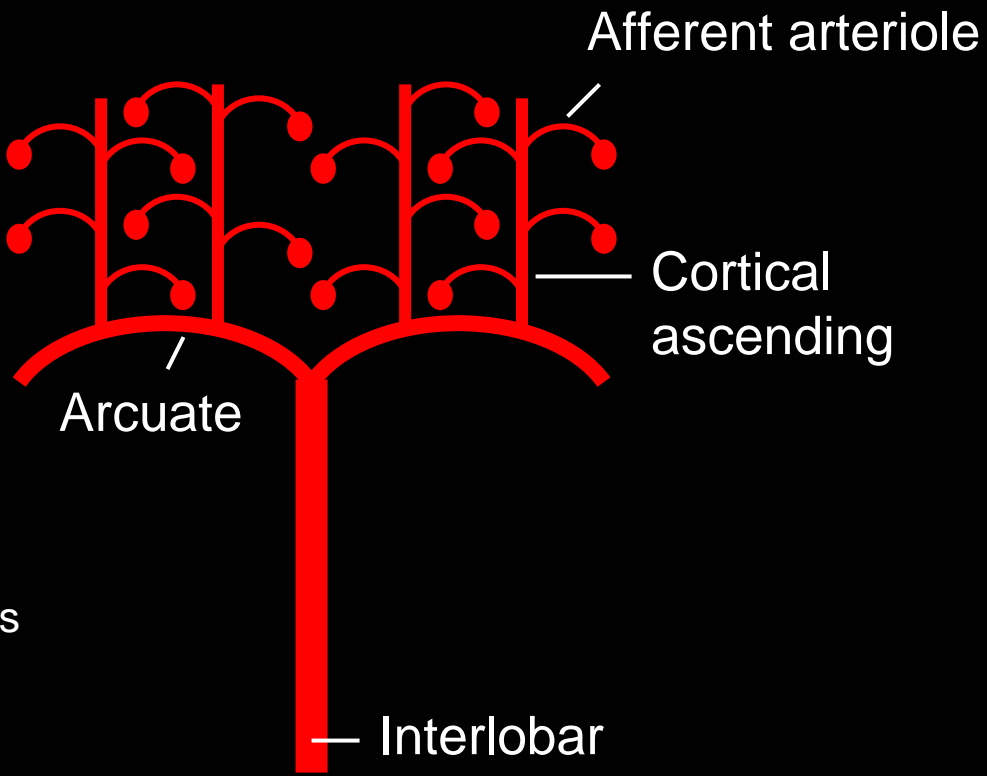
Ureter

Renal Vasculature



Renal artery
Segmental branches
Main branch
Interlobar

Arcuate

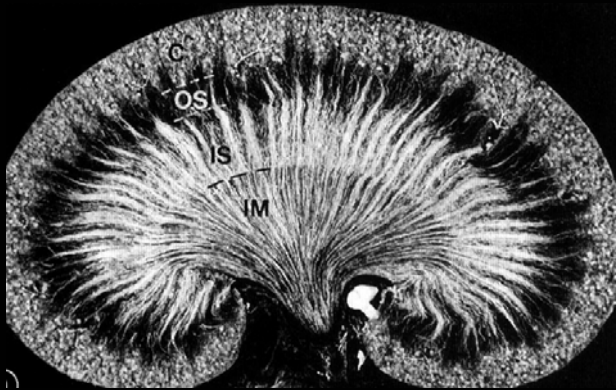


Afferent arteriole

Cortical ascending

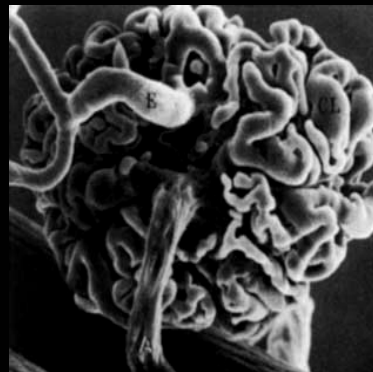
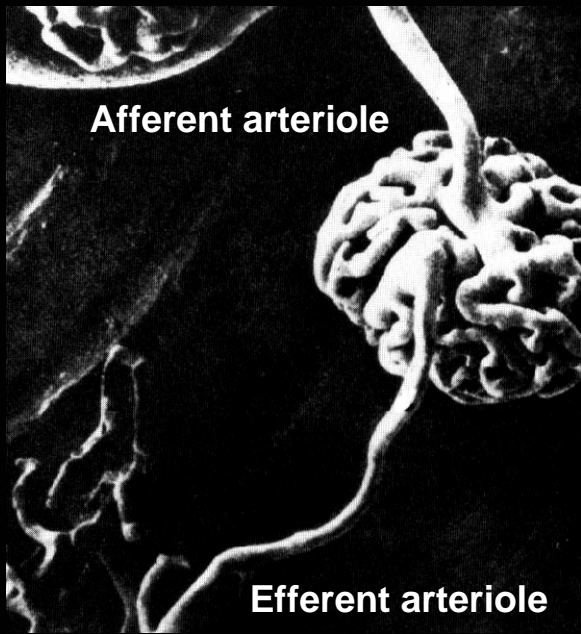
Arcuate

Interlobar



Cortical ascending

Arcuate



Renal Circulation



Little or no anastomoses

Highest blood flow per gram tissue

Multiple capillaries in tandem

Functional arteriovenous shunts

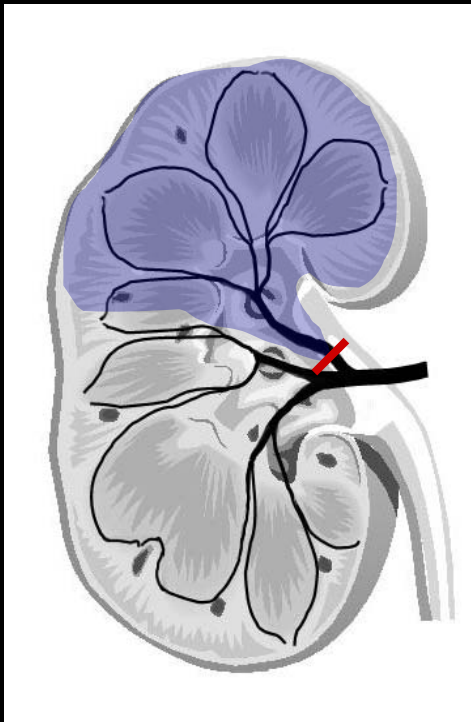
Renal Circulation

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Functional AV shunts



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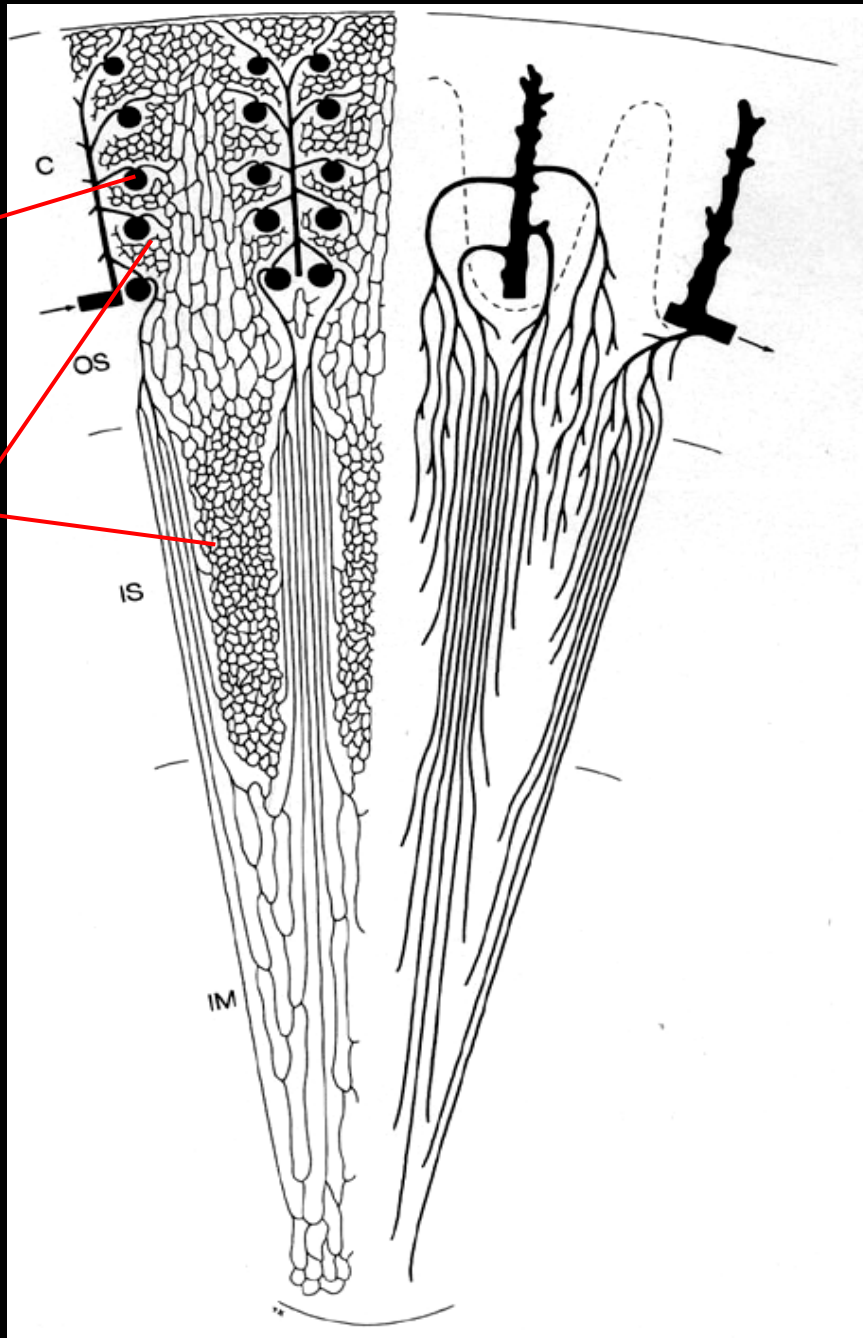
25-30% Cardiac output



<2%
Body mass

Renal venous pO_2
Renal A- VO_2 difference

Highest (60-70 mm Hg)
Lowest (10-15%)



Glomerular capillary

Peritubular capillary

tion

oses

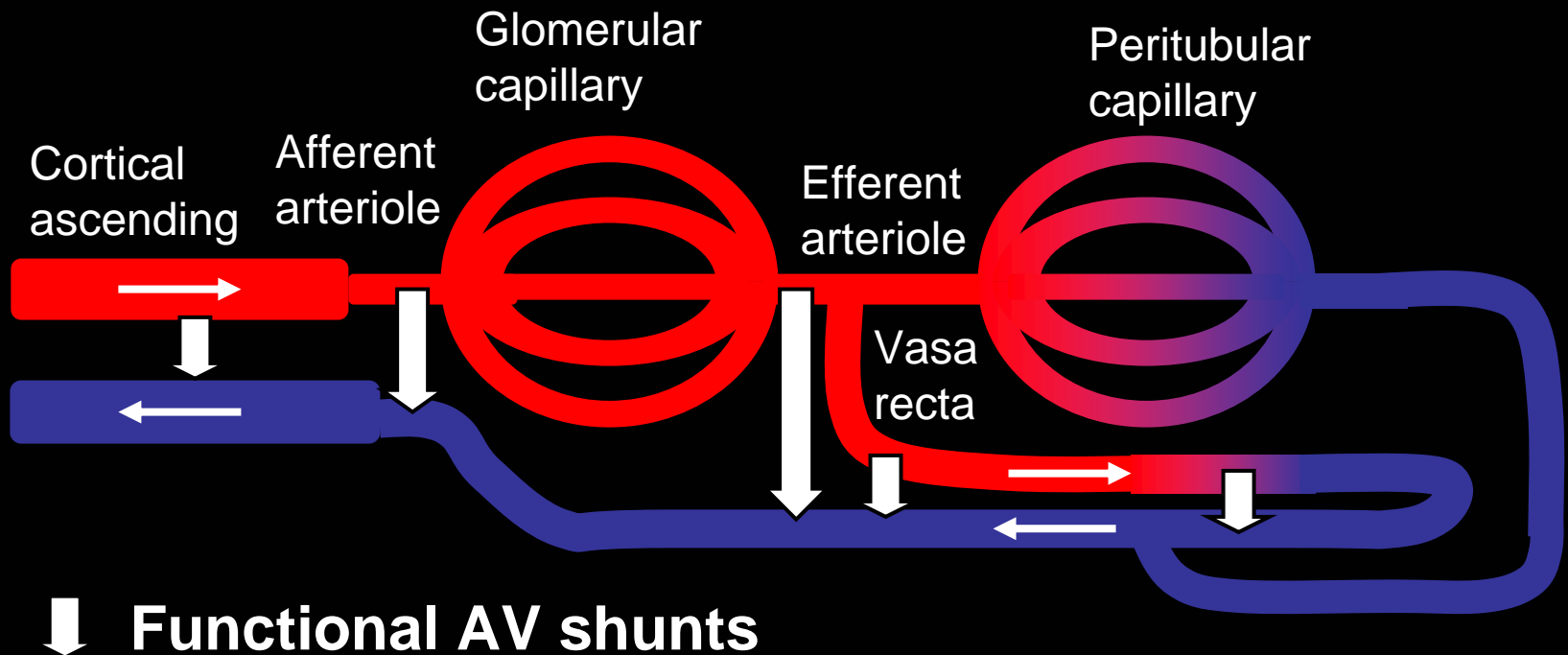
m tissue

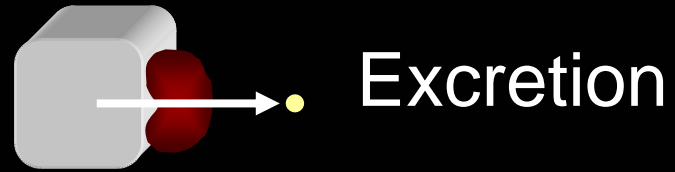
n tandem

S

Renal Circulation

- Little or no anastomoses
- Highest flow per gram tissue
- Multiple capillaries in tandem
- Functional AV shunts**



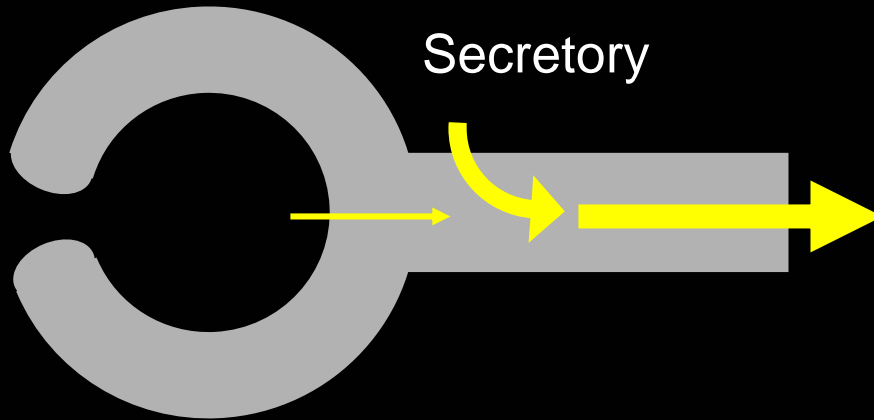


Ultrafiltration

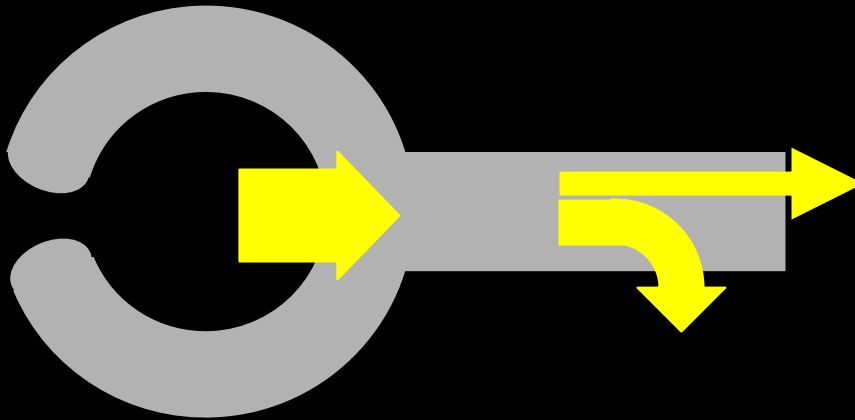
Secretion

Reabsorption

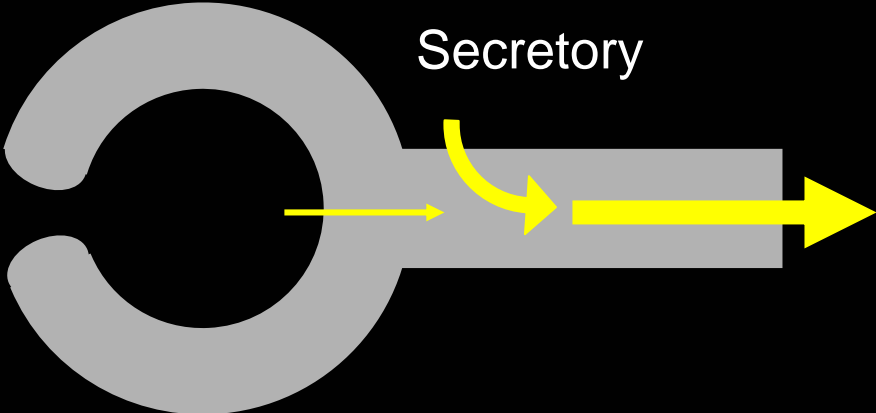
Nephron



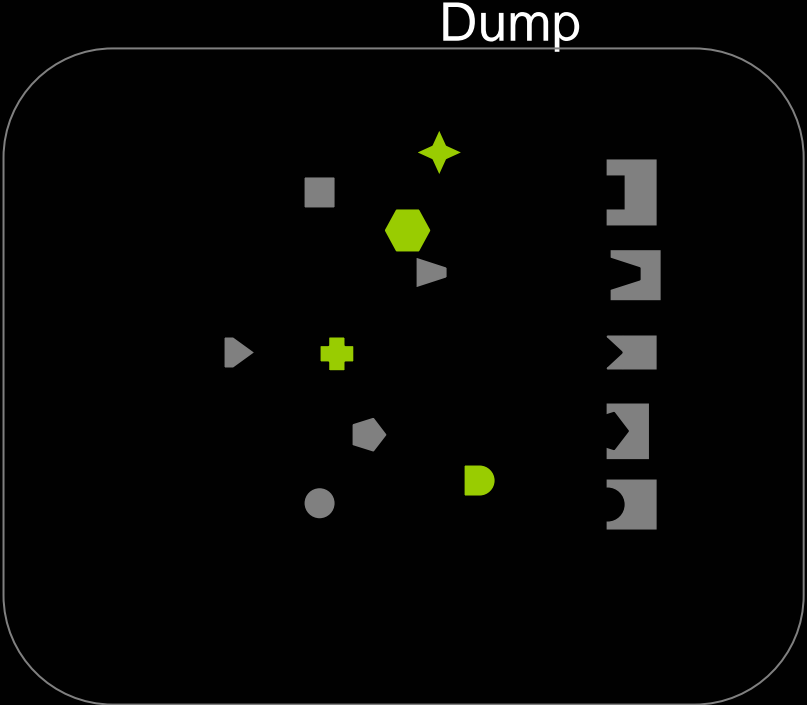
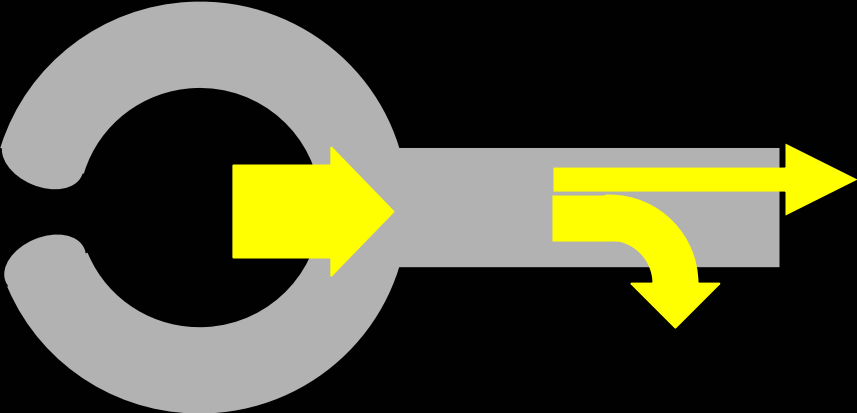
Filtration-Reabsorption



