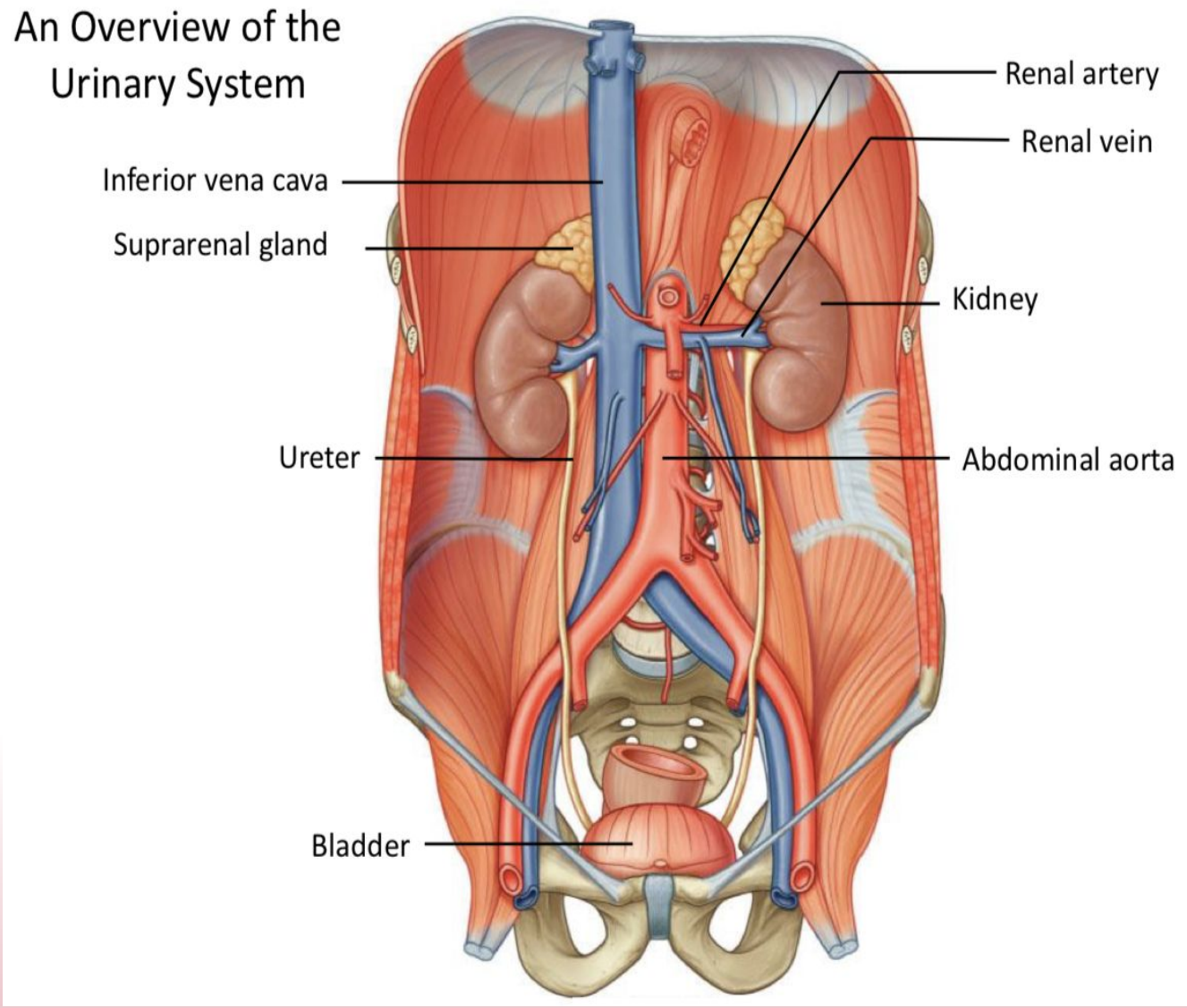

RENAL SYSTEM REVIEW

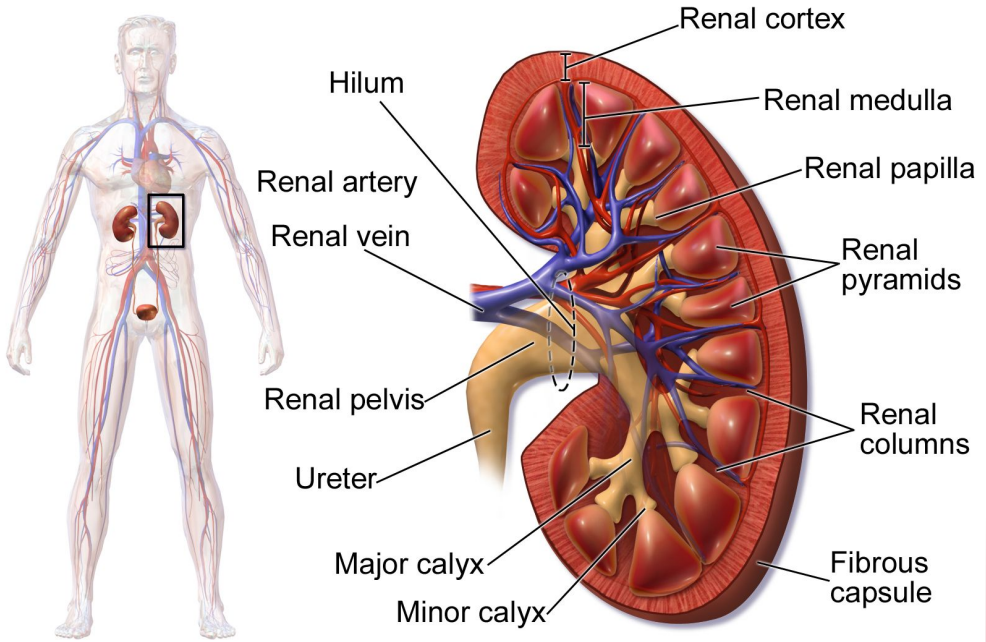
ANATOMY OF KIDNEY

- Kidneys are retroperitoneal structure, with the left kidney sitting higher (as right kidney accommodates for liver)
- Upper lobe of left kidney is at 11th rib with the upper lobe of right kidney being T12 (transpyloric plane)



ANATOMY OF KIDNEYS

