URINE FORMATION PART 2

E-MODULE

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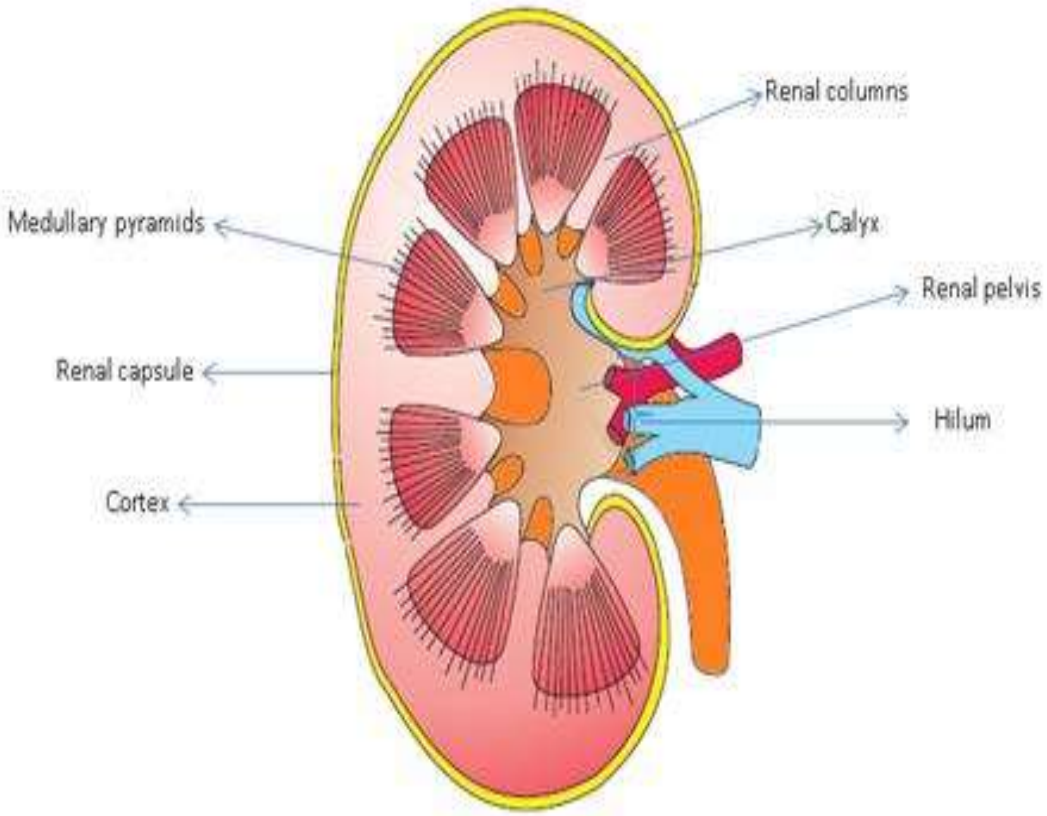
ZOOLOGY DEPTT.

URINE FORMATION PART 2

- Substances like glucose, amino acids, salts and good amount of water, are selectively re-absorbed as the urine flows along the tubular part of nephron.
- The amount of water absorbed depends upon the amount of wastes in the body & the amount of excess water in the body.
- Urine passes through the ureters to the urinary Bladder.
- Gets collected in Urinary bladder till the pressure increases.
- Finally passed out through the urethra.