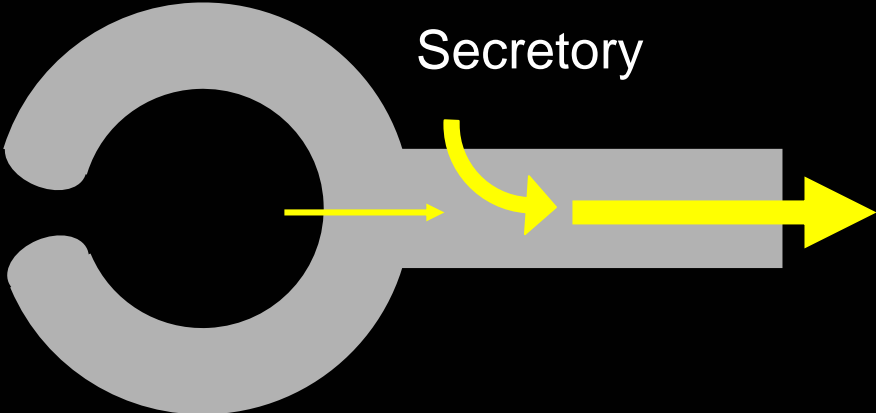
Nephron



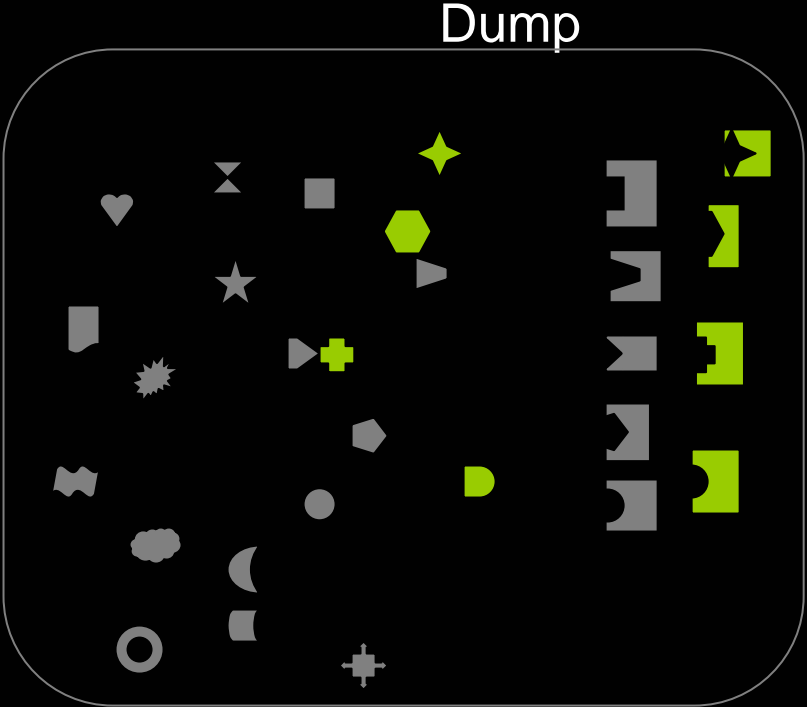
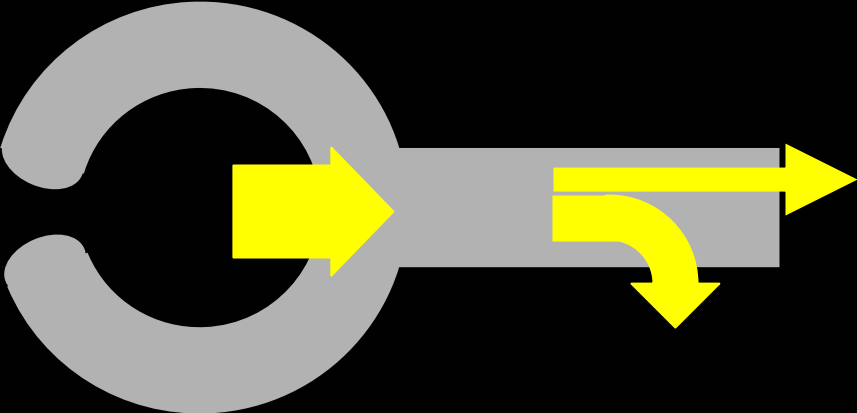
Filtration-Reabsorption

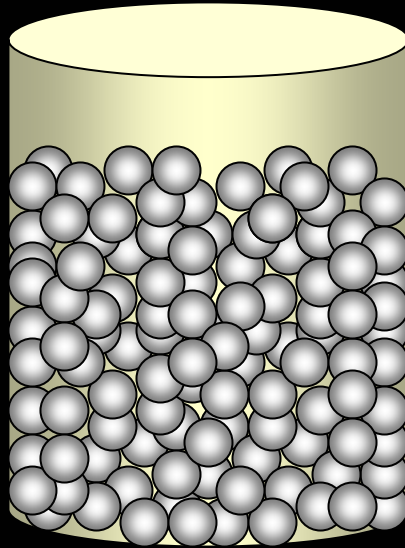


Nephron



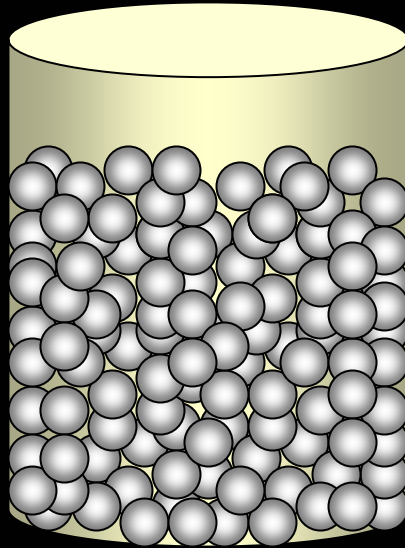
Filtration-Reabsorption





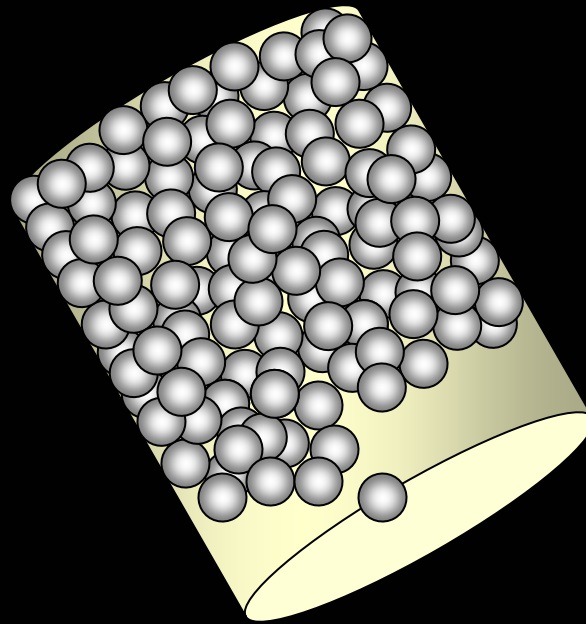
300 marbles

Remove 294



300 marbles

Remove 294

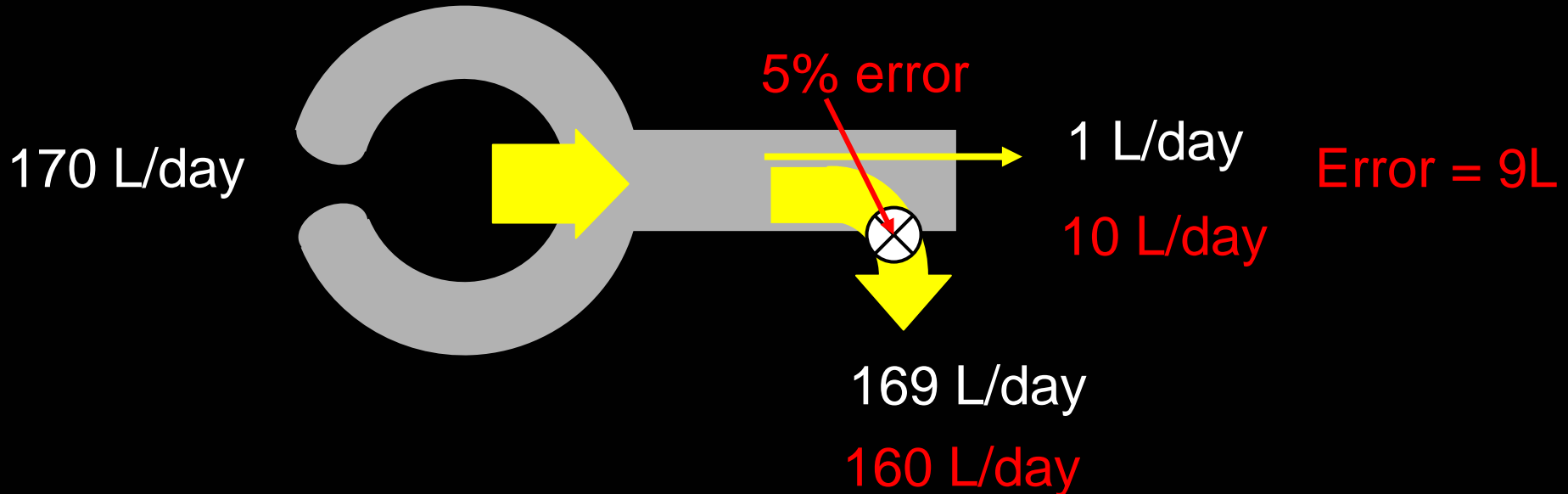
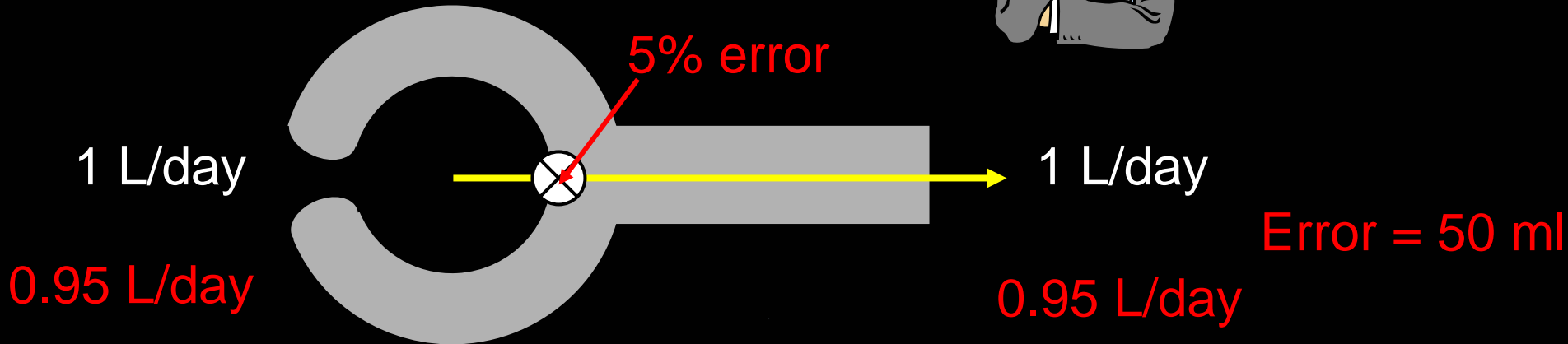


300 marbles

Remove 294

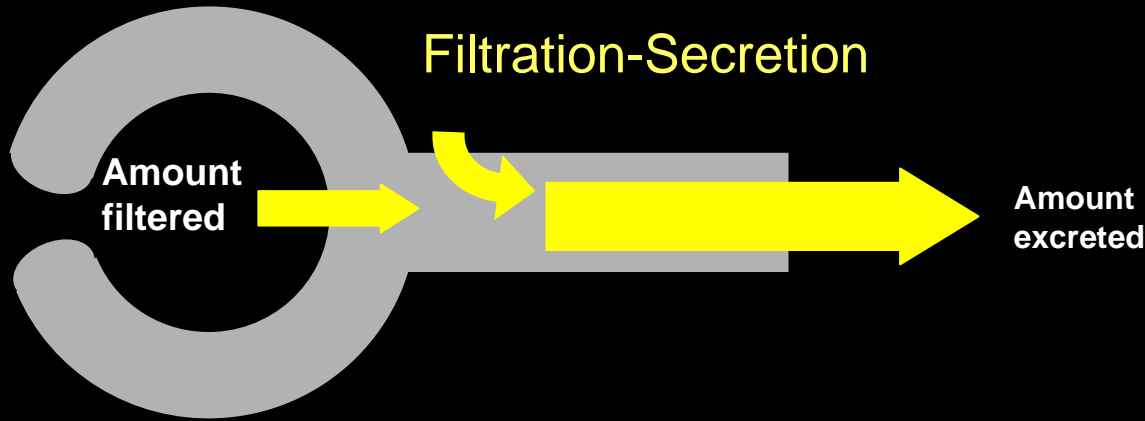
Put 6 back

What does that mean?

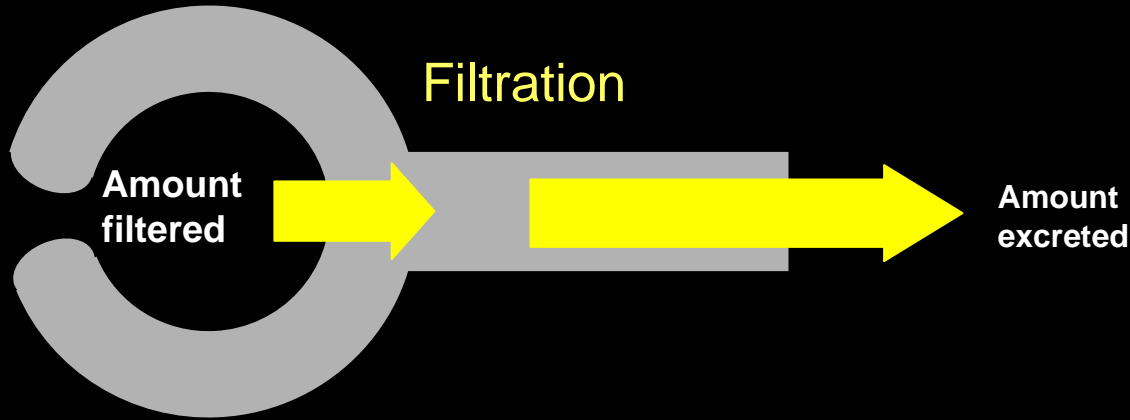


Fractional excretion

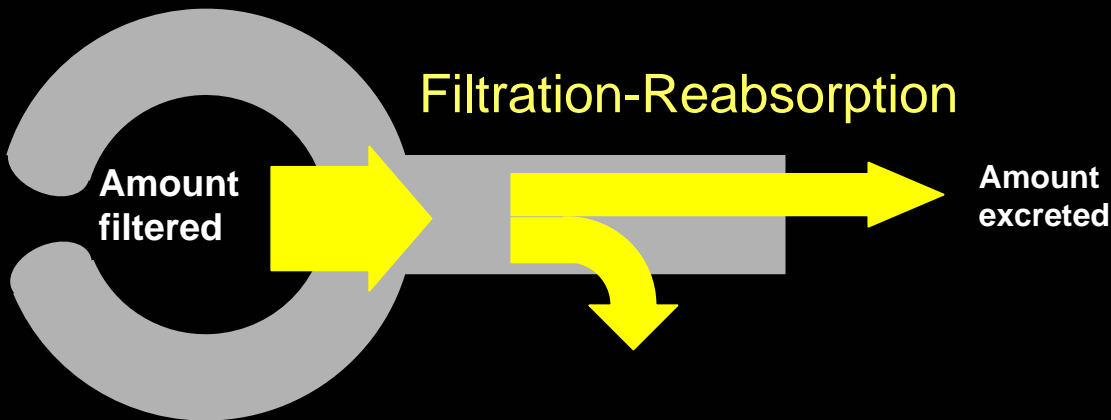
$$\frac{\text{Amount excreted}}{\text{Amount filtered}}$$