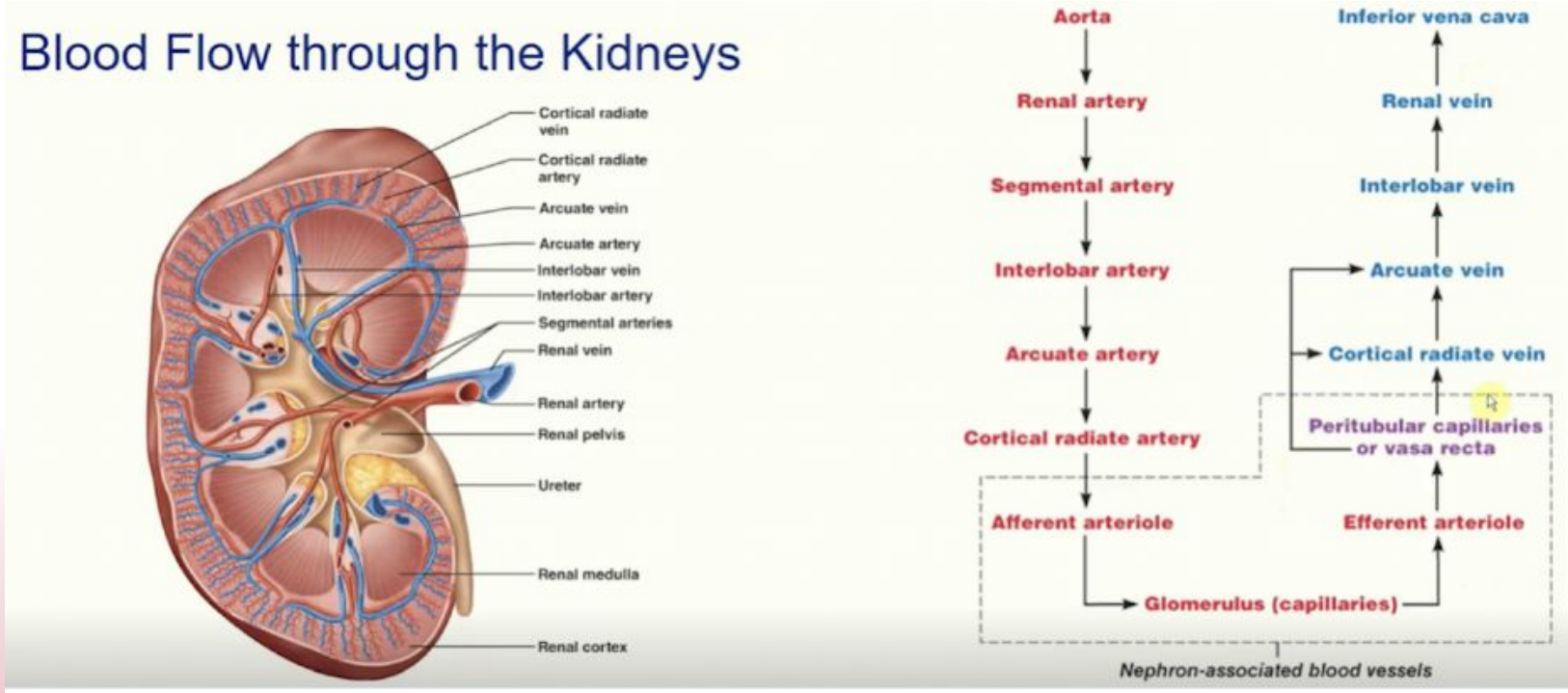
- Renal artery and Vein enter through the Hilum
- Thin fibrous capsule makes the outer layer
- Renal Columns separate the medulla
- Medulla is arranged into pyramids with the apices of pyramid projecting towards the papillae
- Papilla is where urine is released into Renal Sinus
- Minor calyces □ Major Calyces □ Renal Pelvis □ Ureter