STRUCTURE OF KIDNEY

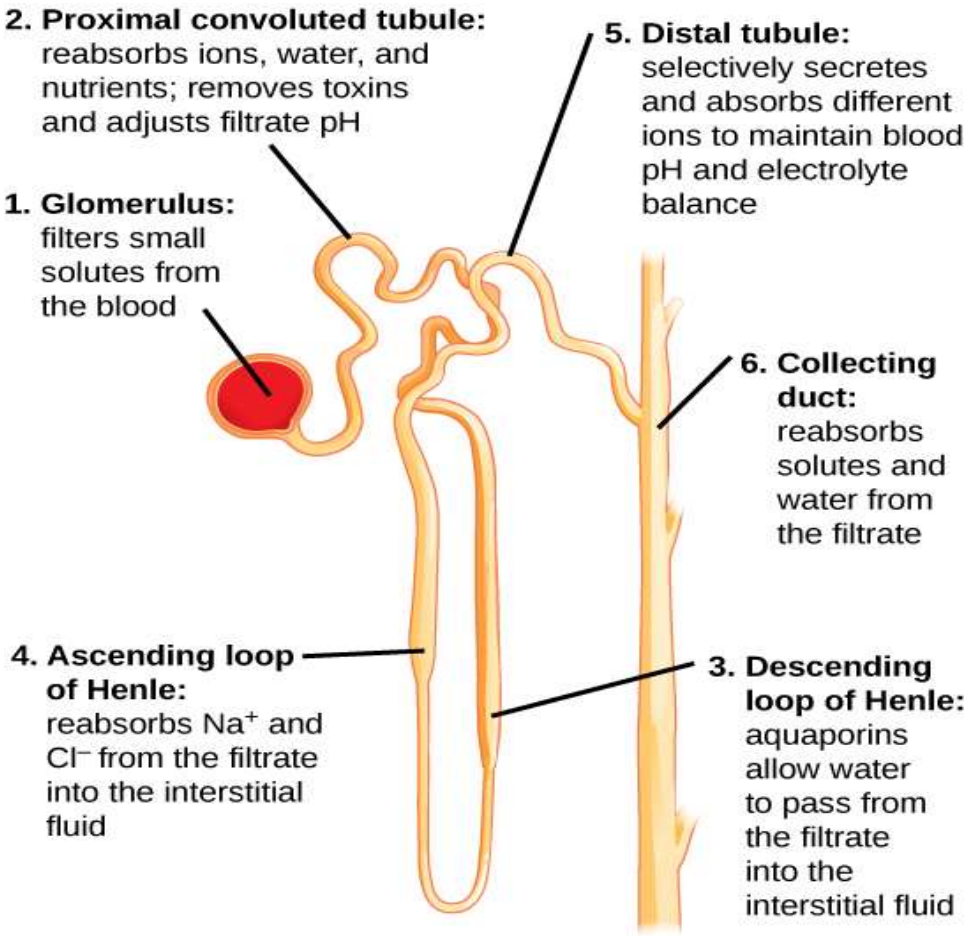


STRUCTURE OF KIDNEY

- Zones of kidney: **Cortex and Medulla**

- **Hilum** is the centre of the of kidney and ureter, blood vessels & nerves enter the kidney here.
- **Renal pelvis i**s the funnel-shaped space inside the hilum and receives urine from kidney nephrons.
- **Calyx P**rojections of the Renal pelvis are small hollow tubes to collect urine.
- **Minor calyces** merge to form major calyces which in turn form the hollow renal pelvis.
- **Renal capsule** is the thin fibrous layer of connective tissue surrounding kidney which ensures protection of inner soft tissues and provides shape to the kidneys

NEPHRON


2. Proximal convoluted tubule: reabsorbs ions, water, and nutrients; removes toxins and adjusts filtrate pH
5. Distal tubule: selectively secretes and absorbs different ions to maintain blood pH and electrolyte balance
1. Glomerulus: filters small solutes from the blood
6. Collecting duct: reabsorbs solutes and water from the filtrate
4. Ascending loop of Henle: reabsorbs Na^+ and Cl^- from the filtrate into the interstitial fluid
3. Descending loop of Henle: aquaporins allow water to pass from the filtrate into the interstitial fluid