> 1



$= 1$

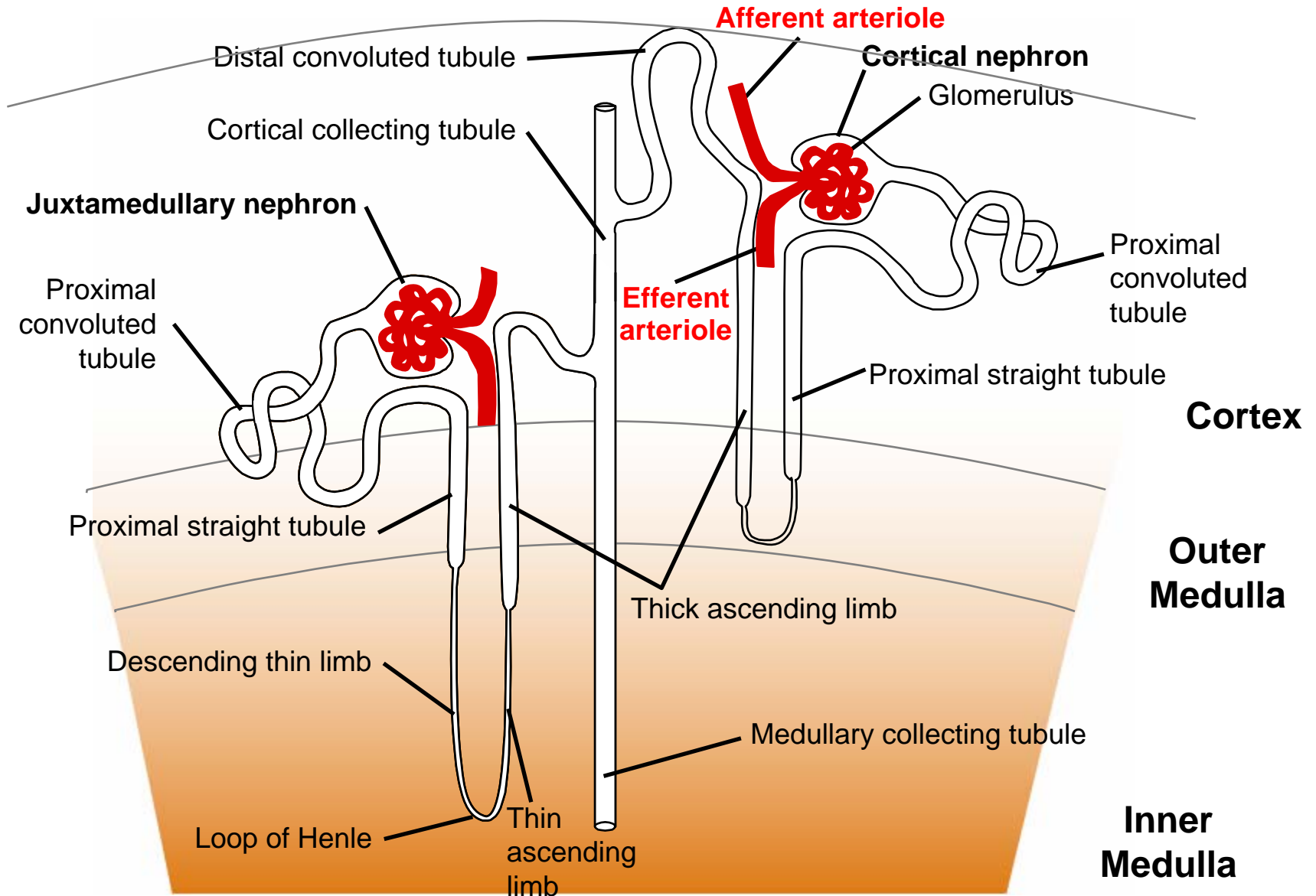


< 1

Walk the nephron

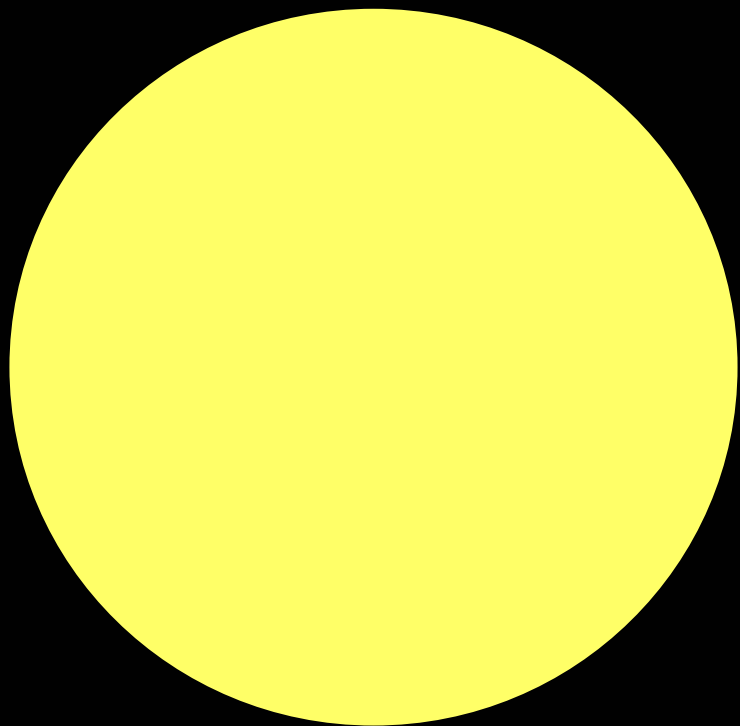


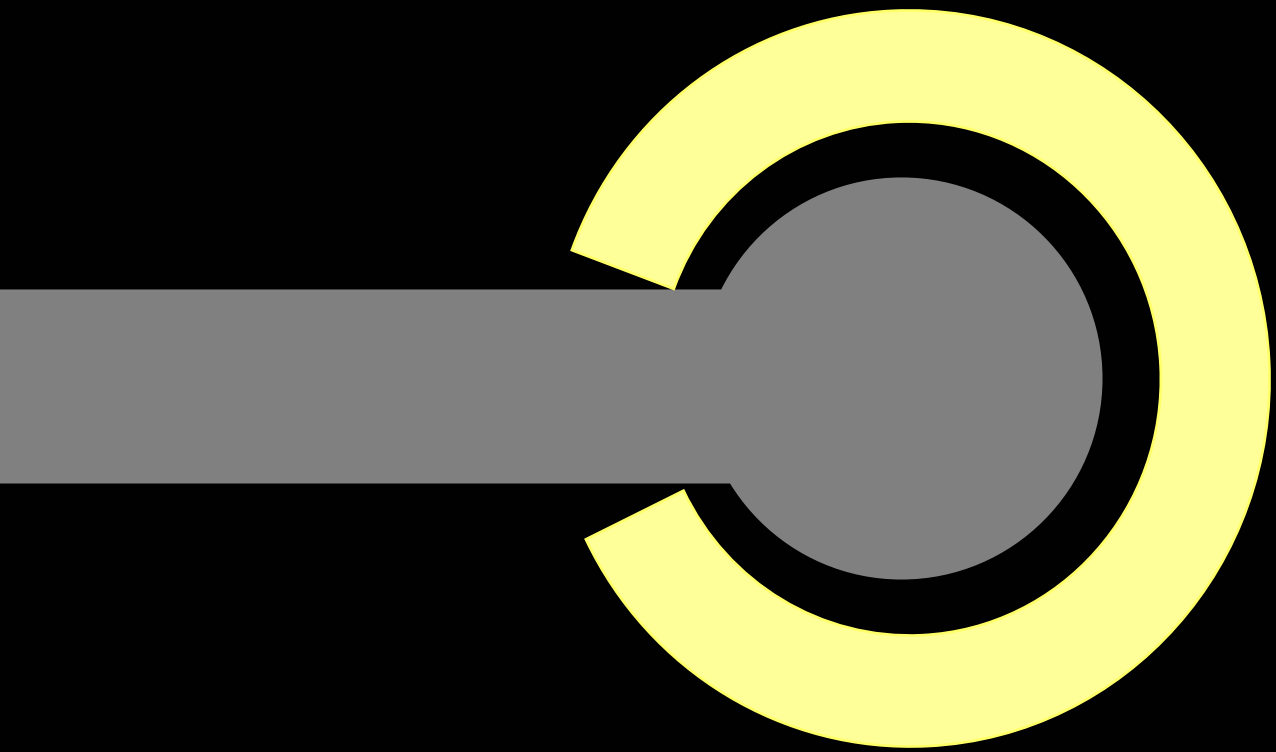
Overview

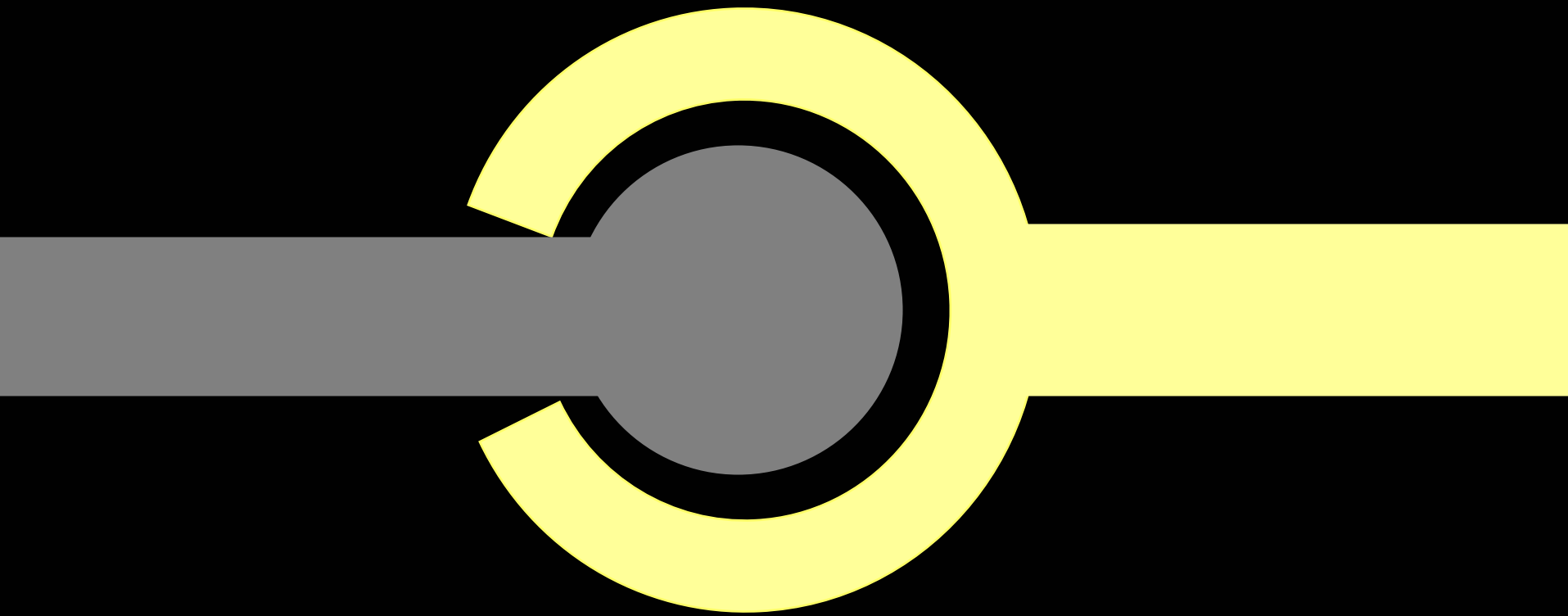


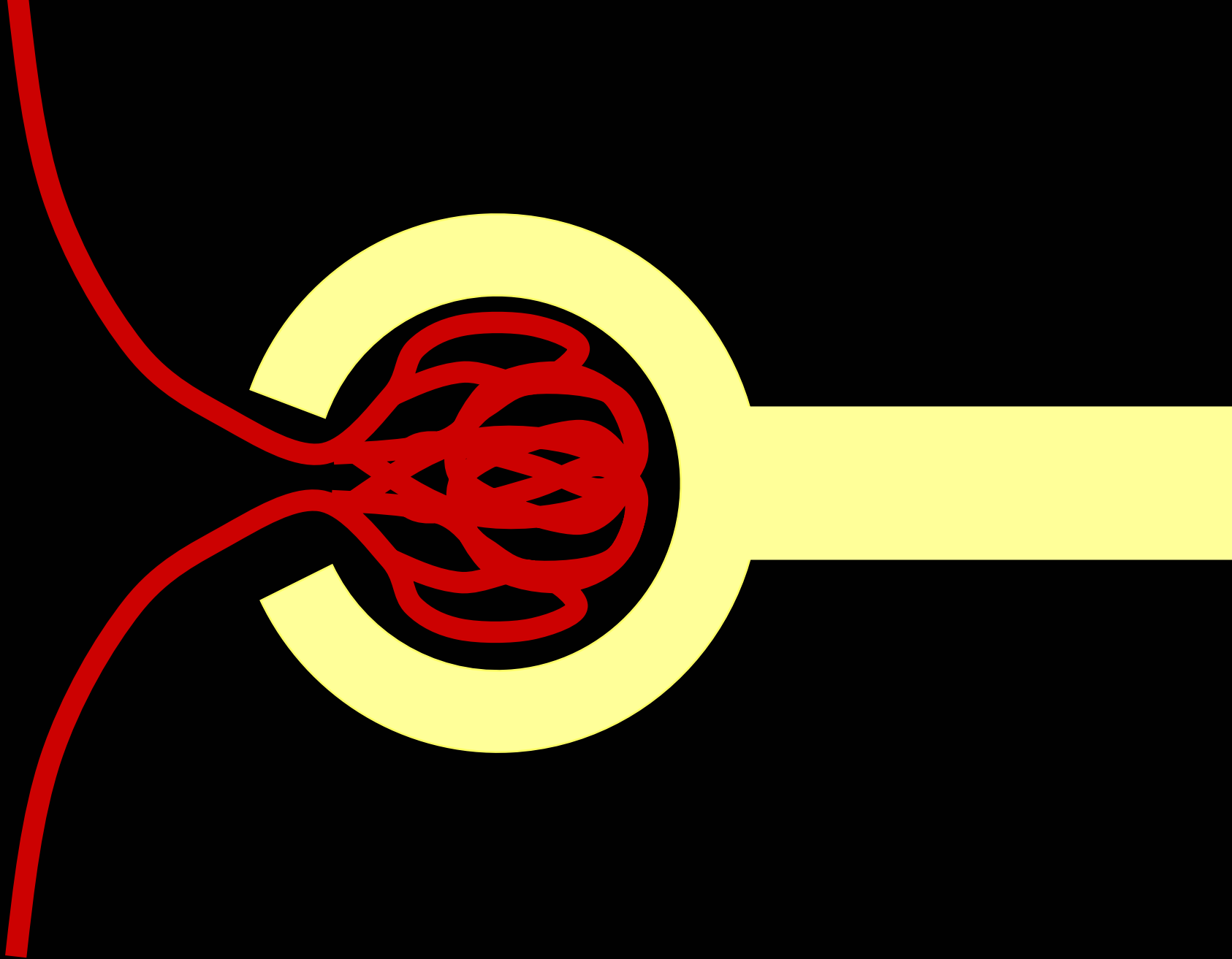
The Glomerulus