Kidney Anatomy

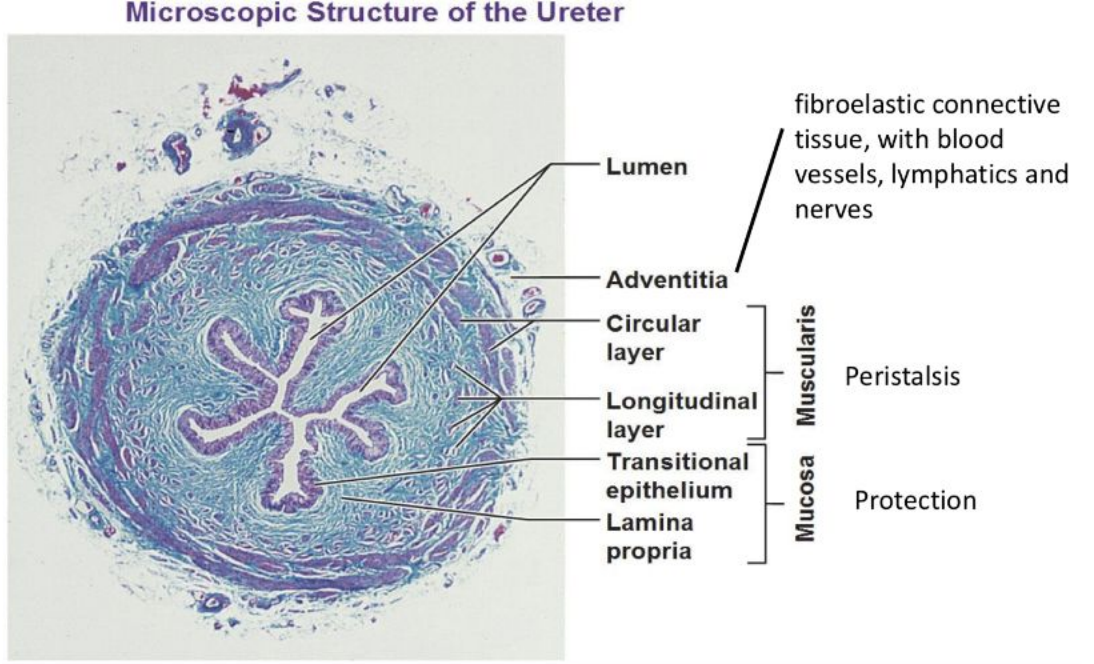
BLOOD FLOW THROUGH THE KIDNEYS

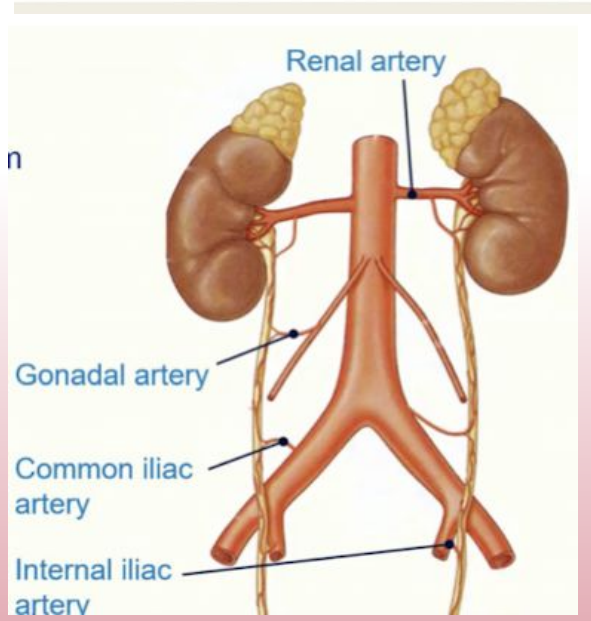
- NO Segmental Vein
- To learn this just learn one side and remember the exceptions being no segmental vein and that there is vasa recta on the efferent side
- Segmental □ Interlobar □ Arcuate □ Cortical Radiate
- Interlobar arteries runs in renal columns
- Arcuate arteries which arch over the top of external surface of pyramids

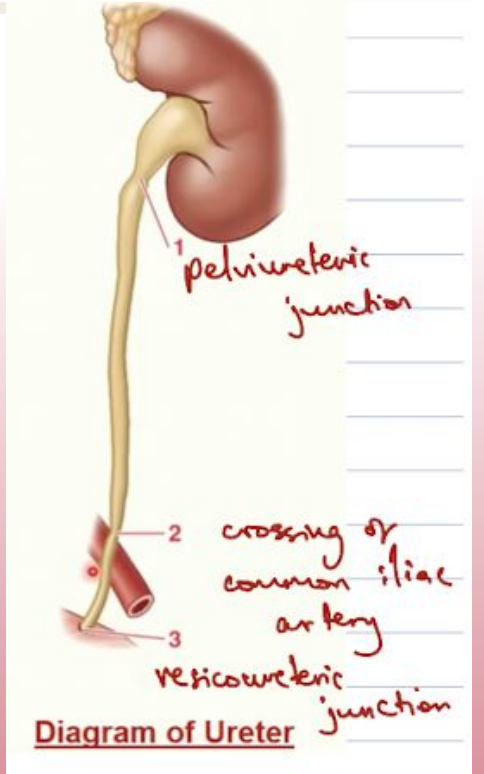


URETER ANATOMY

- They are approx. ~25cm
- Ureter and bladder lined by **Transitional epithelium** (urothelium)
- Has narrow lumen which is easily blocked especially at the constriction points where caliculi (stones) most likely form
- Mucosal folds prevents urine backflow, urine moves in small volumes via peristalsis
- Supplied by **Gonadal** artery, **Common iliac** and **Internal iliac** at various points as you go down the ureter
- **Constriction points:**
  - **Pelviureteric junction**
  - **Crossing of common iliac artery**
  - **Vesicoureteric junction**