TYPES OF NEPHRONS

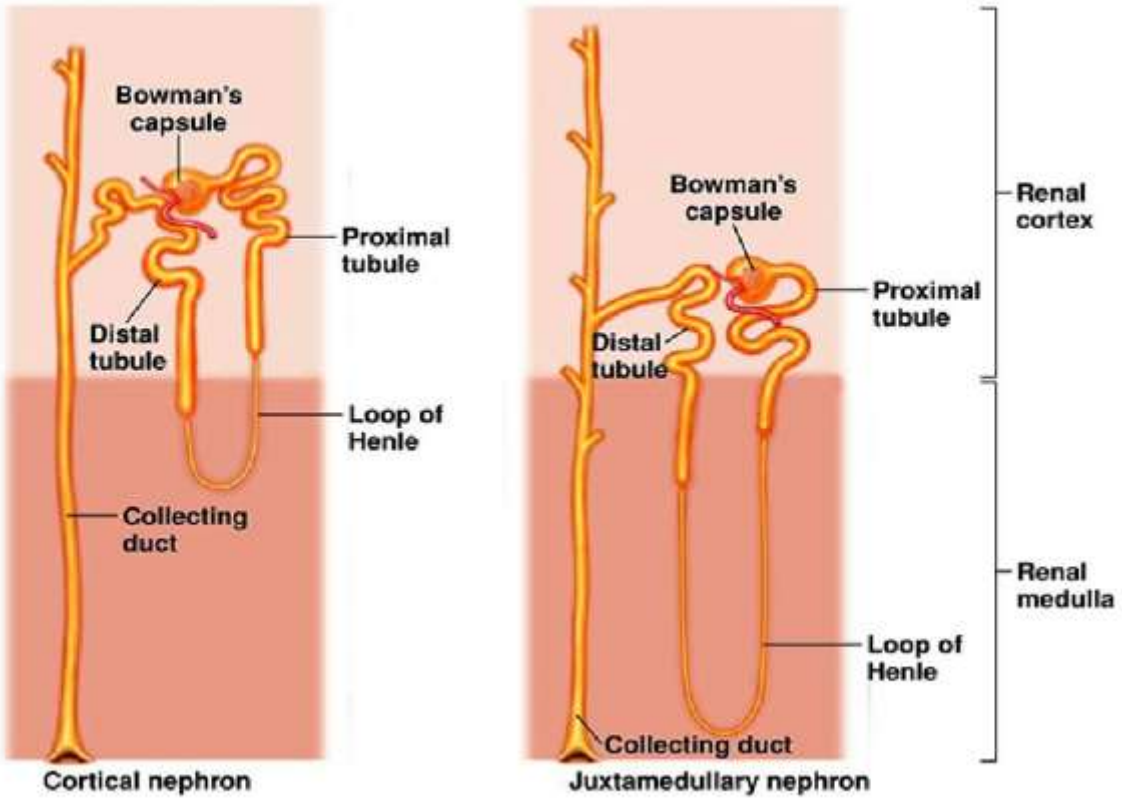
Cortical nephron

- These are the nephrons present within the cortex. These are short and comprise about 80% of the total nephrons.