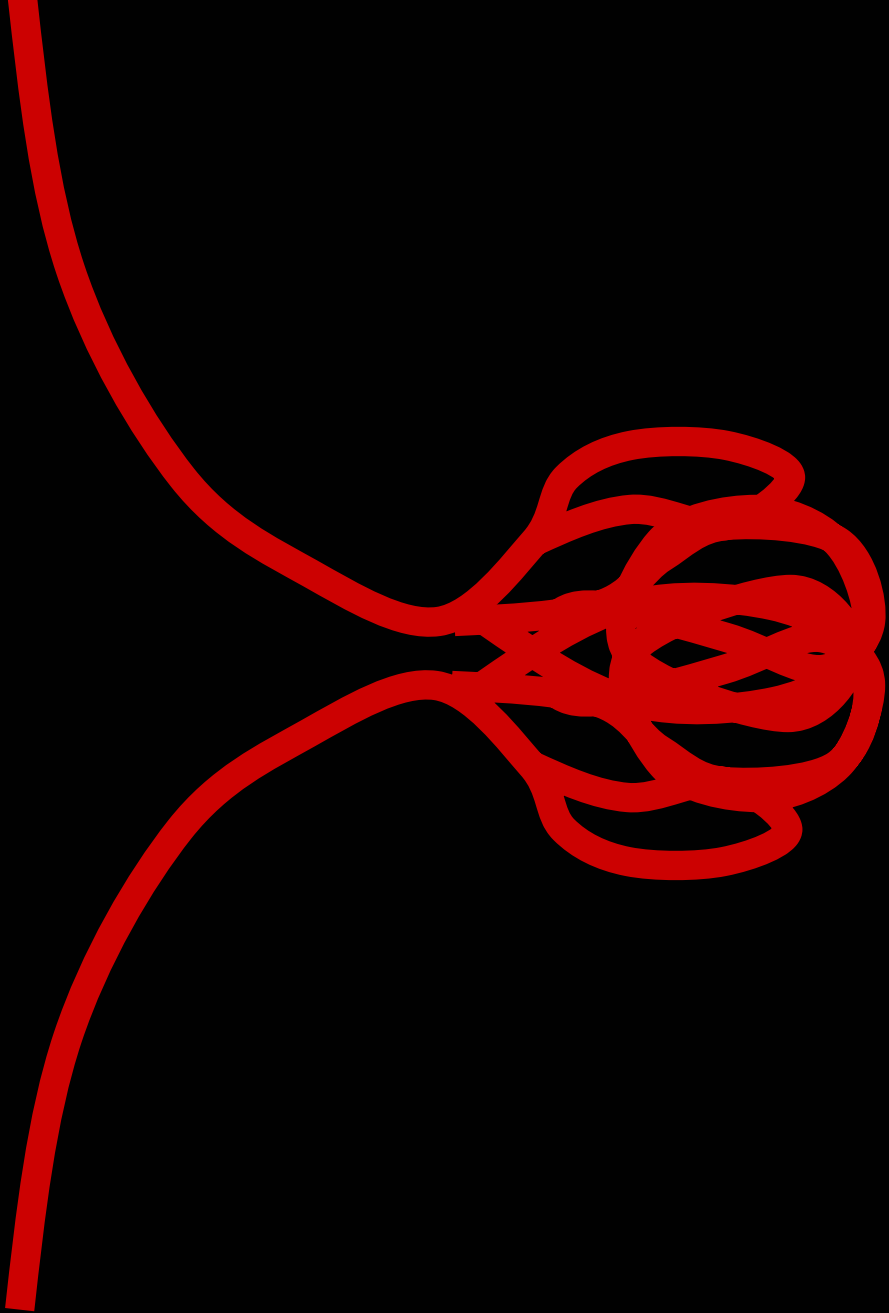
Form an ultrafiltrate

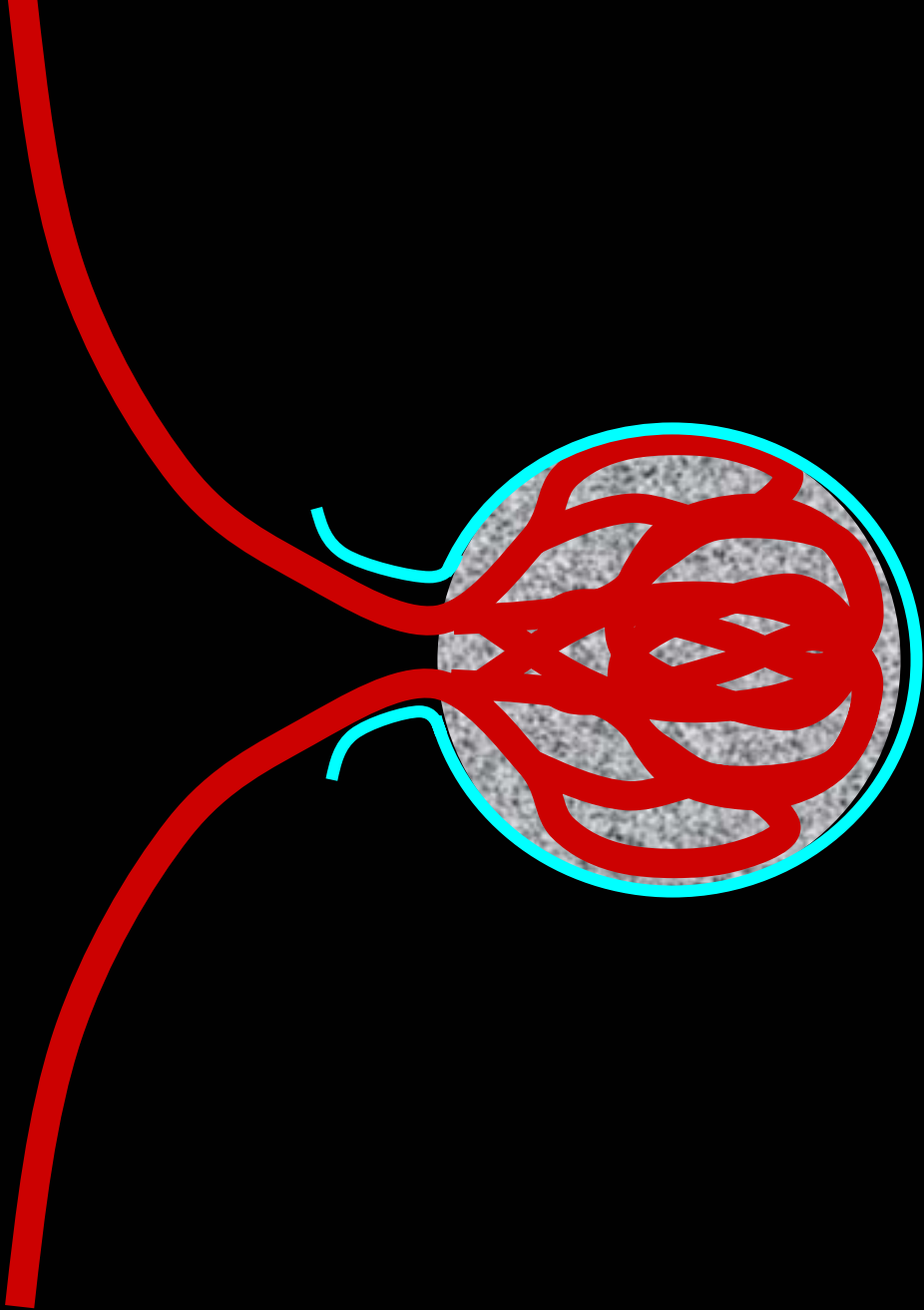


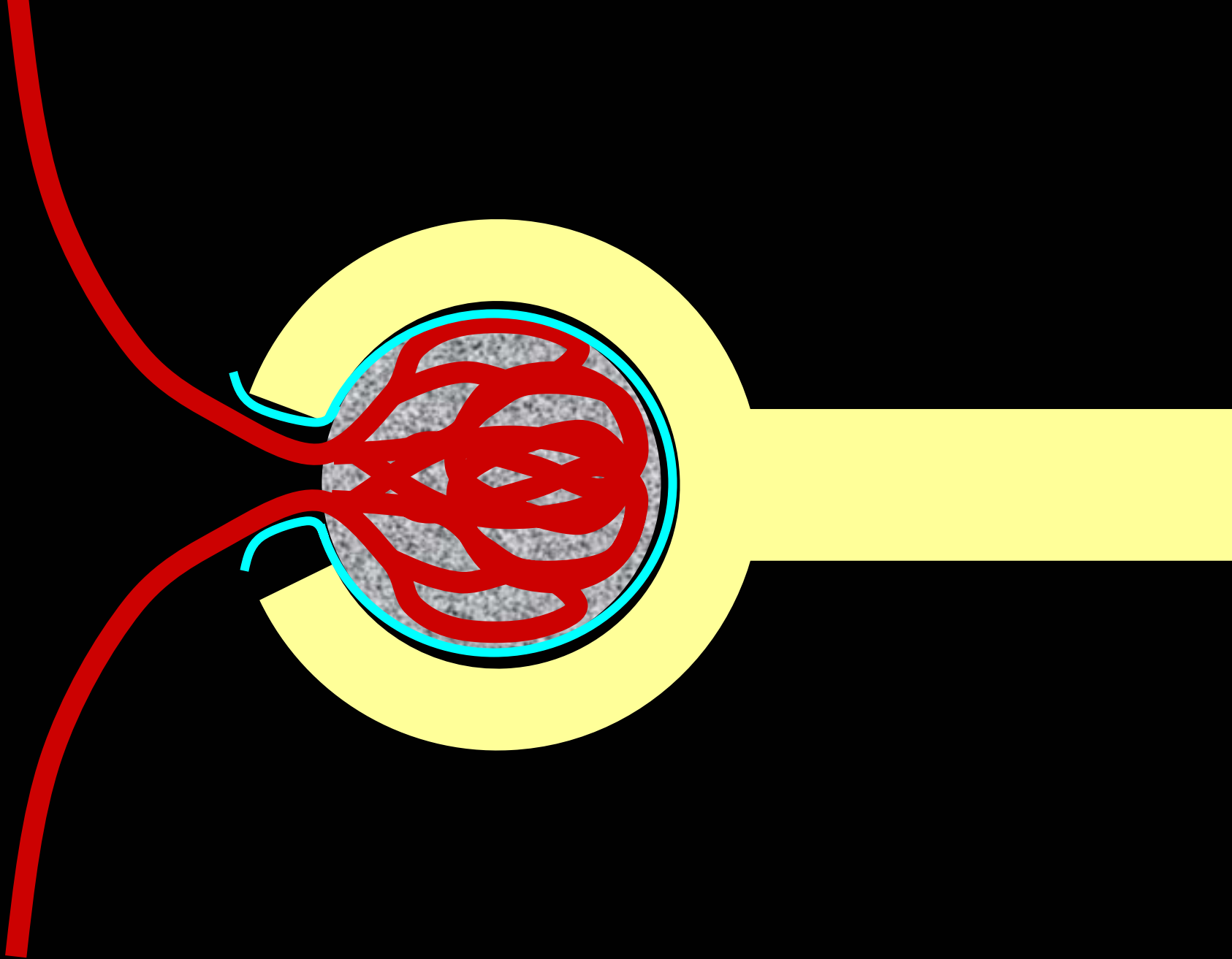


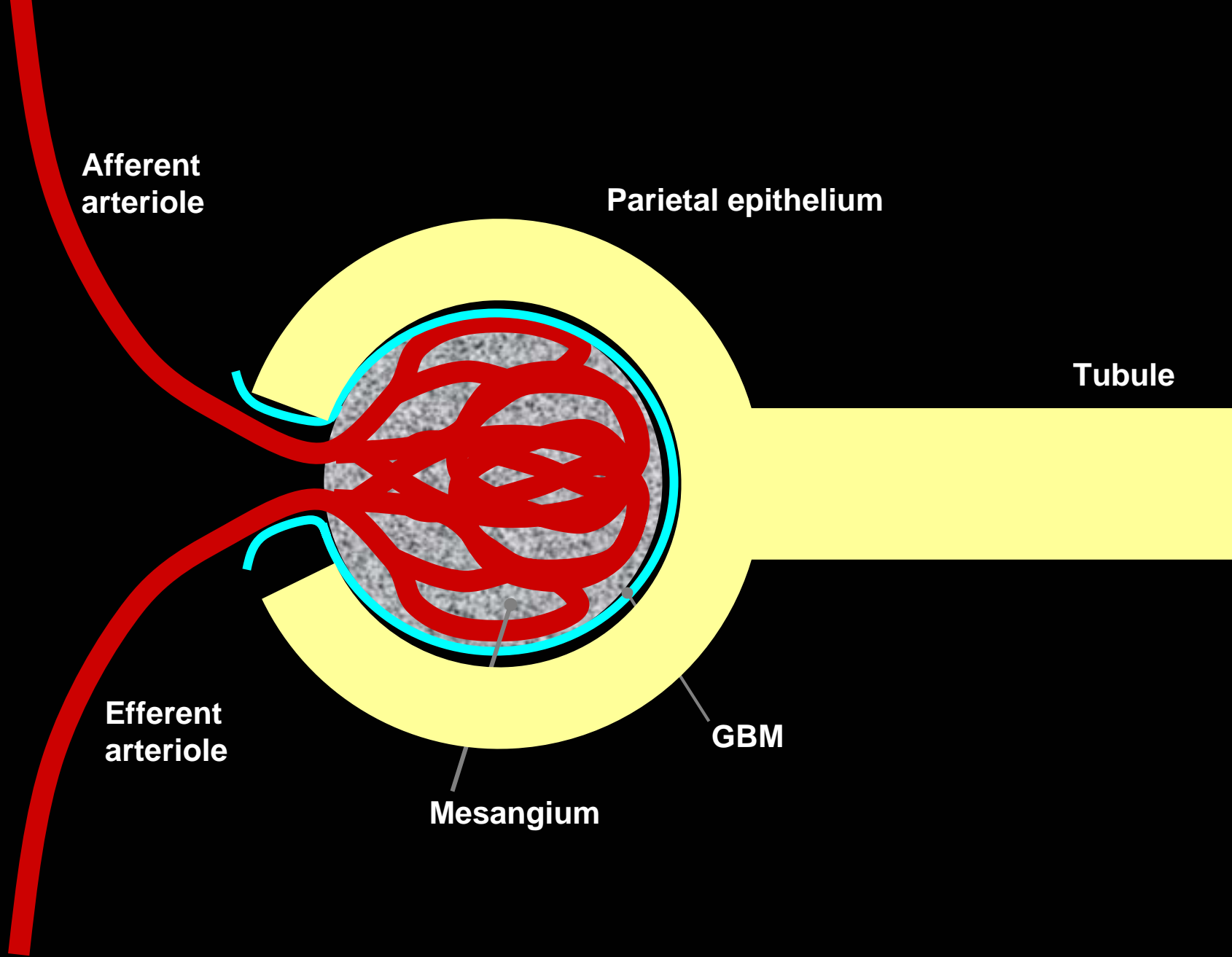


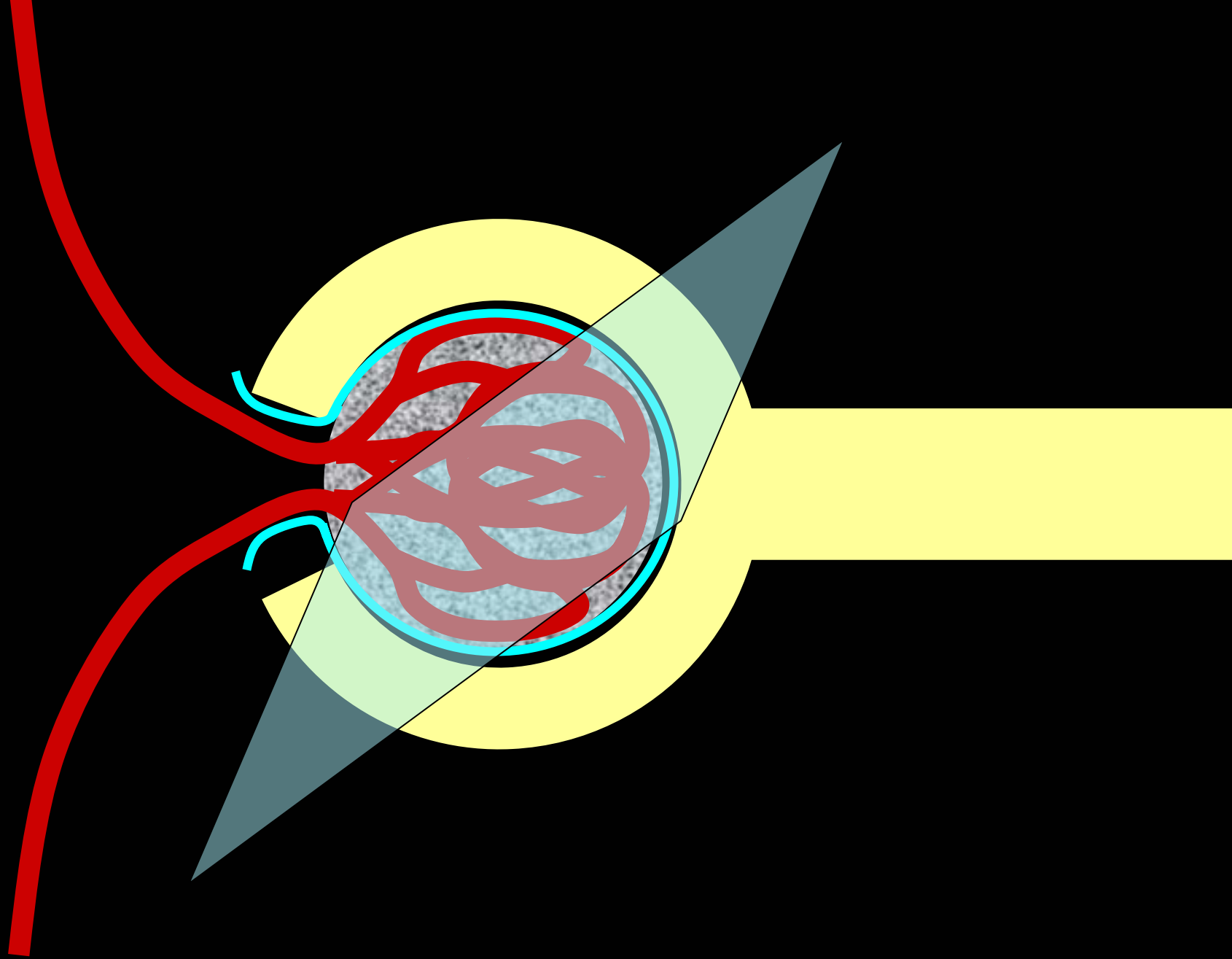


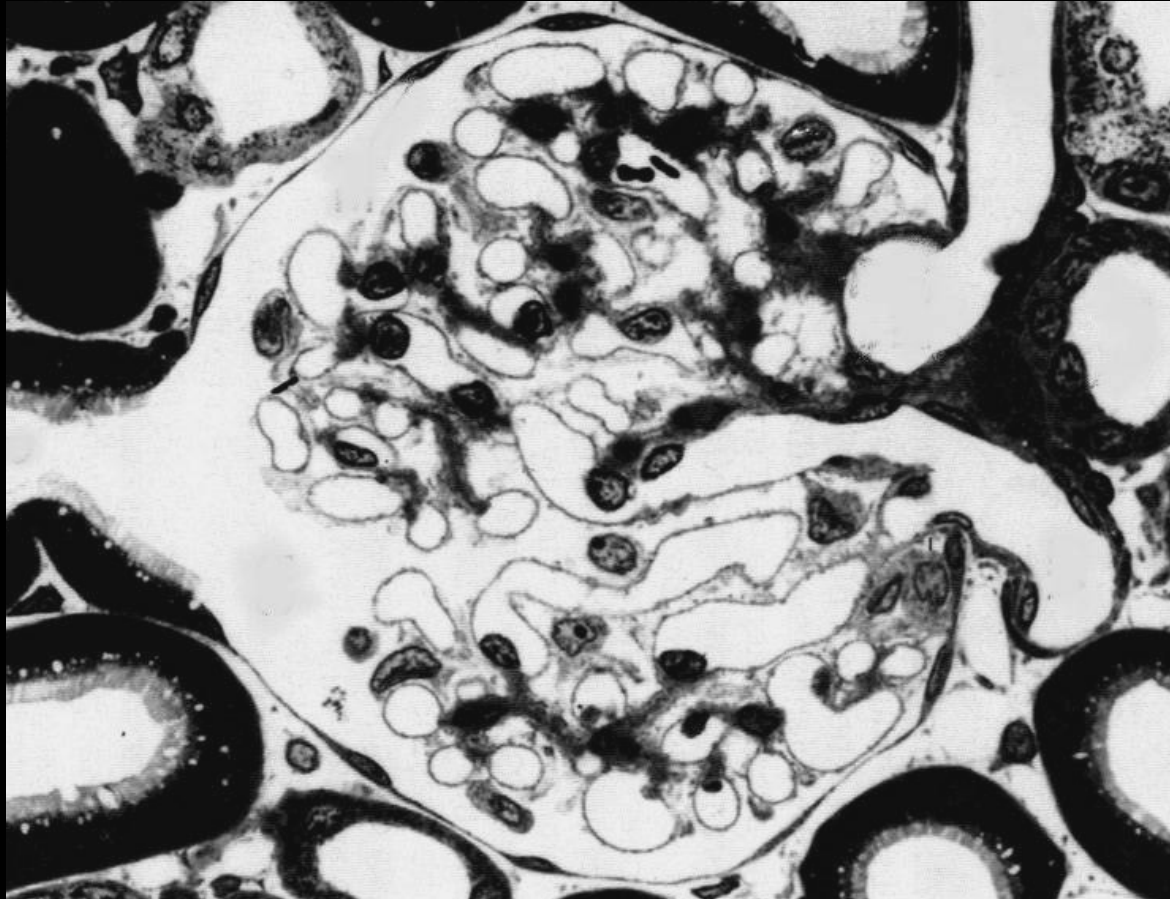