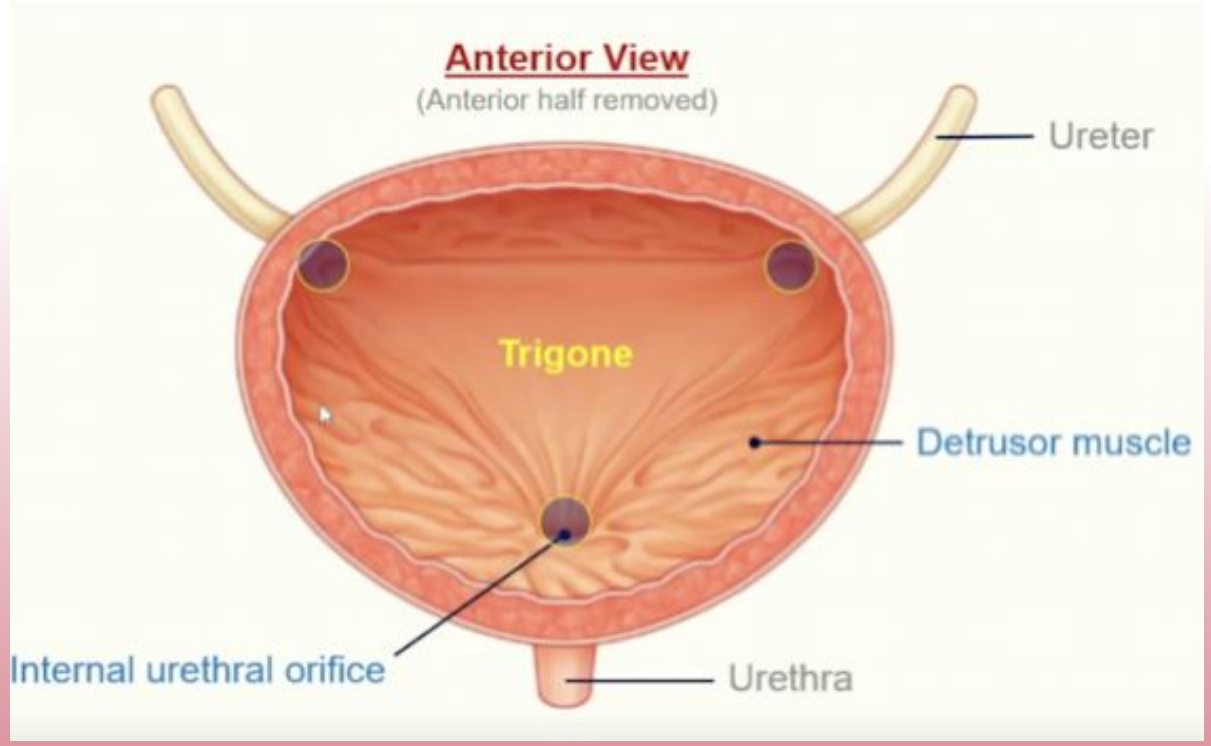






BLADDER ANATOMY

- **Detrusor muscles** line the inside of the bladder
- Internal surface of the base of the bladder is **Trigone**
- In male, prostate surrounds top of urethra and sits under bladder



MICROANATOMY - GLOMERULUS

- Renal Corpuscle comprises of Glomerulus + Bowman's Capsule and is found in the Cortex of Kidney
- Blood flow:

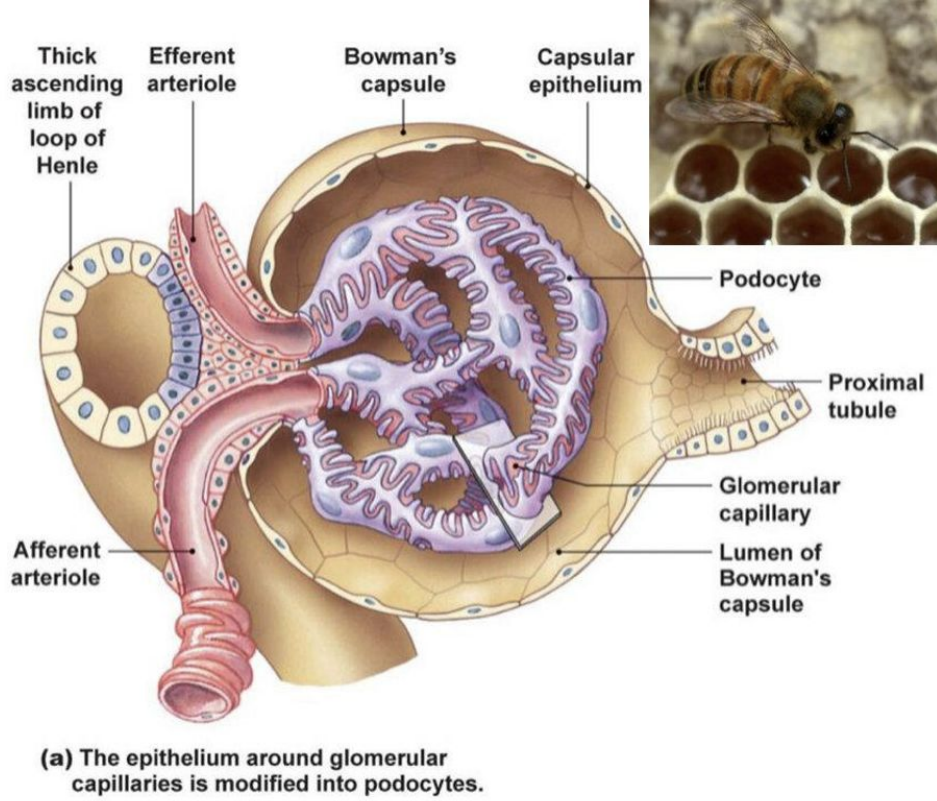
  Afferent Arteriole □ Glomerular capillary □ Efferent Arteriole