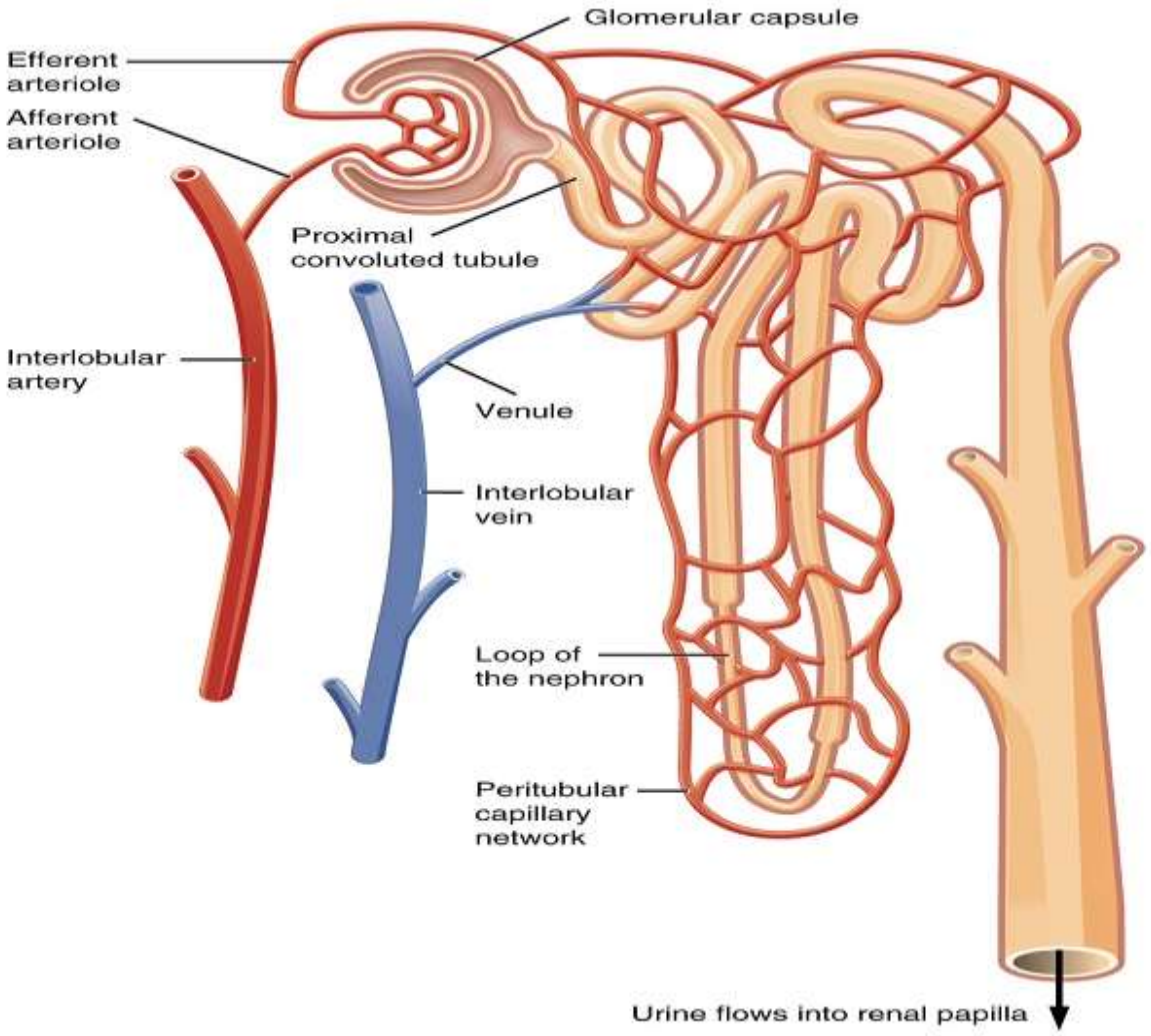
Juxtamedullary nephron

- These have long loops of Henle and extend into the medulla. These are about 20%.

TYPER OF NEPHRONS



NEPHRON AND BLOOD SUPPLY



COUNTER CURRENT MECHANISM

- *The mechanism by which kidneys concentrate urine is called the counter current* mechanism.
- The flow of filtrate in the ascending and descending limbs is in opposite directions of loop of Henle and it is **countercurrent mechanism.**
- As mammals excrete hypertonic urine,countercurrent mechanism helps in conservation of water.

URINE FORMATION

- Although the loops of Henle are essential for concentrating urine, they do not work alone. The specialized blood capillary network (the vasa recta) that surrounds the loops are equally important.
- The vasa recta capillaries are long, thin walled blood vessels are made up of descending and ascending capillary that run parallel to the loops of Henle. These capillaries turn slow the rate of blood flow, which helps maintain the osmotic gradient required for water reabsorption.
- The cells of vasa recta are permeable to ions ,water and urea.

Counter current mechanism

Filtrate flows in opposite direction through the two limbs of Henle's loop and follows a counter current mechanism.

The first thick part of descending limb is impermeable to water,ions and urea.The second thin part of descending limb is permeable to water.

The ascending limb is impermeable to water along its entire length but is permeable to ions(NaCl).

COUNTERCURRENT MECHANISM

- Both cortical and juxtamedullary nephrons regulate the concentrations of solutes and water in the blood.

  Fluid leaving the ascending limb of the loop of Henle enters the distal convoluted tubule and then drains into collecting tubules.
- These tubules empty into collecting ducts that descend back through the medulla,and eventually connect to the ureter, which transports urine to the bladder.