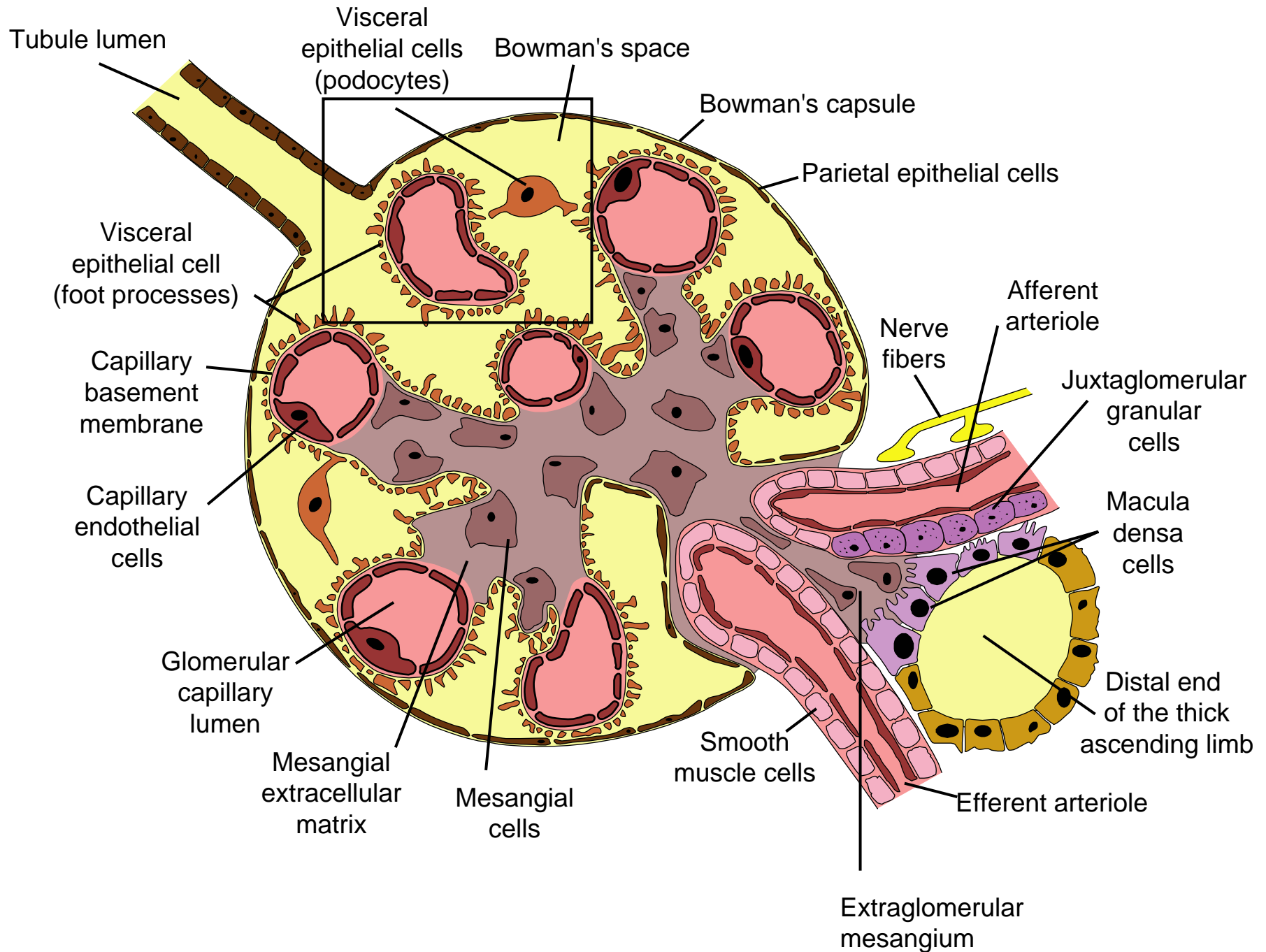


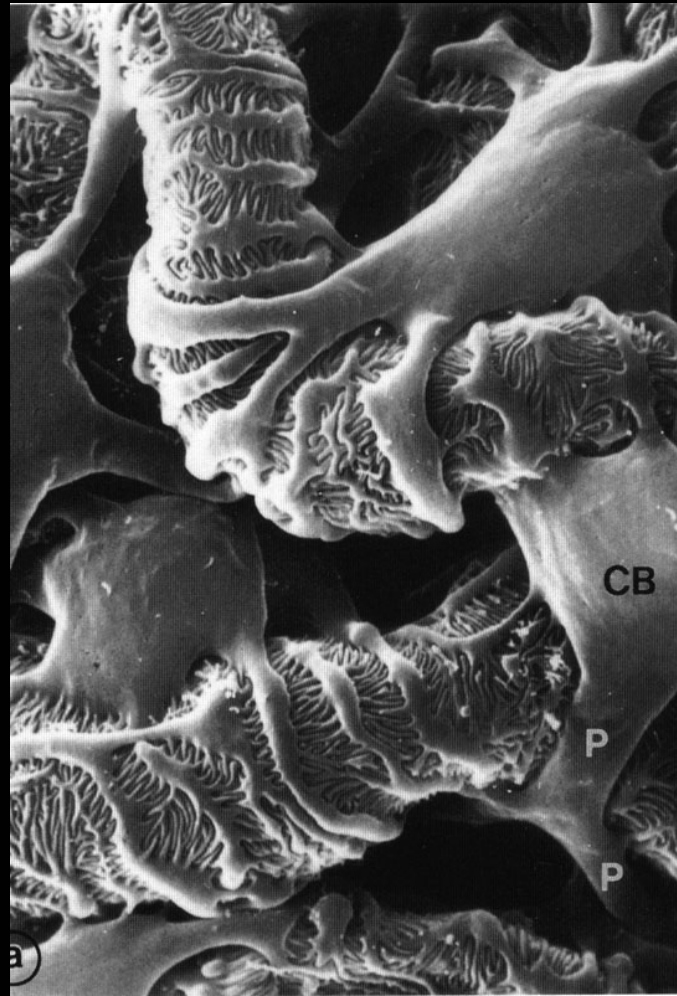
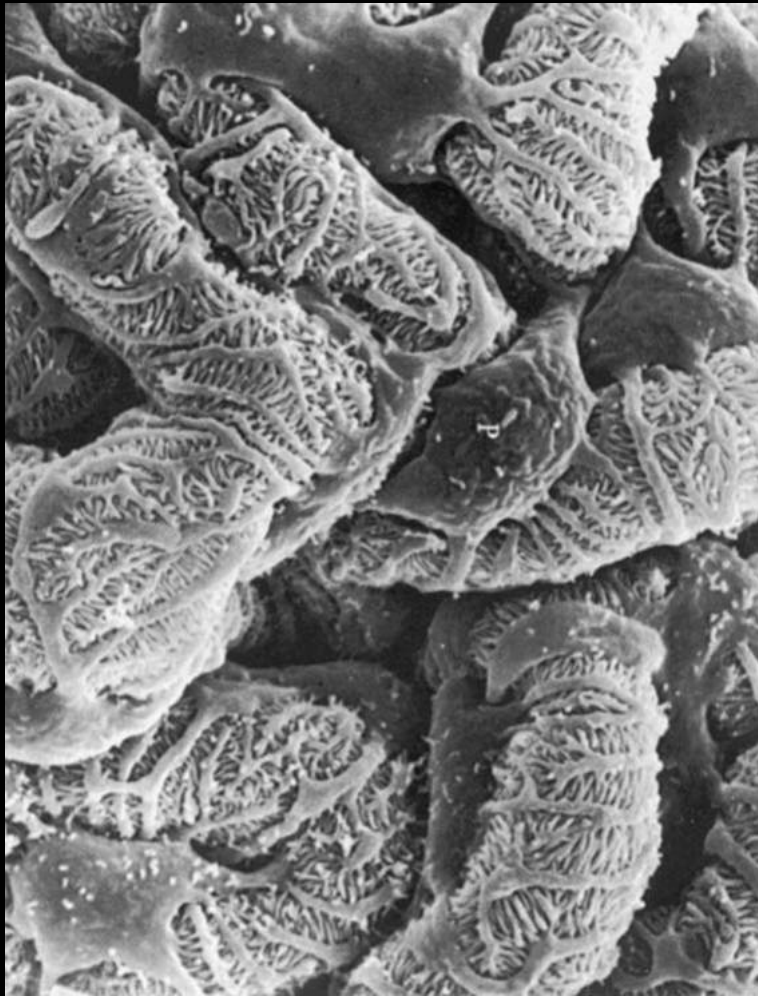


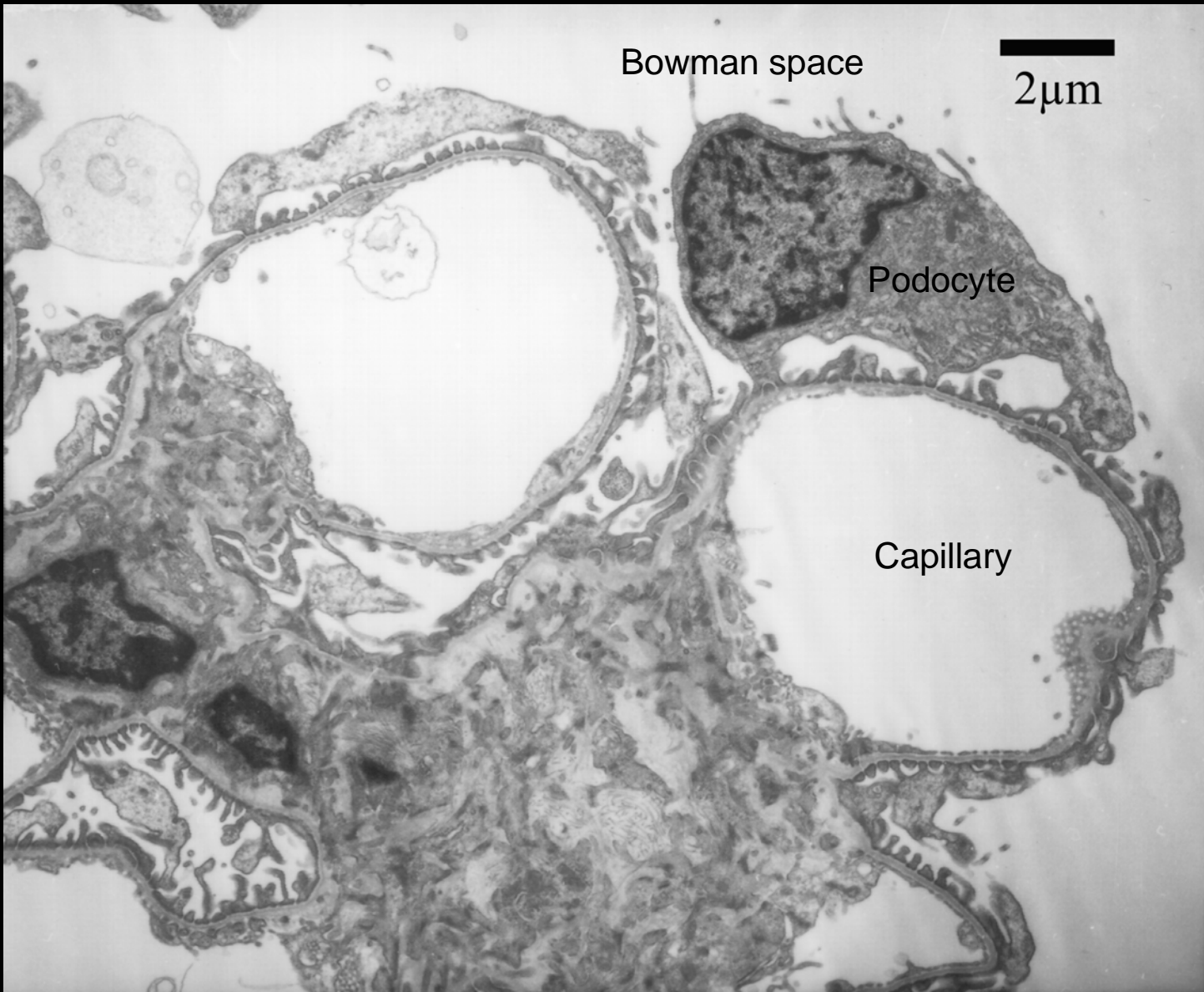










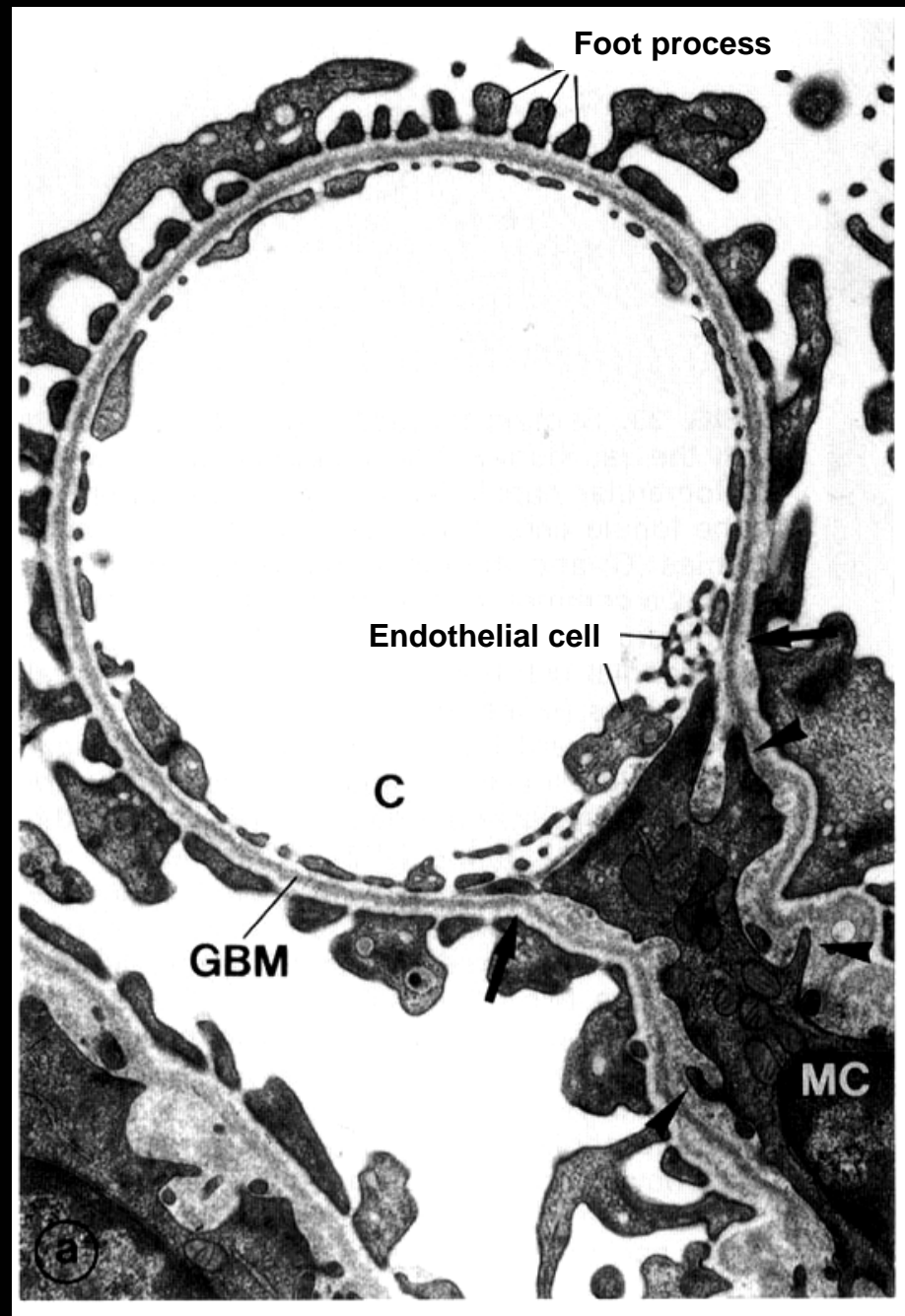
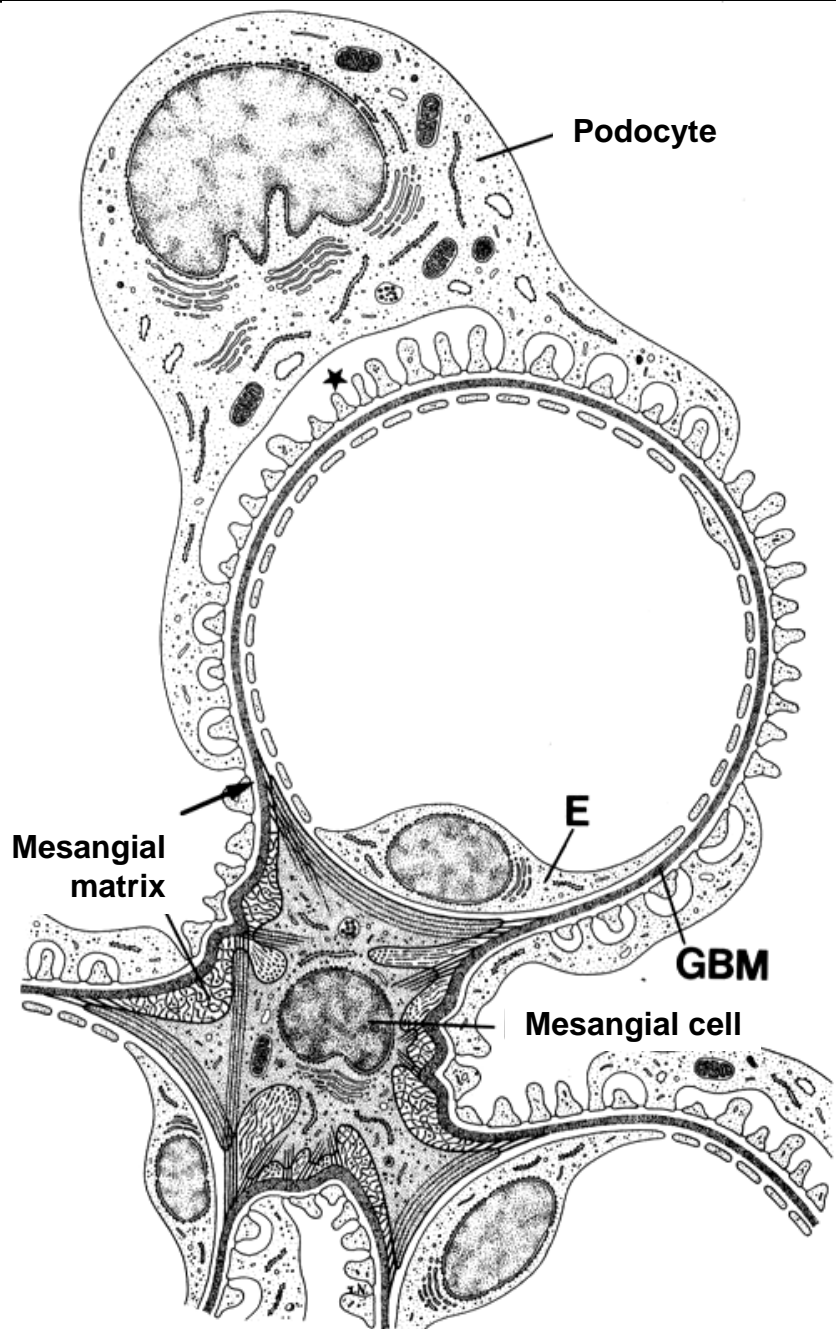