- Capillary wall has 3 layers:

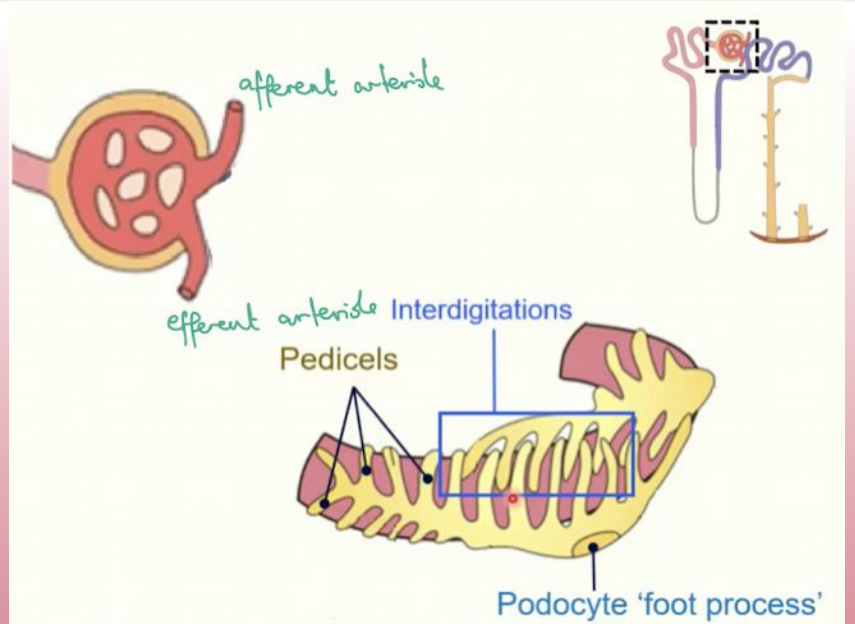
  - Endothelium, Basement membrane, Podocytes (foot like processes which form pedicels)

  Pedicels are tightly interdigited for filtration

- Bowman's capsule is a layer of epithelium that surrounds glomerulus
- Juxtaglomerular cells (**secretes Renin**) and Macula Densa (senses Na+ conc.) are next to renal corpuscle

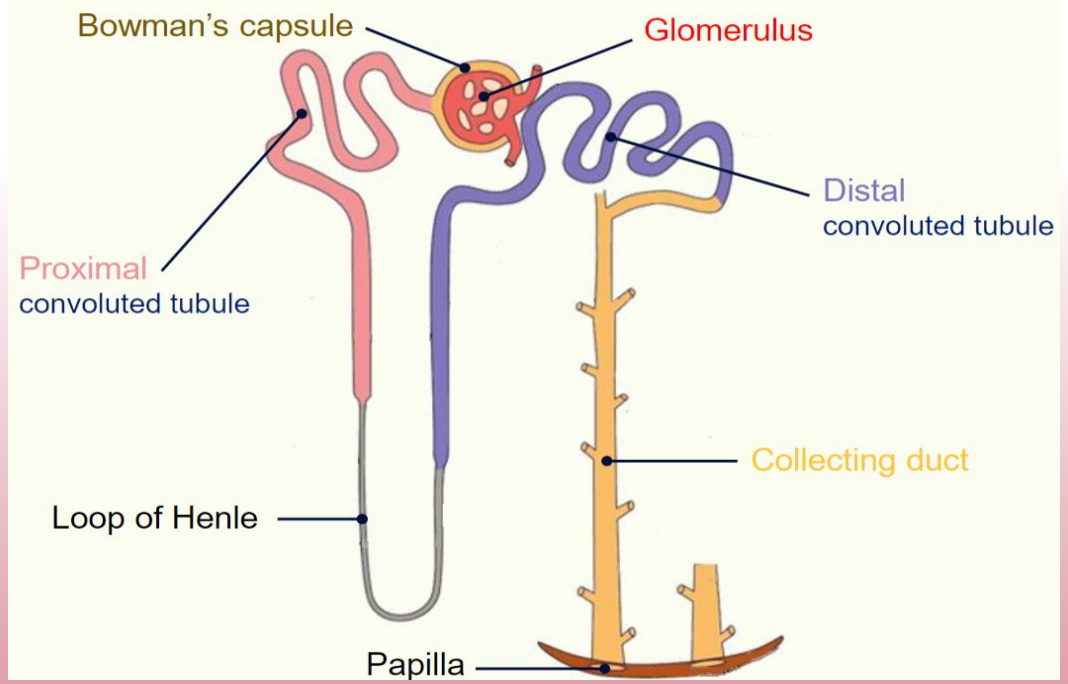


(a) The epithelium around glomerular capillaries is modified into podocytes.