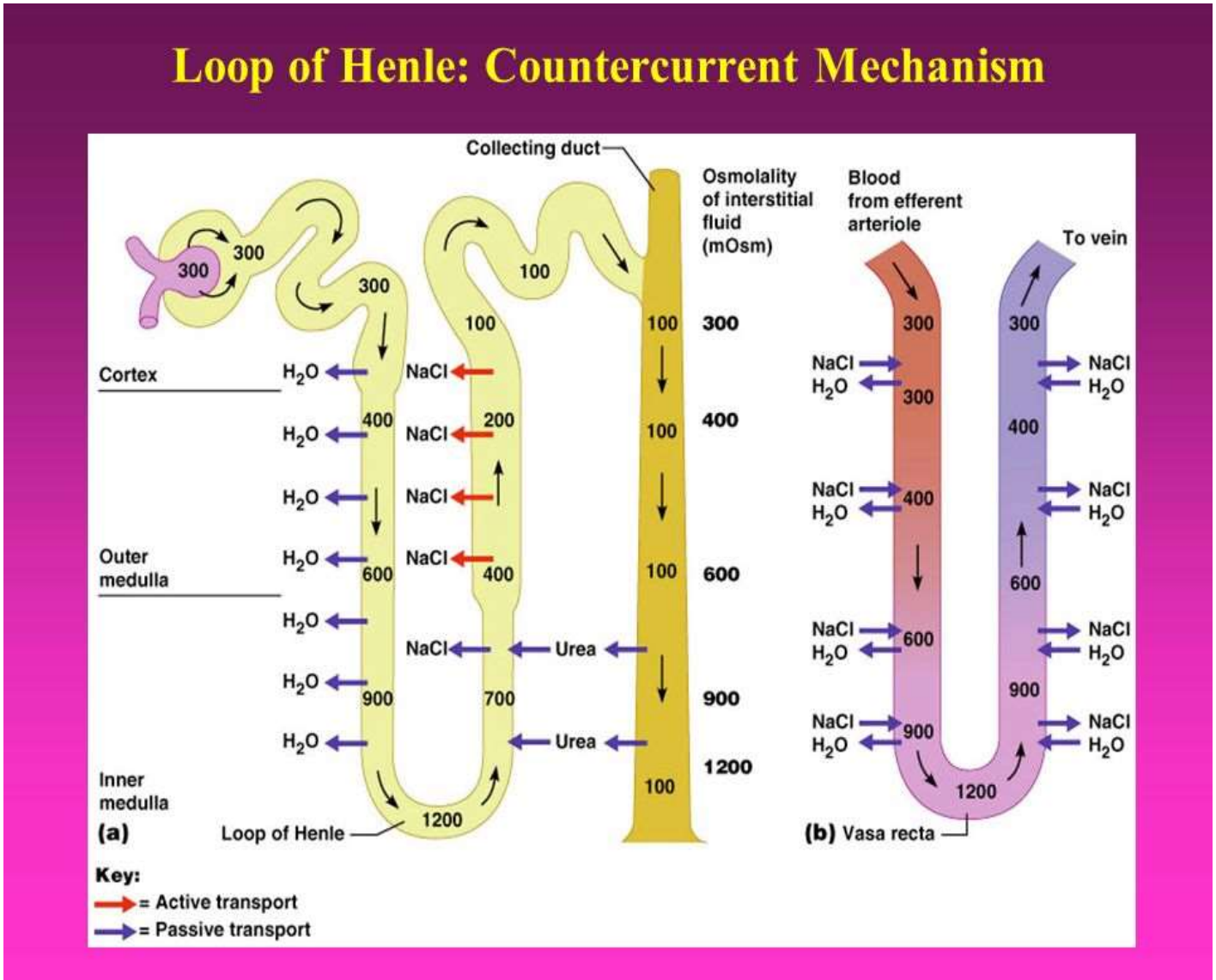
COUNTERCURRENT MECHANISM

- The short wide part of descending limb is impermeable to water,urea and ions and the *thin descending* limb is passively permeable to both water and small solutes such as sodium chloride and urea.
- As the filtrate passes through the ascending limb it looses NaCl by diffusion in narrow region and Na and Cl by active transport in wide region in the interstitial fluid.
- The increased conc. of solutes in interstitial fluid draws out water by osmosis from narrow region of descending limb and also from collecting duct as both are permeable to water.
- The water is then immediately enters vasa recta and is carried away.
- As such, water moves out of the tubular fluid and solutes to move in. This means, the tubular fluid becomes steadily more concentrated or hyperosmotic (compared to blood) as it travels down the thin descending limb of the tubule.

COUNTERCURRENT MECHANISM

- Vasa recta is permeable to ions ,water and urea.As blood flows through narrow descending capillary of vasa recta towards renal medulla ,water is drawn from blood plasma by diffusion.
- As blood flows in wide ascending capillary towards renal cortex,reverse occurs i.e water renters plasma and ions,urea leave.
- The countercurrent exchange in vasa recta a)prevents loss of Na and Cl ions from renal medulla b)helps in maintaining concentration gradient in renal medulla and therefore help in concentrating the urine by the loop of Henle.