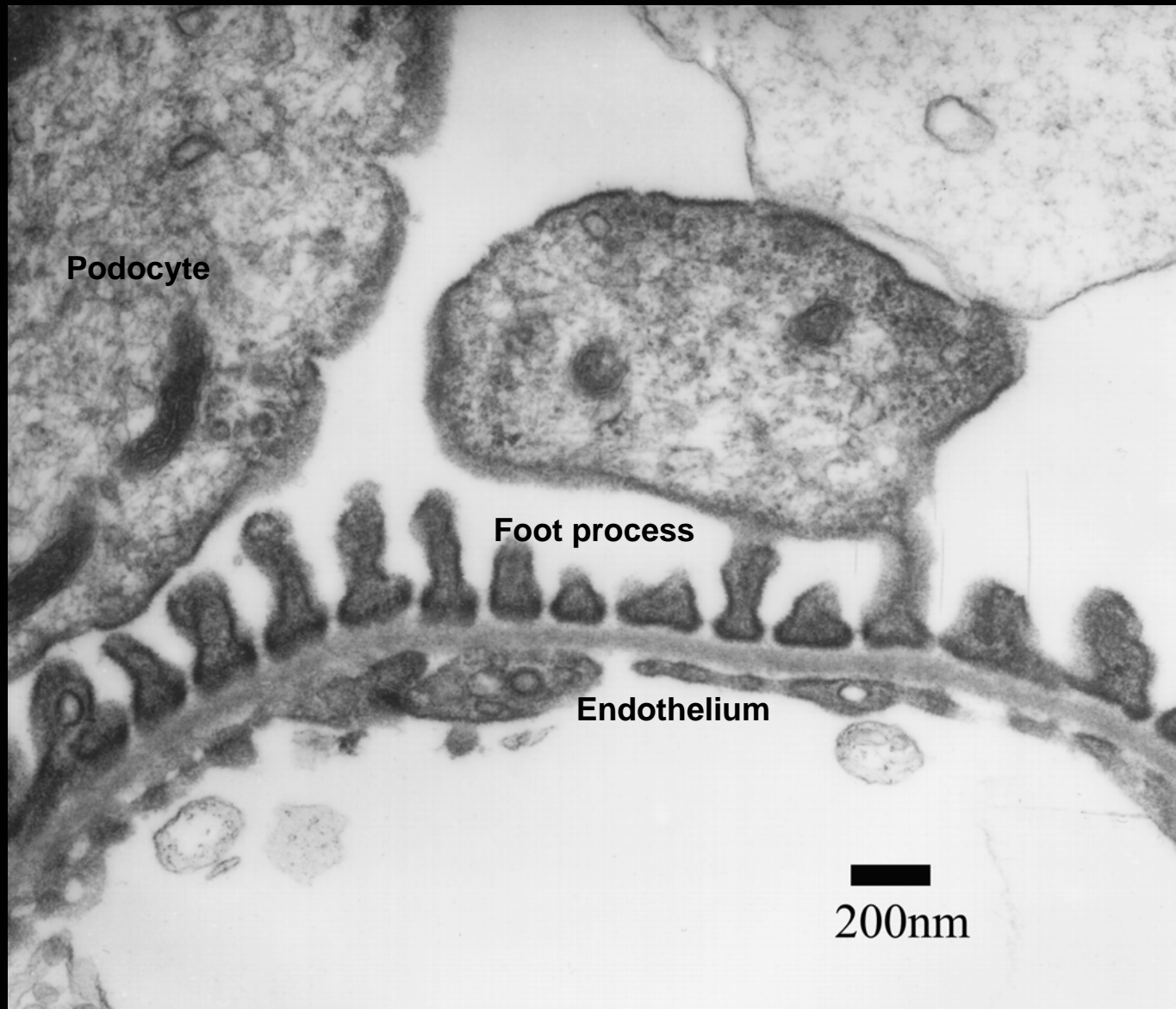
Bowman space

2 μm

Podocyte

Capillary



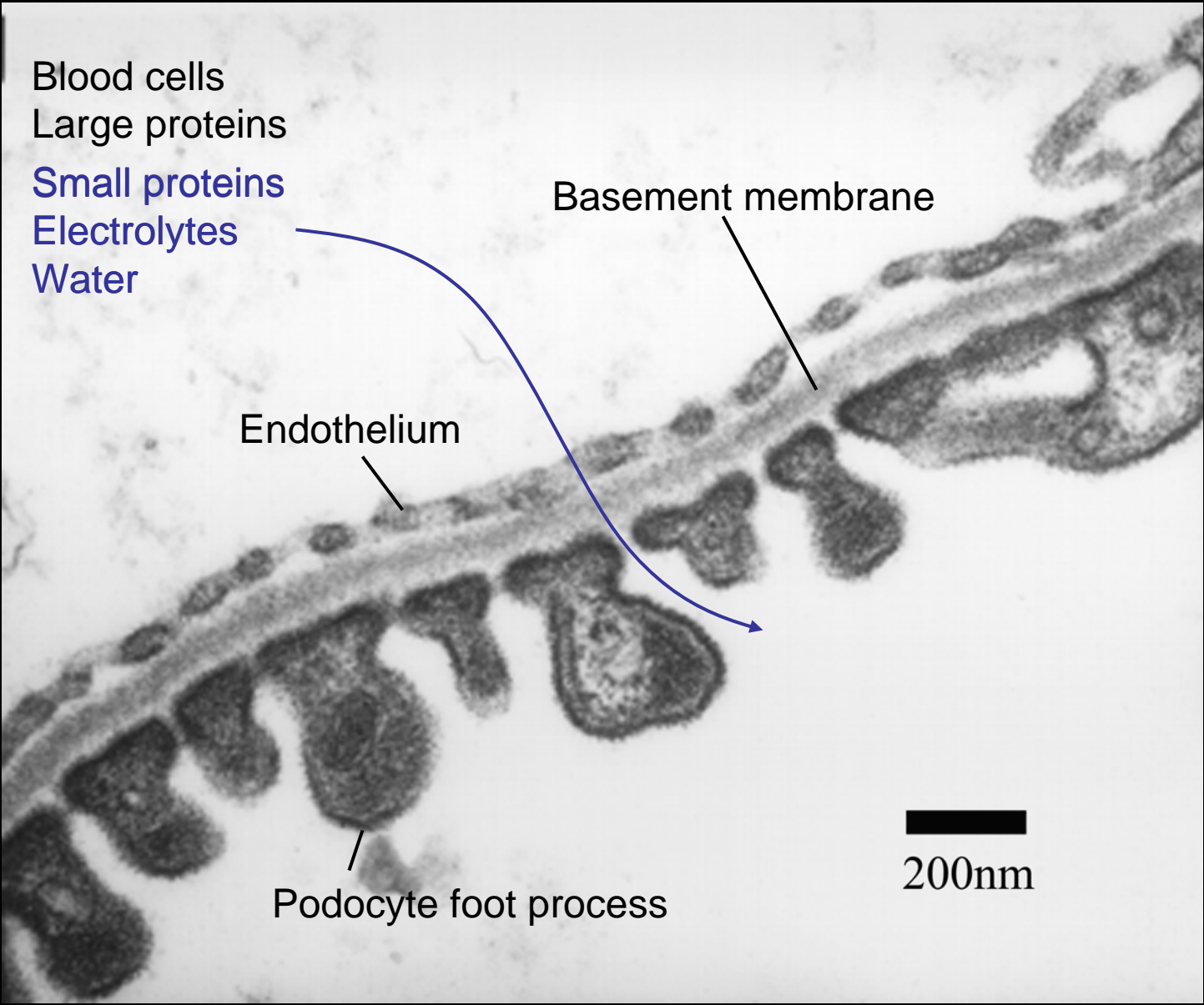


Podocyte

Foot process

Endothelium

200nm



Blood cells
Large proteins
Small proteins
Electrolytes
Water

Basement membrane

Endothelium

Podocyte foot process

200nm

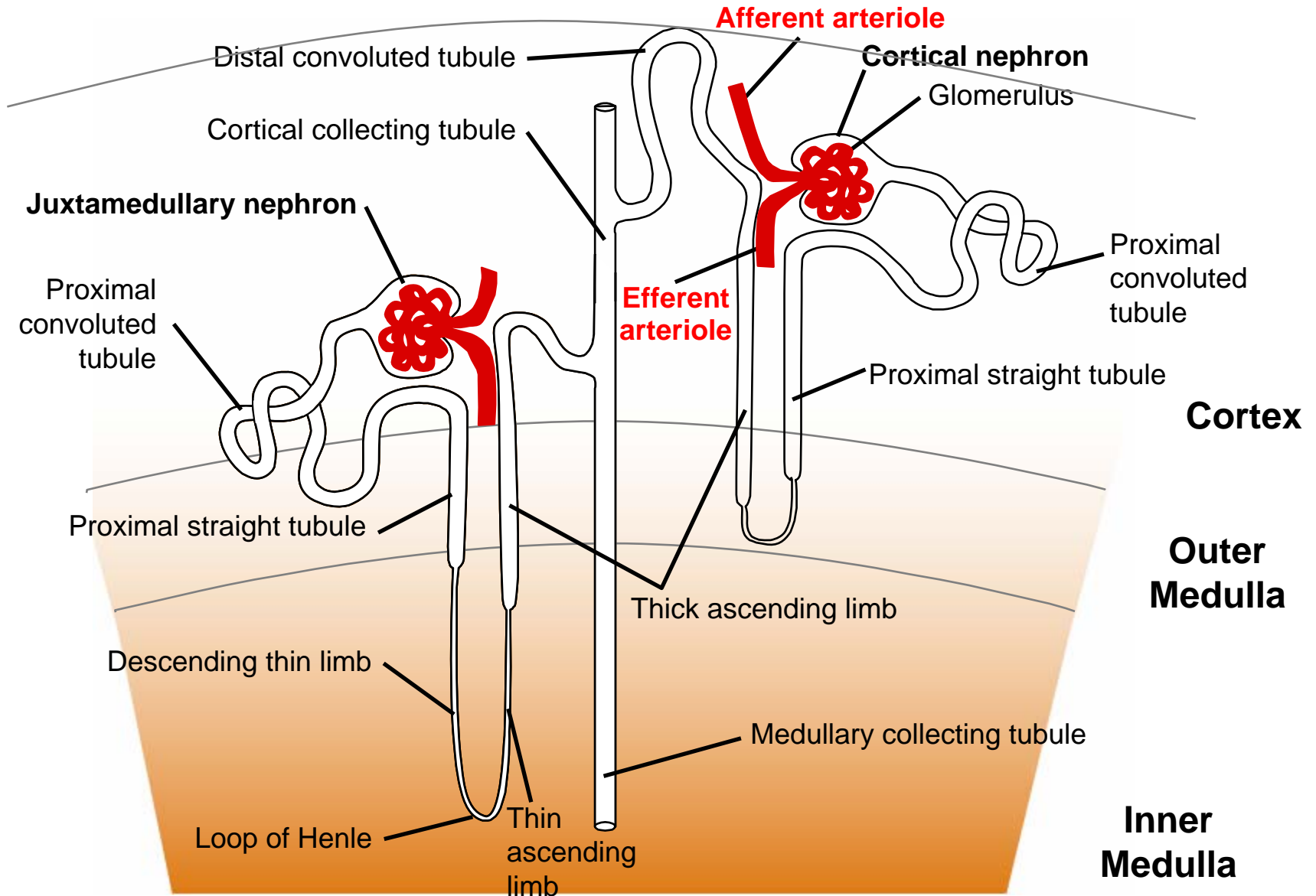
Transition to tubule



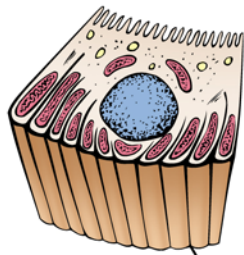
Renal Tubules

Modify the ultrafiltrate into final urine

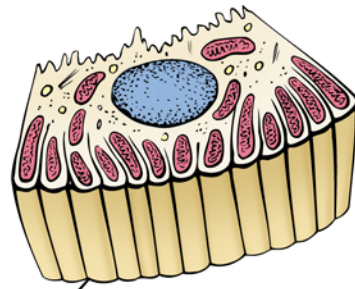
Overview



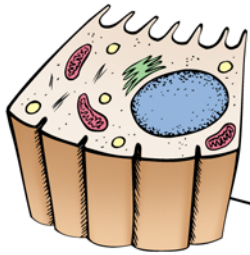
Proximal convoluted tubule



Distal tubule



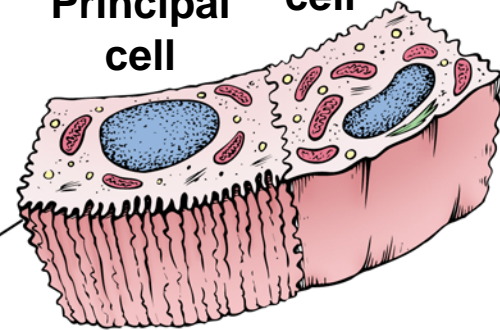
Proximal straight tubule



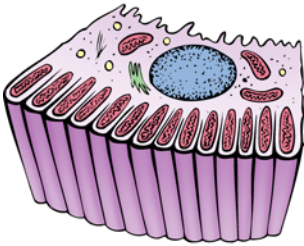
Intercalated cell

Principal cell

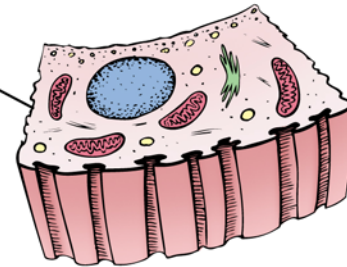
Cortical collecting tubule



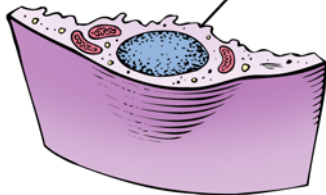
Thick ascending limb



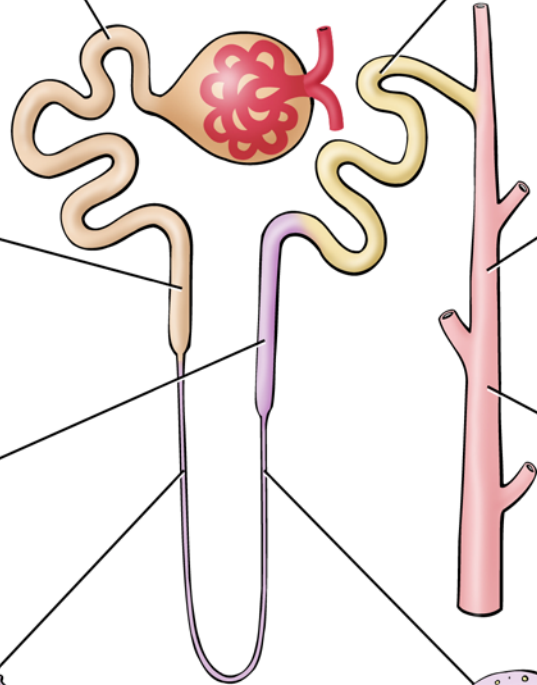
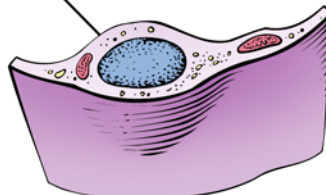
Inner medullary collecting tubule