NEPHRON AND JUXTAGLOMERULAR APPARATUS

- 3 cells types:
  - Macula Densa
  - Juxtaglomerular cells
  - Extraglomerular mesangial cells (smooth muscle for autoregulation of blood flow)
- Nephron consists of Renal corpuscle and Renal tubules (PCT, loop of Henle, DCT and Collecting Duct)



NEPHRONS

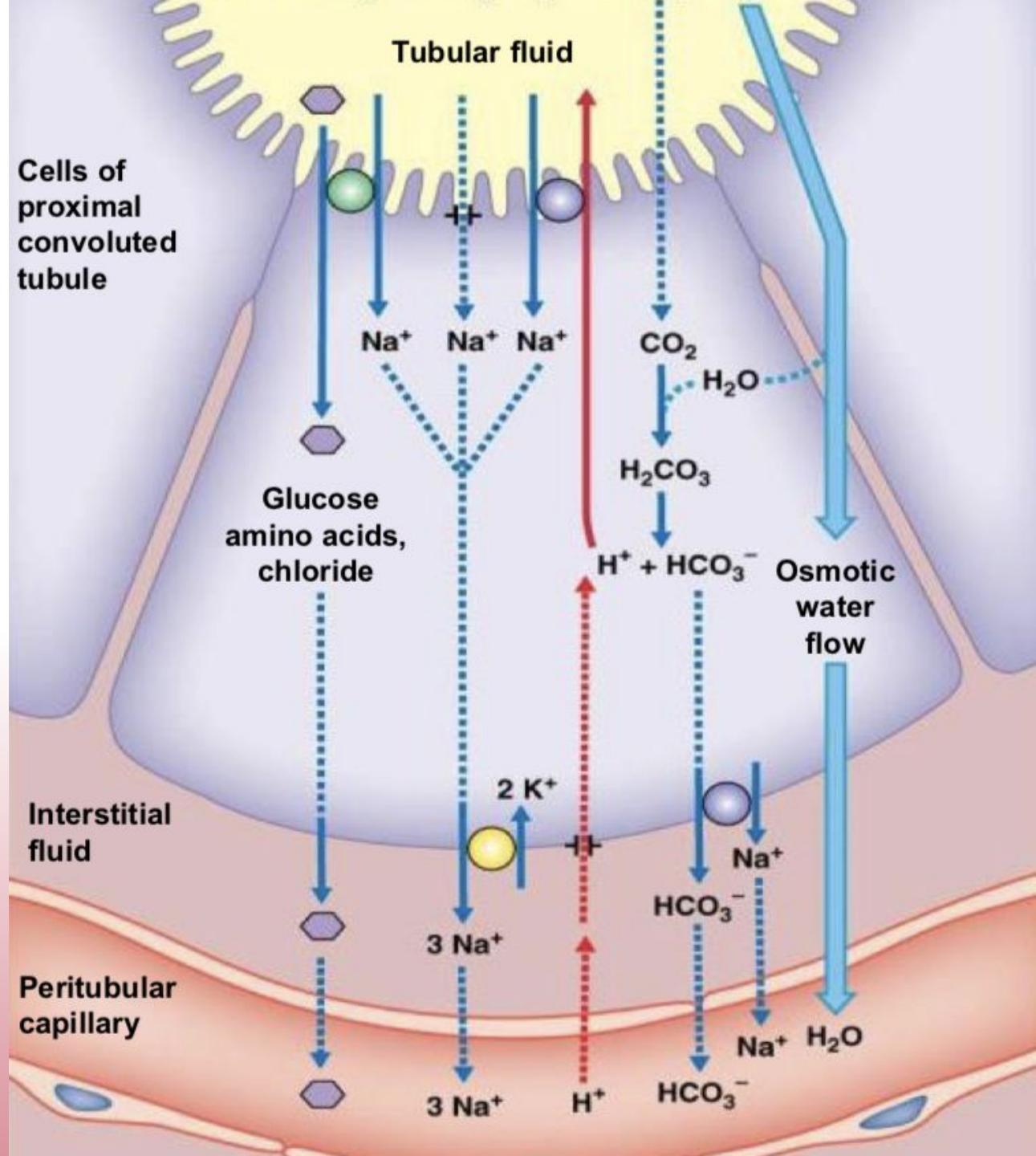
- PCT lined by single layer of **Simple Columnar cells**
- PCT has a brush border of microvilli □ increases contact with tubular fluid
- Loop of Henle □ Thin Descending limb and Thick Ascending limb
- Thin descending limb is lined by **simple squamous** whilst thick ascending lined by **simple cuboidal**
- DCT has Macula Densa inside

PCT MOVEMENT

- Na^+ and $HCO3^-$ from tubule lumen □ blood

and H^+ from blood to tubular fluid

- Na^+ transported via glucose co-transport (**SGLT**), Na^+/H^+ antiporter and Na^+/K^+ pump by active transport



LOOP OF HENLE

- Descending Limb:
  - Permeable to water, impermeable to salt
  - Osmotic potential of blood increases as you go along (solute conc. increases)
- Ascending Limb:
  - Impermeable to water, permeable to salt
  - Vasa Recta next to Ascending limb has lower osmotic pressure
  - NaCl → capillaries down gradient, small amount of Na^+ moved via active transport (K^+ exchange)

DCT AND COLLECTING DUCT

- Aldosterone stimulates cells in the DCT to reabsorb more Na^+ and secrete more K^+ into the tubular fluid
- Macula Densa senses Na^+ conc
- Juxtaglomerular cells secrete Renin (an enzyme that cleaves Angiotensinogen into Angiotensin I) in response to this