COUNTERCURRENT MECHANISM



COUNTERCURRENT MECHANISM

- The *thick ascending* limb is passively permeable to small solutes, but impermeable to water, which means water cannot escape from this part of the loop.
- As a result, solutes move out of the tubular fluid, but water is retained and the tubular fluid becomes steadily more dilute as it moves up the ascending limb of the tubule.

COUNTERCURRENT MECHANISM

- The *thick ascending* limb actively reabsorbs Na,K and Cl ions. It is also impermeable to water, so water cannot escape from this part of the loop. This segment is also called diluting segment.

COUNTERCURRENT MECHANISM

- Countercurrent multiplication moves sodium chloride from the tubular fluid into the interstitial space deep within the kidneys.
- Although in reality it is a continual process, the way the countercurrent multiplication process builds up an osmotic gradient in the interstitial fluid can be thought of in two steps.

COUNTERCURRENT MECHANISM

- *The single effect*. The single effect is driven by active transport of sodium chloride out of the tubular fluid in the thick ascending limb into the interstitial fluid, which becomes hyperosmotic. As a result, water moves passively down its concentration gradient out of the tubular fluid in the descending limb into the interstitial space, until it reaches equilibrium.
- *Fluid flow*. As urine is continually being produced, new tubular fluid enters the descending limb, which pushes the fluid at higher osmolarity down the tube and an osmotic gradient begins to develop.