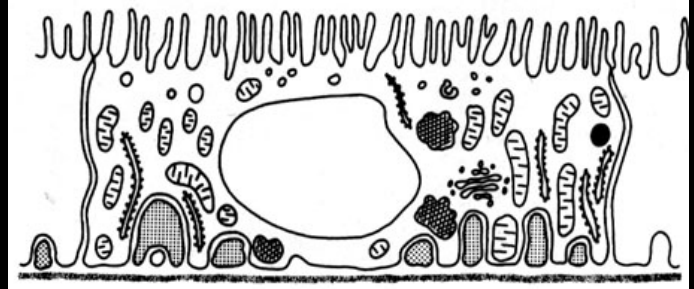
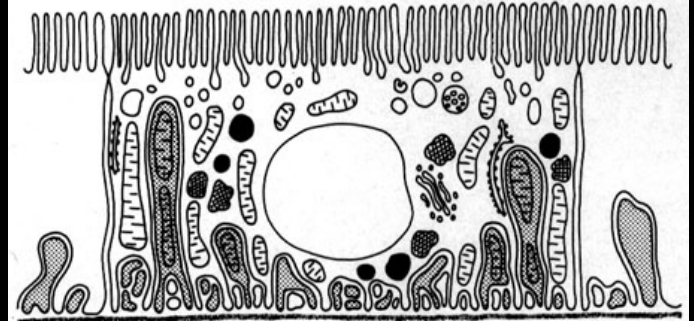
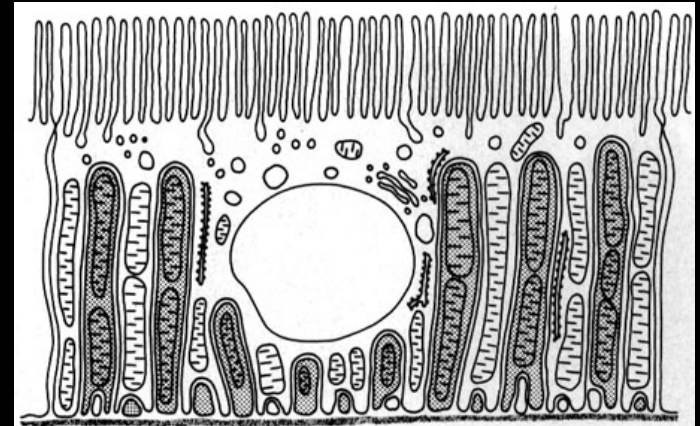
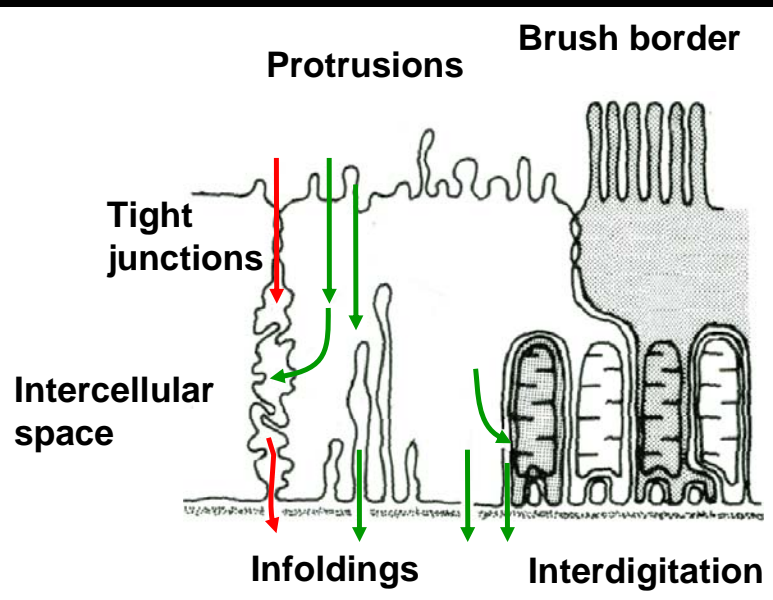
Descending thin limb