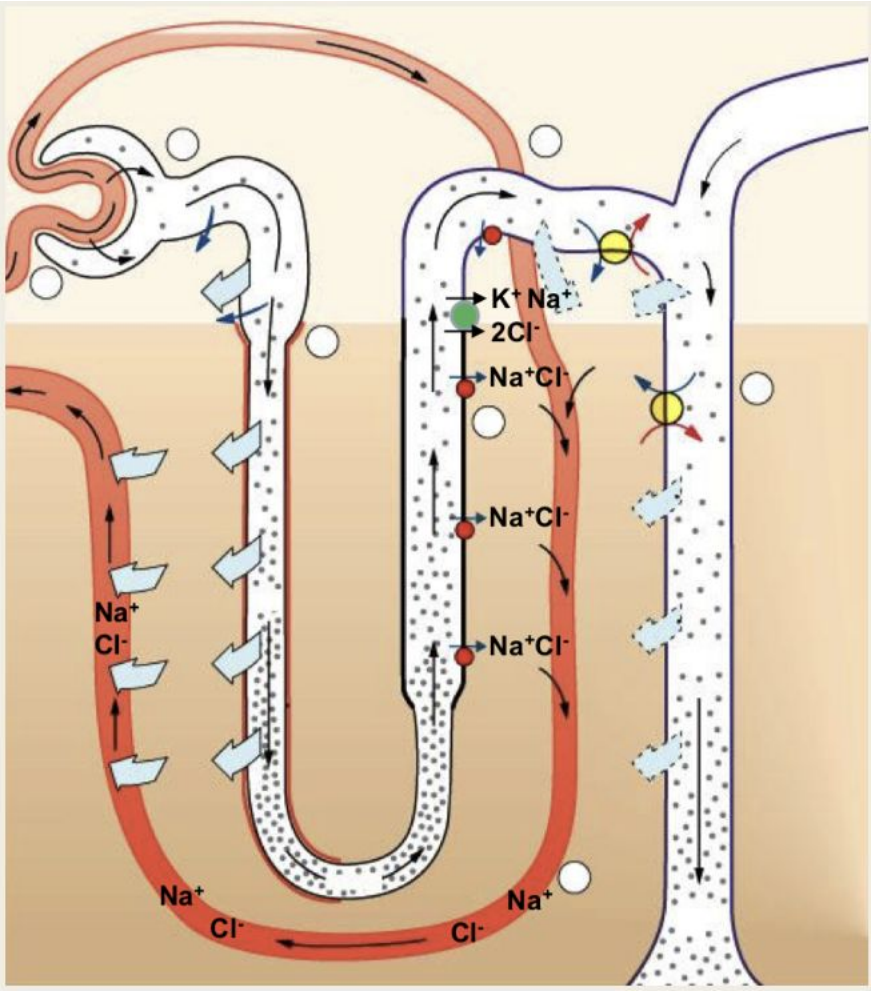
Na^+ absorption

- 65% in PCT
- 25% in Thick ascending limb of Loop of Henle
- 10% in DCT

COUNTER-CURRENT MULTIPLIER

- Blood first passes ascending limb where the blood has low Na+ conc.
- Over here Na+ Cl- move from filtrate □ interstitial space □ blood
- Water can't leave here
- As you go down vessel, salt concentration increases
- Blood passing descending limb has high Na+ conc. And since descending limb is permeable to water, water moves into the circulating blood from filtrate
- **Pathology:**

  - if glucose or protein is present in tubular filtrate, it affects osmotic potential by increasing it.
  - reduced Na+ reabsorption and increased filtrate flow rate



MICTURITION

- Internal and external urethral muscles relax
- The detrusor muscle contracts and urine passes from the bladder and out of the body via the urethra
- Parasympathetic fibres originate as the pelvic splanchnic nerves from S2-S4 stimulate contraction of the detrusor muscle and inhibit the internal urethral sphincter (sphincter vesicae) allowing passage for urine
- Sympathetic fibres originate in L1-L2, descending via the hypogastric plexuses - stimulate closure of the sphincter vesicae
- Somatic fibres control external sphincter through the pudendal nerve S2-S4