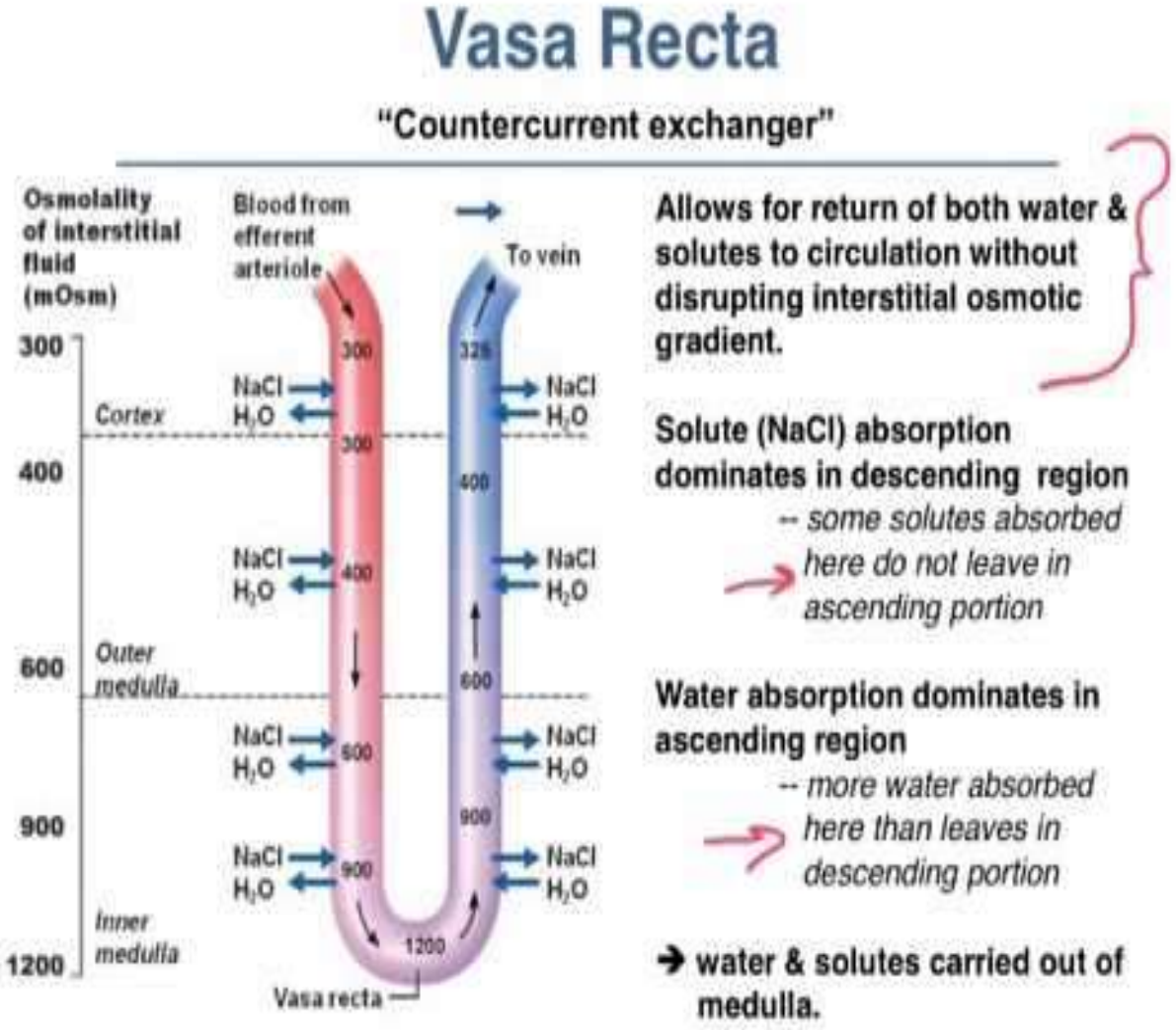
COUNTERCURRENT MECHANISM

- As a result, water moves passively down its concentration gradient out of the tubular fluid in the descending limb into the interstitial space, until it reaches equilibrium.
- As the fluid continues to move through the loop of Henle, these two steps are repeated again and again causing the osmotic gradient to steadily multiply until it reaches a steady state.
- The length of the loop of Henle determines the size of the gradient - the longer the loop, the greater the osmotic gradient.

COUNTERCURRENT MECHANISM

- Absorbed water is returned to the circulatory system via the vasa recta, which surrounds the tips of the loops of Henle.
- Because the blood flow through these capillaries is very slow, any solutes that are reabsorbed into the bloodstream have time to diffuse back into the interstitial fluid, which maintains the solute concentration gradient in the medulla.
- This passive process is known as countercurrent exchange.

COUNTERCURRENT EXCHANGER



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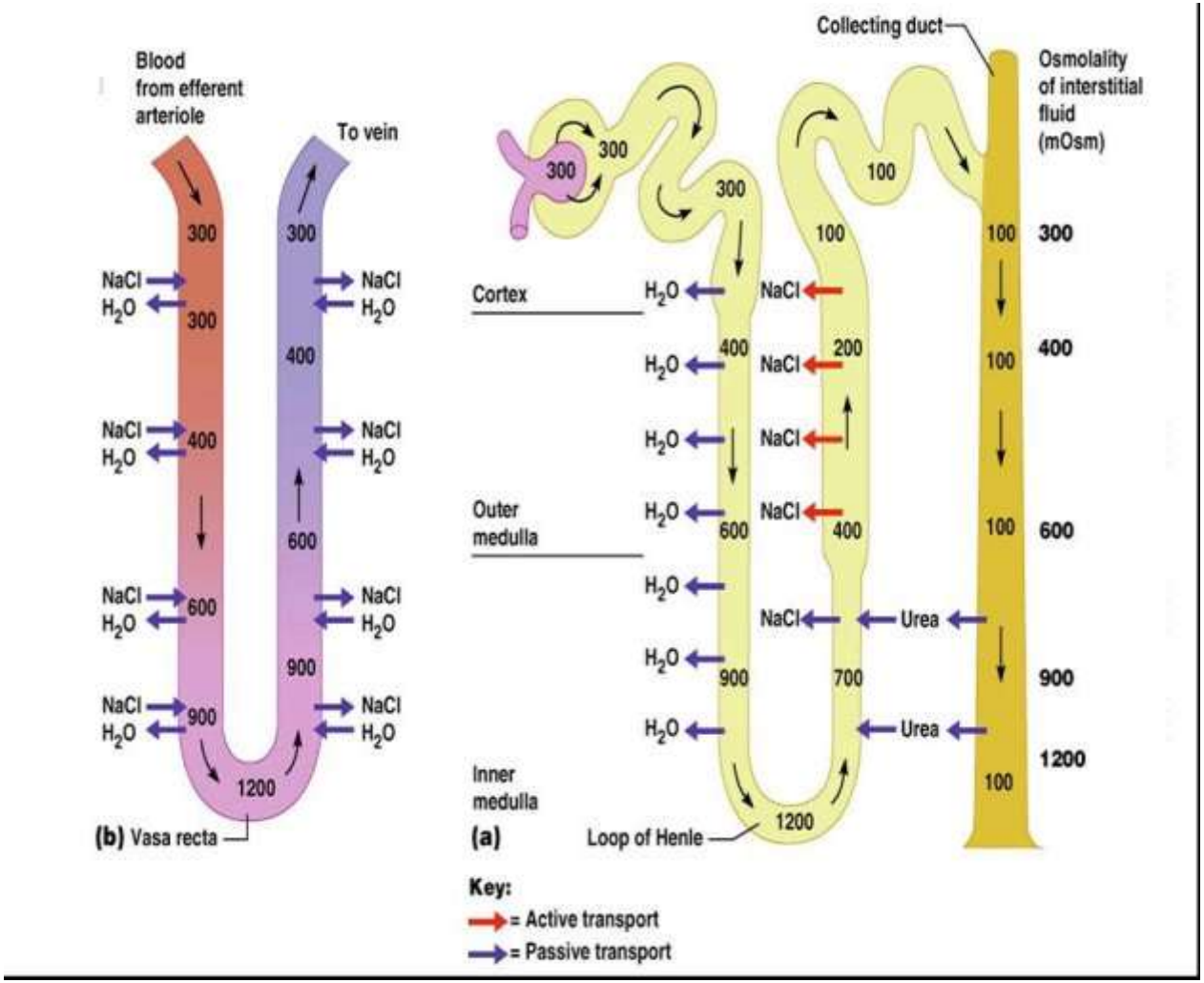