Ascending thin limb



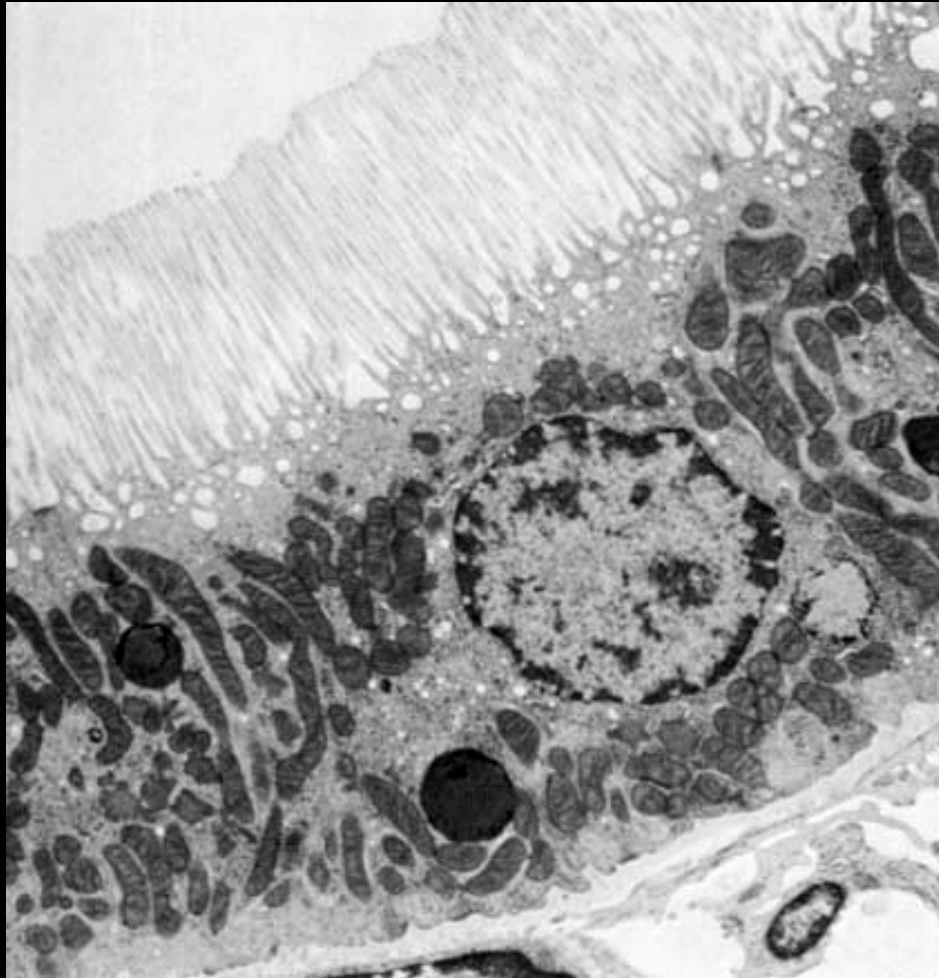
Features of tubular epithelia



Polarized
Apical
Basolateral

Amplification of surface area
Brush border
Infolding
Interdigitation

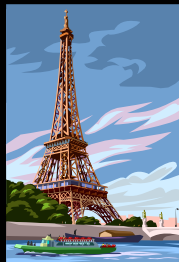
Transport
Transcellular
Paracellular



Currency for Solute Transport



High energy metabolic substrates



ATP



Electrochemical gradients

¥ Glutamine

€ ATP

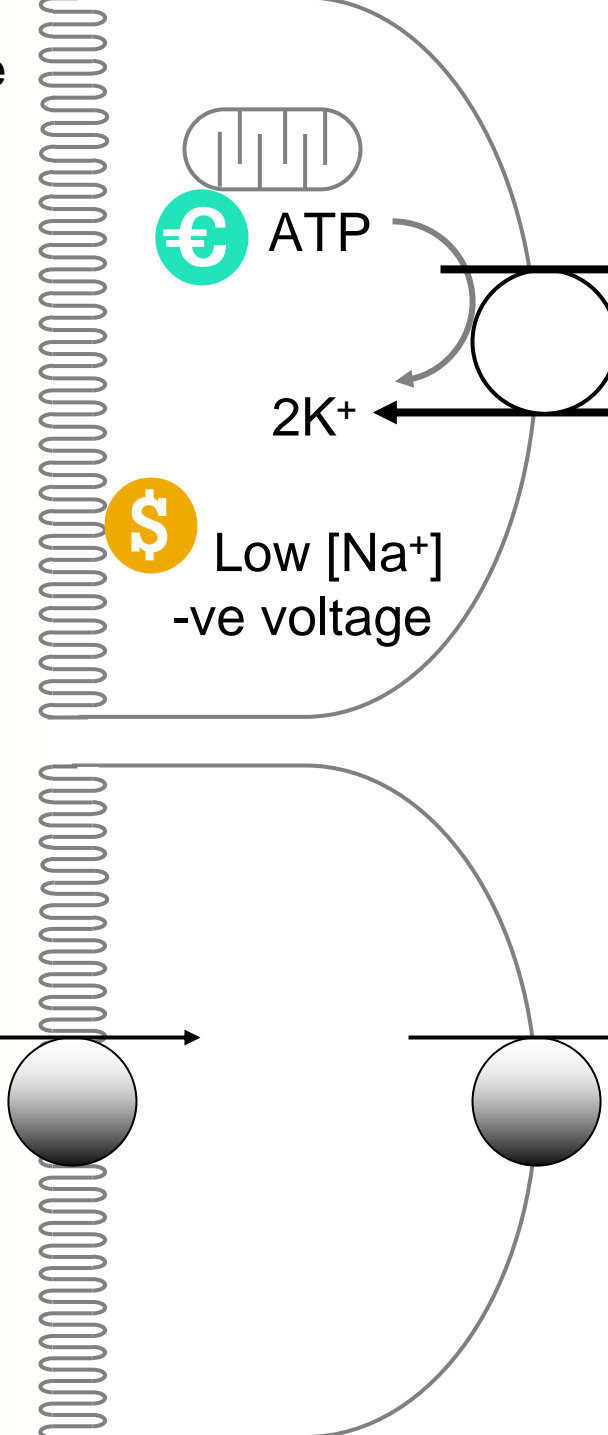
3Na⁺

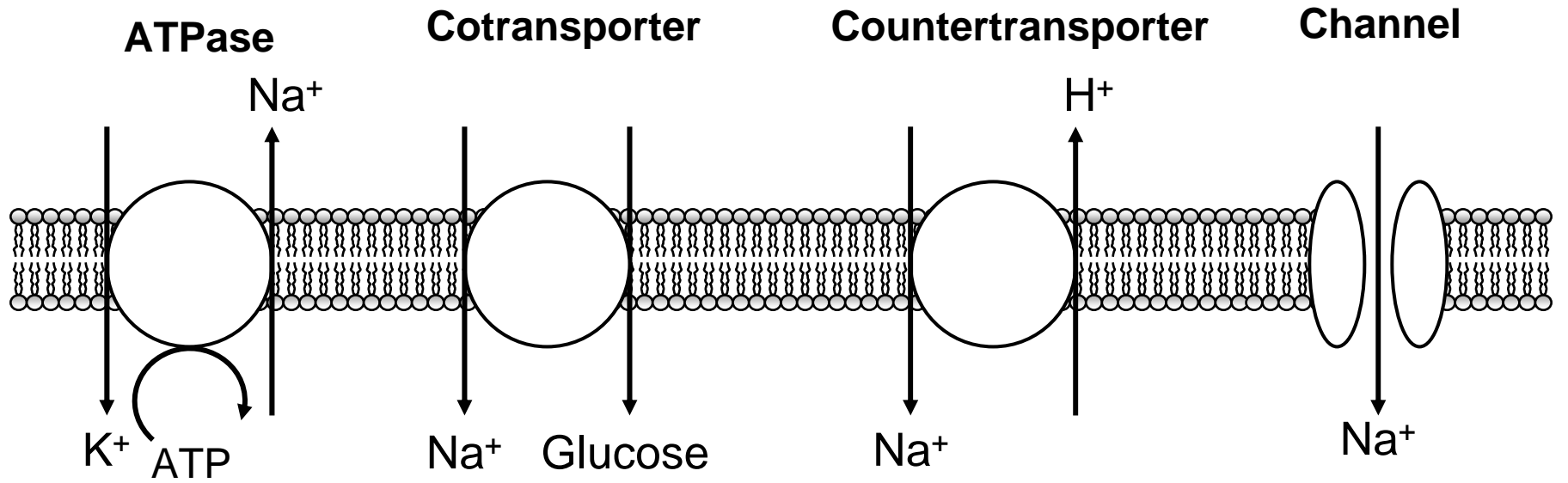
2K⁺

\$ Low [Na⁺]
-ve voltage

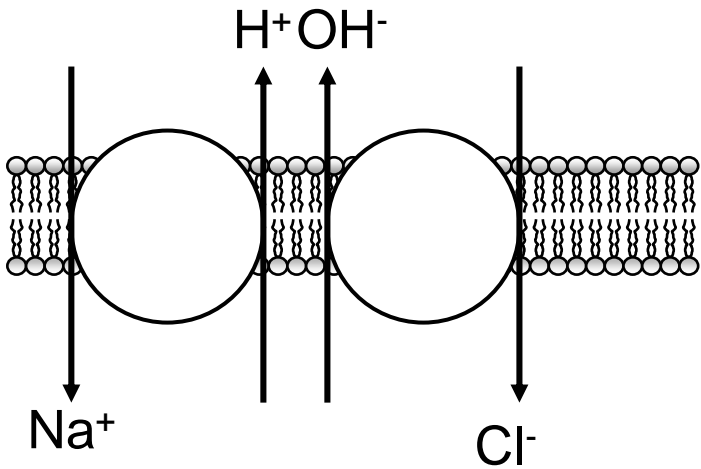
Urine

Interstitium/ Plasma

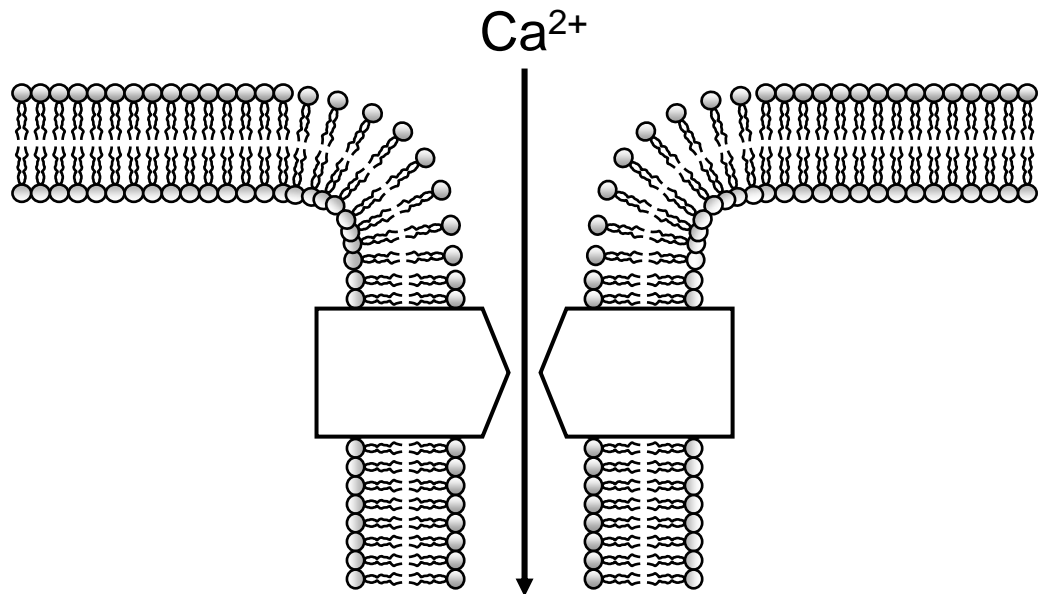




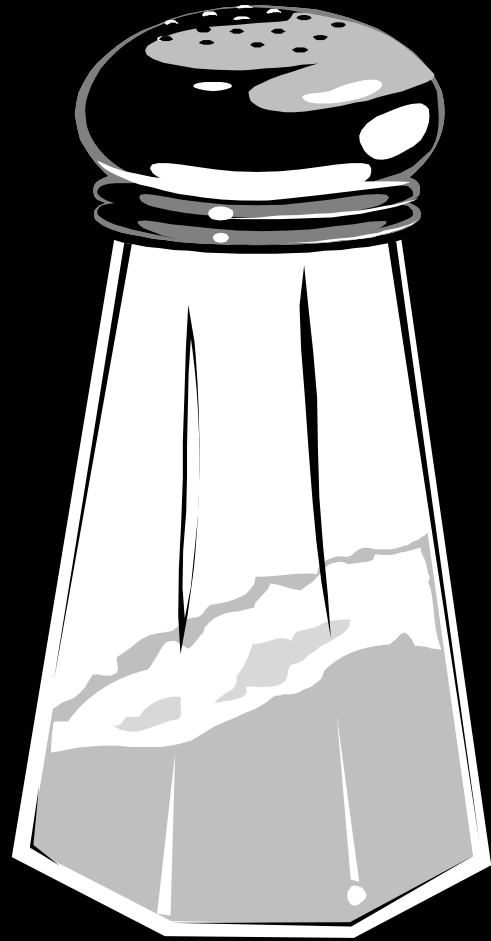
Coupled Transporters



Paracellular Transport Proteins



NaCl



Yanomami Indians



Daily ingestion & excretion

Yanomani
K⁺ 400-500 mEq/day
Na⁺ <10 mEq/day

Dallasite
40 mEq/day
200 mEq/day



NaCl

100%

50-60%

7-10%

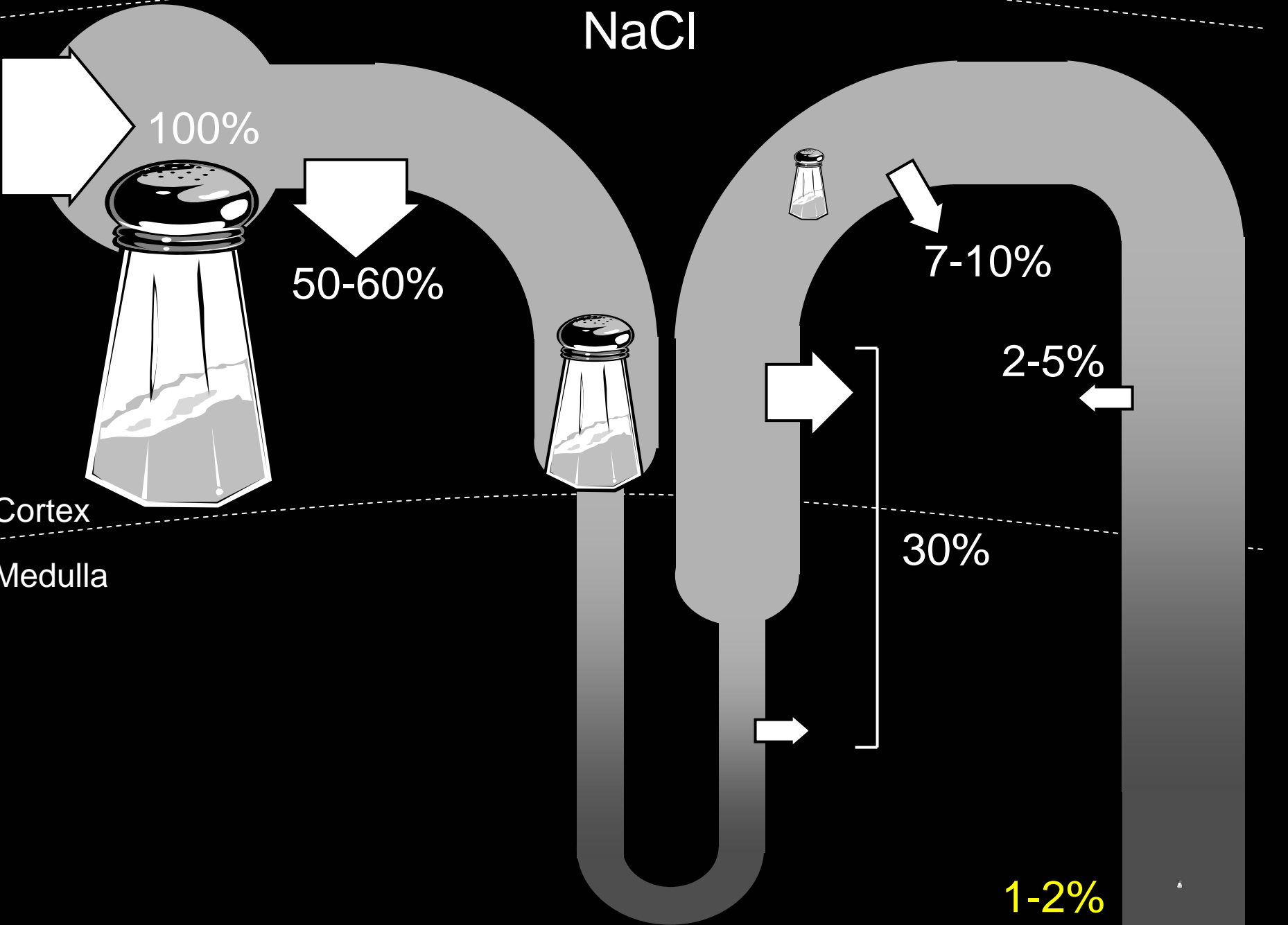
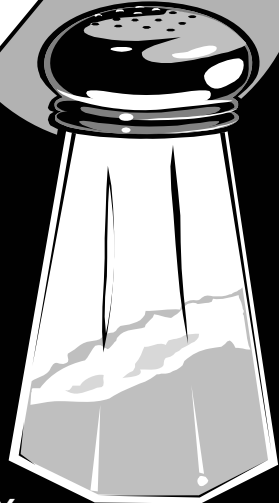
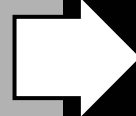
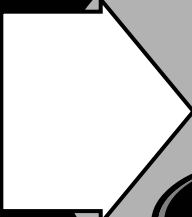
2-5%

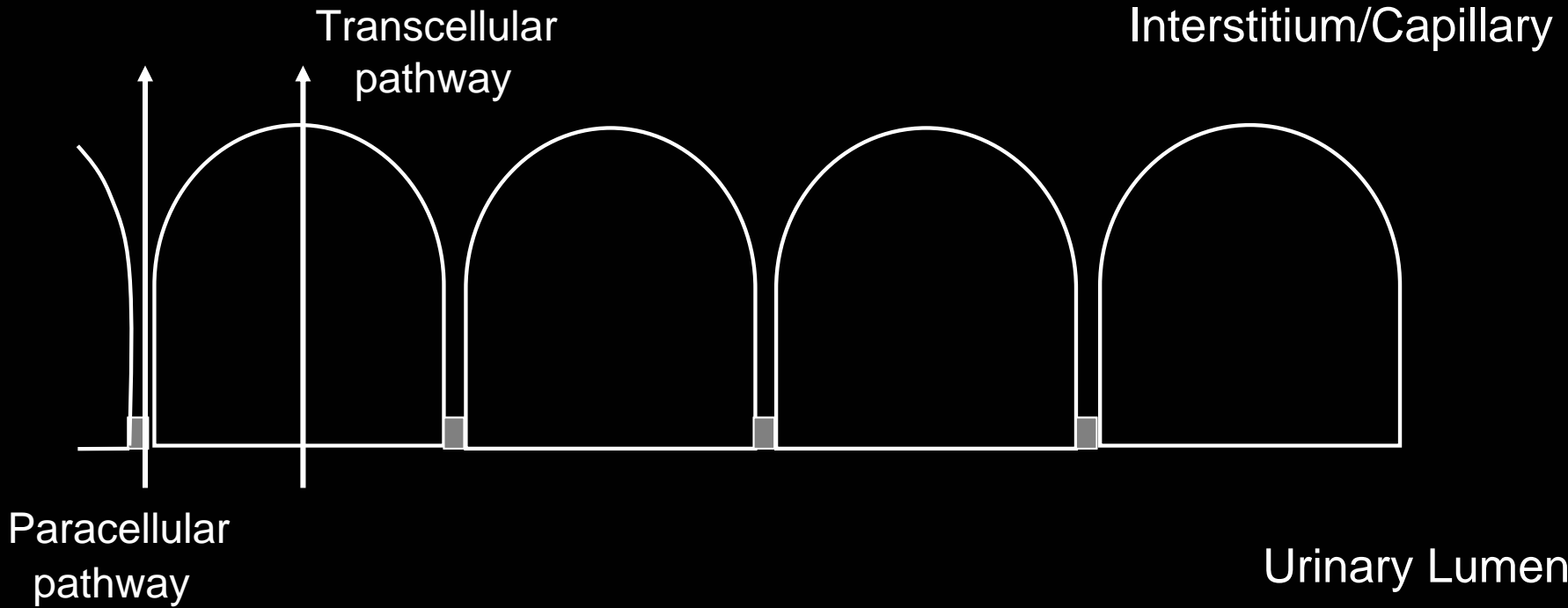
30%

1-2%

Cortex

Medulla

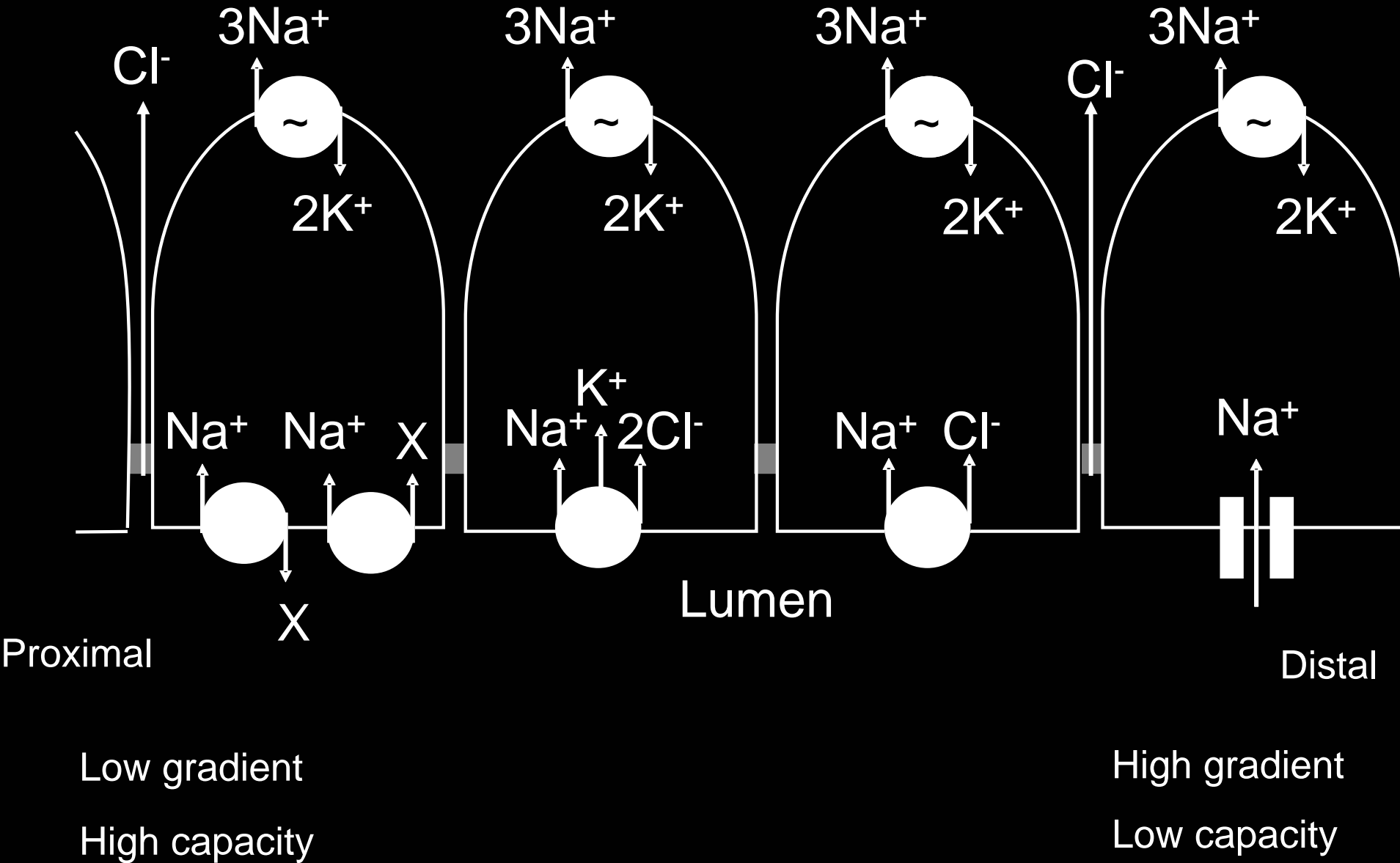




Low gradient
High capacity

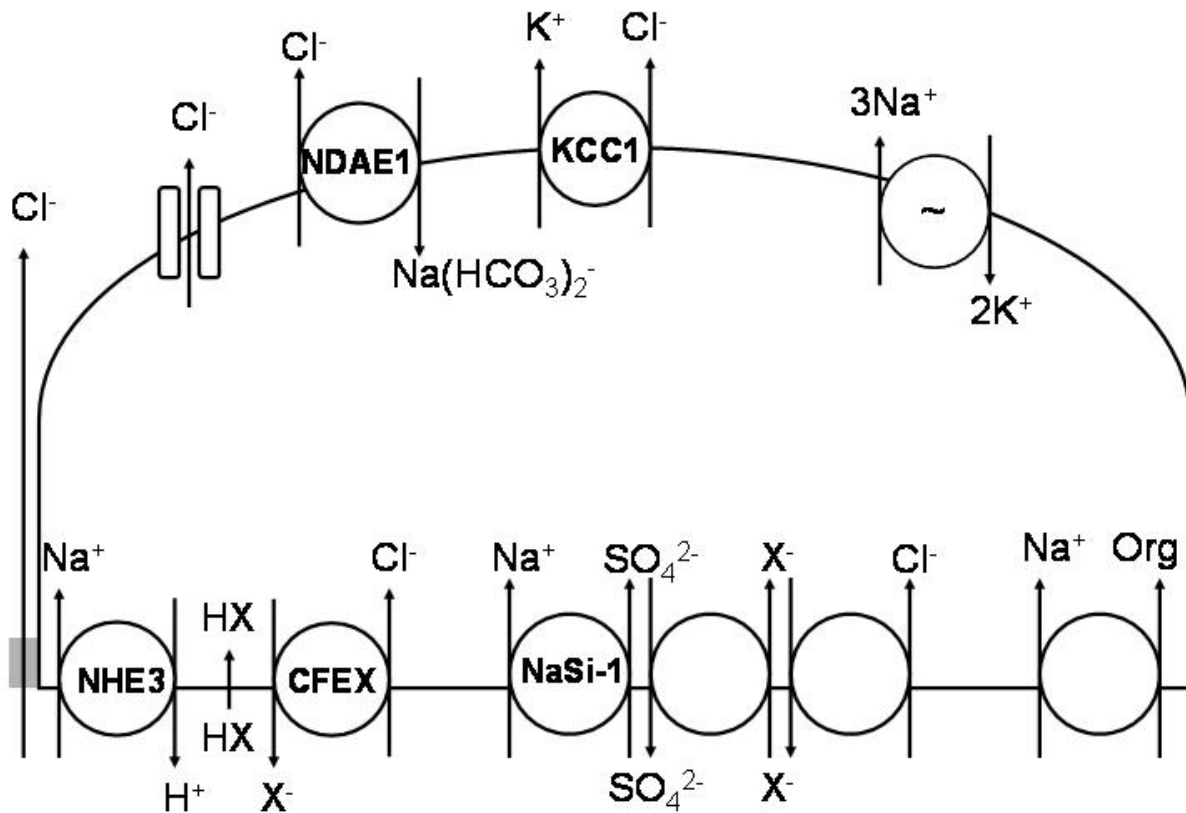
High gradient
Low capacity

Capillary

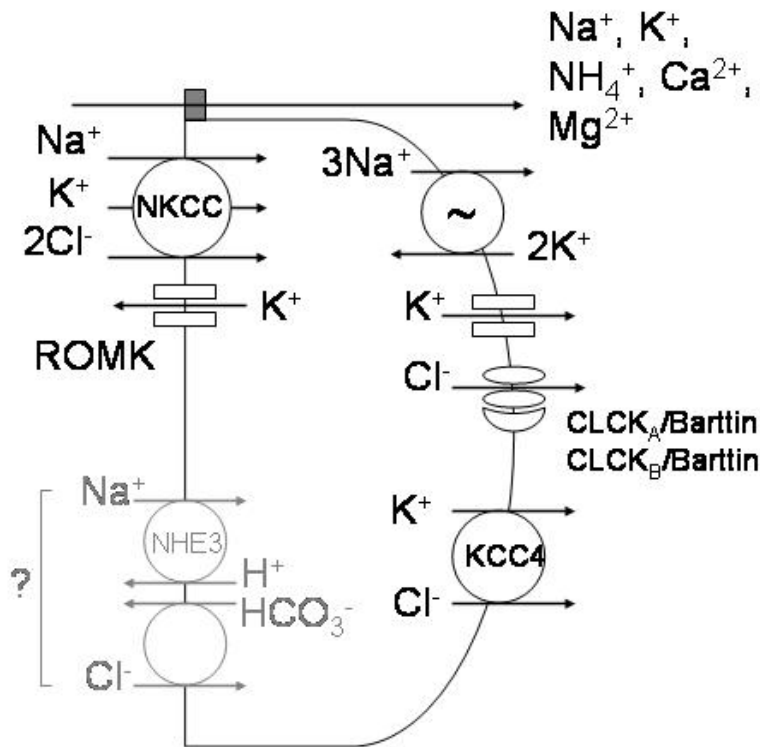


Proximal tubule

Proximal tubule NaCl transport



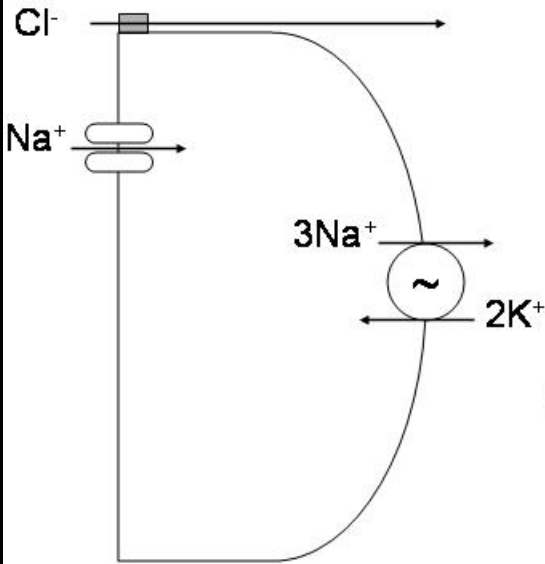
Thin and thick ascending limb NaCl transport



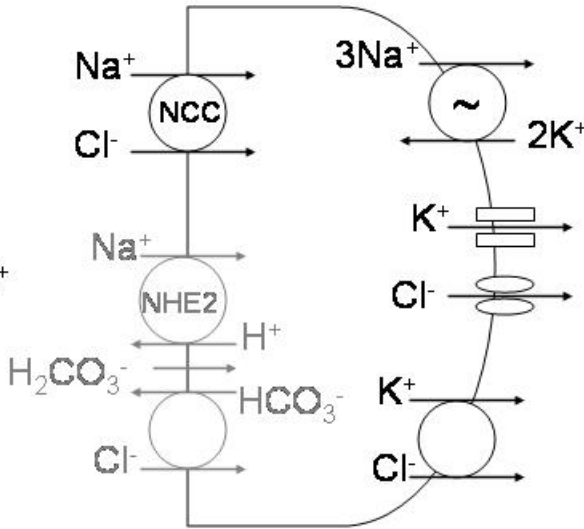
Thick
ascending
limb

Distal convoluted tubule

Distal convoluted tubule NaCl transport



Electrogenic Na⁺ transport



Electroneutral Na⁺ transport

Collecting duct NaCl transport