GFR

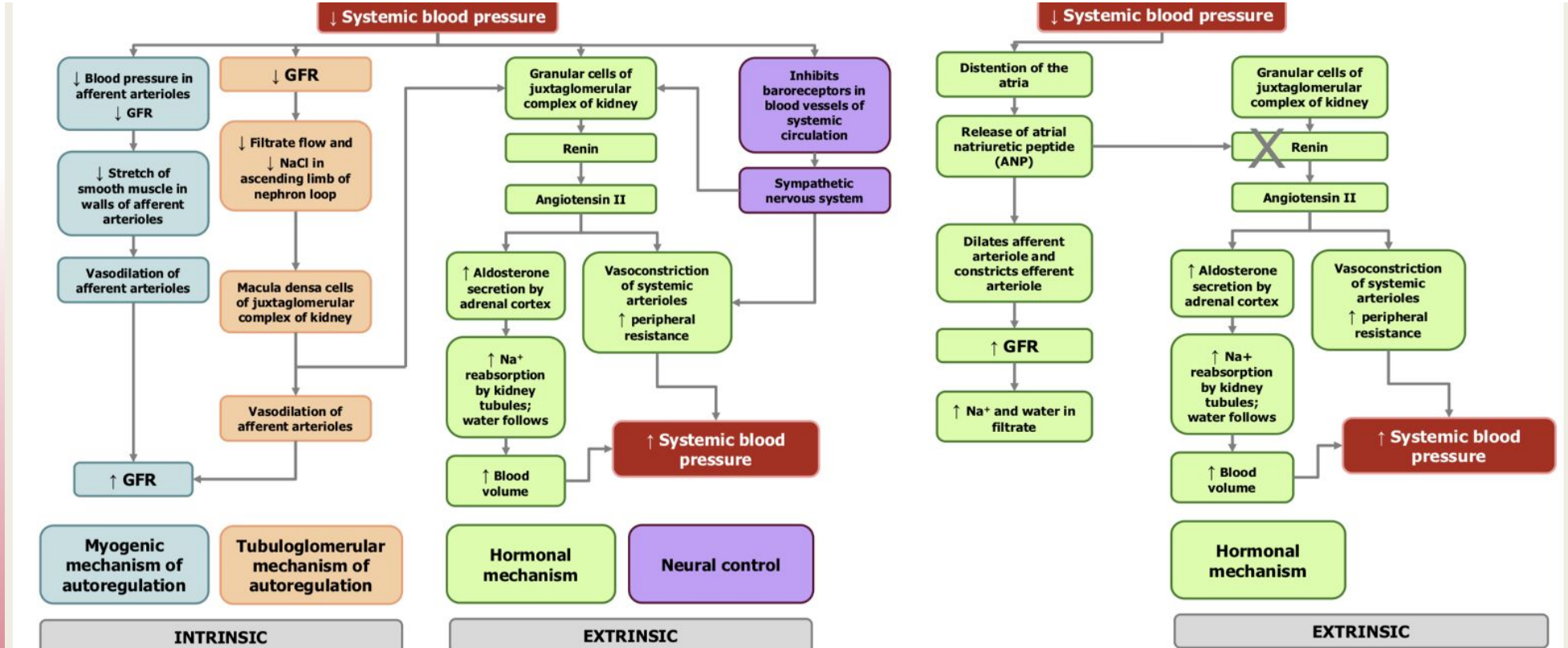
- The amount of fluid passing from the blood, across the basement membrane, into the Bowman's Space (millilitres per minute into the glomerular filtrate)
- Outside extremities (for example changes in blood pressure) do not affect the GFR due to autoregulation)
- Normal filtration rate is 125 mL/min
- RPF = Renal plasma flow
- Amount of blood PLASMA that flows through glomerulus per min
- Normally 625 mL/min
- FF = Filtration fraction
- FF = GFR/RPF
- Usually 125/625 = 20%

HOW GFR IS CALCULATED

- Can be calculated when the substance being measured to calculate GFR is filtered freely, not secreted or reabsorbed, not toxic or not metabolised
- Creatinine is used (metabolite of creatine) but it is secreted by kidney epithelial cells in low amounts – generally used as easier to measure
- Due to compensatory nature of kidneys, serum creatinine levels may remain normal until about a reduction of 50% in GFR
- Inulin (a polysaccharide) is probably the most effective choice but is added intravenously as it is infused at a steady state (more expensive and less convenient)
- As small amounts of creatinine are secreted, clearance is not equal to GFR but a close estimate
- Inulin clearance = GFR

GFR AUTOREGULATION

- Myogenic mechanism □ regulates afferent and efferent arteriole constriction and most rapid response to alter GFR
- Neural control □ constricts vessels to elevate blood pressure and also redirect blood, also very rapid
- Tubuloglomerular □ Macula Densa sense Na+ conc, signals to juxtaglomerular cells to secrete Renin if Na+ conc low
  - **Drop in blood pressure means more Na+ absorbed at PCT**
- Hormonal □ slow response



MYOGENIC AUTOREGULATION OF GFR

- As BP increases GFR increases
- However, stretching occurs in the smooth muscle fibres of afferent arteriole
- In response – smooth muscle contacts narrowing the arteriole lumen
- (For low BP the efferent arteriole contracts)

TUBULOGLOMERULAR AUTOREGULATION OF GFR

- The macula densa (area of closely packed specialized cells lining the wall of the distal convoluted tubule) detects a rise in systemic BP
- This is accomplished by detecting a greater concentration of Na^+ and Cl^- in the filtration fluid – as there is less time for the fluid to be absorbed by tubule
- Macula densa cells inhibit the release of nitric oxide (NO) from cells in the juxtaglomerular cells (which would cause vasodilation)

HORMONAL REGULATION OF GFR

- Angiotensin 2 – a potent vasoconstrictor narrows afferent and efferent arterioles – reducing renal blood flow and as a result – reducing GFR
- Atrial Natriuretic Peptide (ANP) triggers the relaxation of the glomerular mesangial cells – increasing capillary SA and hence increasing renal blood flow and GFR

NEURAL REGULATION OF GFR

- Baroreceptors in the carotid body and the arch of the aorta detect high blood pressure – sends signal to medulla
- The medulla sends a signal via sympathetic fibres to the kidneys to secrete noradrenaline – which are detected by alpha-1 receptors of smooth muscle
- Causes vasoconstriction of afferent arteriole to maintain GFR