SUMMARY OF COUNTERCURRENT MECHANISM

NaCl is transported from the ascending limb of the Henle's loop to the descending limb of the vasa recta.

- The ascending limb of the vasa recta, in turn, transports NaCl to the interstitial fluid (the tissue fluid between the loop of Henle and the vasa recta). Thus, a concentration gradient is generated.
- Urea contributes to this process by being transported by the descending limb of the loop of Henle to the interstitial fluid.
- As urine flows downwards in the collecting tubule, it encounters higher and higher concentrations of solutes in the interstitial fluid,so it goes on losing water due to osmosis. This is how urine is concentrated.

OSMORGULATION

- The water and solute concentration of body are controlled by kidneys and this function is called osmoregulation
- It is brought about by movement of water and sodium ions into and out of the nephron under influence of certain hormones..
- A)water
- B)Na

REGULATION OF WATER BALANCE

- The kidneys are able to control the reabsorption of water and solutes in the loop of Henle, distal nephron and collecting ducts. This means urine can be made more concentrated or more dilute than plasma, depending upon the level of hydration.
- This process is mainly controlled by antidiuretic hormone(ADH), a hormone that is made in the hypothalamus of the brain and stored in the pituitary gland.
- The release of antidiuretic hormone by the pituitary gland is controlled by sensors in your heart and blood vessels that detect drops in blood pressure, or increased concentrations of salt in your bloodstream that may occur when dehydration occurs.

REGULATION OF WATER BALANCE

- The concentration of urine is controlled by ADH hormone, which helps the kidneys to conserve water.ADH is released when short fall of water occurs in plasma.
- Its main effects in the renal tubules is to increase water permeability in the distal convoluted tubule and collecting ducts, increase active transport of sodium chloride in the thick ascending limb of the loop of Henle, and thereby enhance the countercurrent multiplication and urea recycling.
- Release of ADH is inhibited whenplasma has enough water in it.Walls of DCT and collecting duct become impermeable to water.so less water is absorbed and dilute urine is produced.

REGULATION OF WATER BALANCE

Urea recycling in the inner medulla also contributes to the osmotic gradient generated by the loops of Henle.

ADH hormone increases permeability of collecting duct to urea which diffuses from urine into interstitial fluid in the medulla to concentrate in the tubular fluid in this segment.

So,In the inner medullary collecting ducts it increases both water and urea permeability, which allows urea to flow passively down its concentration gradient into the interstitial fluid. This adds to the osmotic gradient and helps drive water reabsorption.

CONTROL OF BLOOD SODIUM LEVEL

- The hormone Aldosterone from adrenal cortex makes wall of DCT and collecting duct permeable to ions,thereby causing uptake of sodium ions from the filtrate into peritubular capillaries.This leads to equivalent uptake of water .In the absence of ADH,walls of DCT and collecting ducts remain impermeable to ions.

REGULATION OF BLOOD pH

- DCT also helps in maintaining plasma pH.It secretes Hydrogen ions into filtrate and retains HCO_3 (hydrogen carbonate ions) if pH falls and secretes HCO_3 and retains H ions if Ph rises.

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