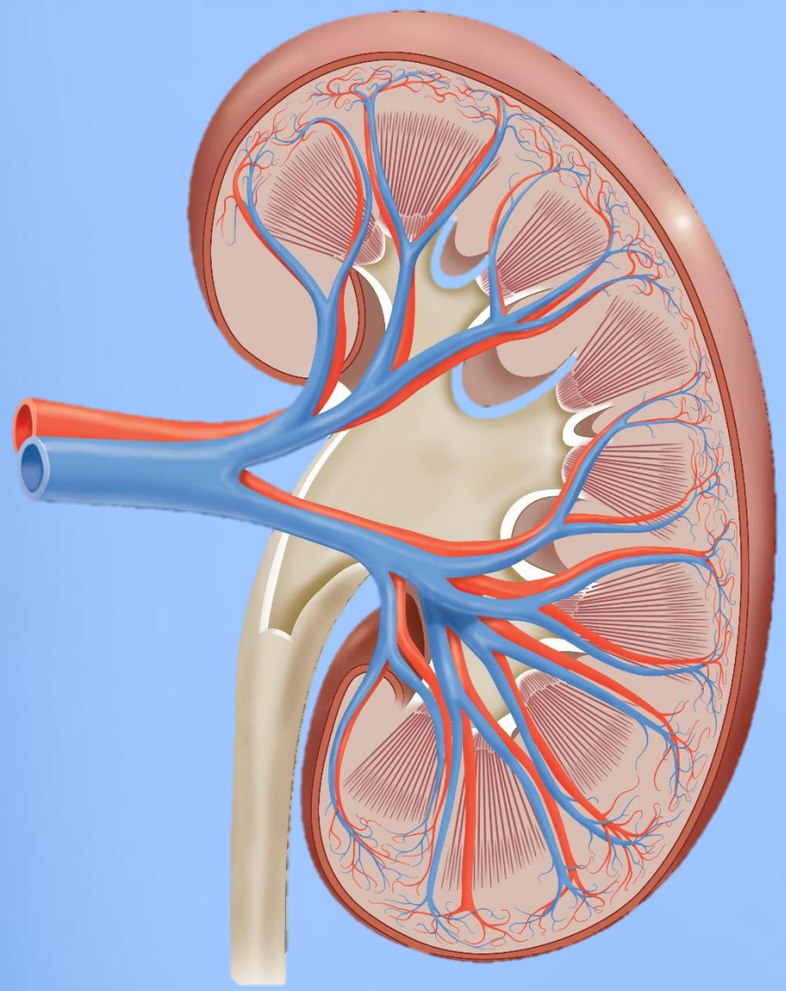
URINE CONCENTRATION MECHANISMS



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Renal Block

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OBJECTIVES

- The loop of Henle is referred to as countercurrent multiplier and vasa recta as countercurrent exchange systems in concentrating and diluting urine.
- Explain what happens to osmolarity of tubular fluid in the various segments of the loop of Henle when concentrated urine is being produced.
- Explain the factors that determine the ability of loop of Henle to make a concentrated medullary gradient.
- Differentiate between water diuresis and osmotic diuresis.
- Appreciate clinical correlates of diabetes mellitus and diabetes insipidus.

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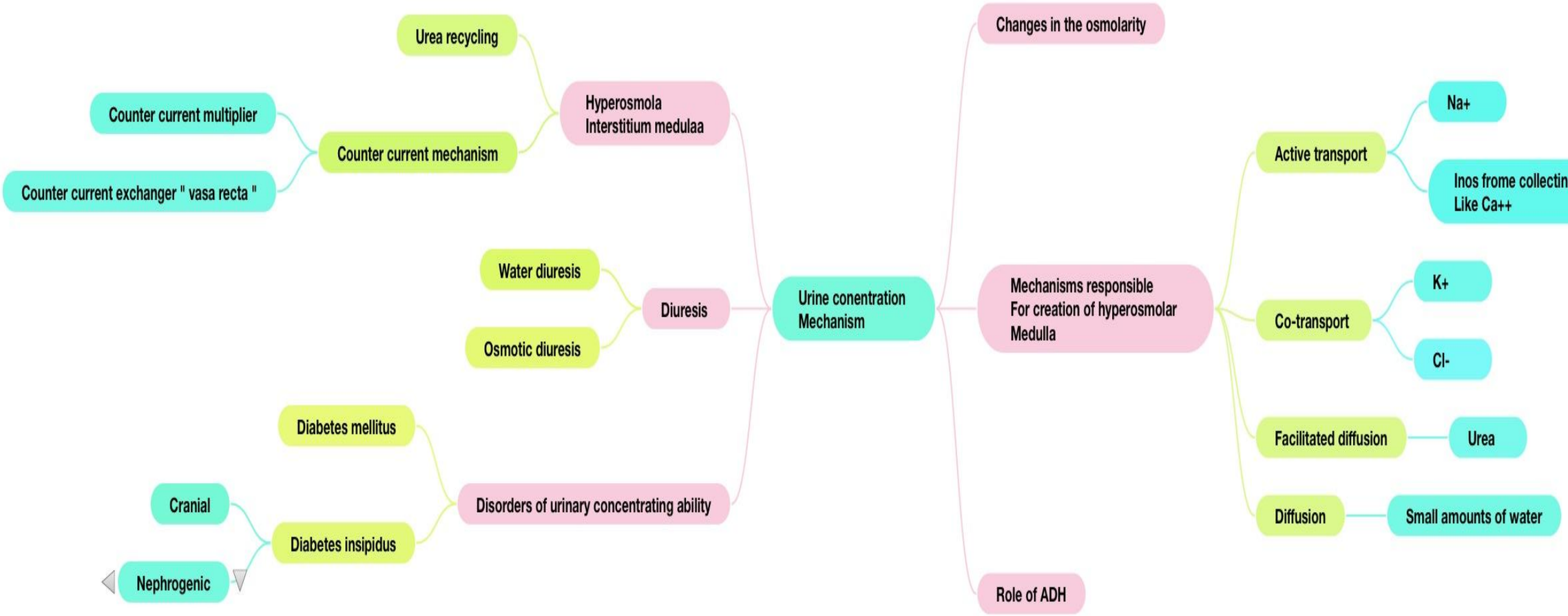
MIND MAP



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The total body water is controled by :

- Fluid intake
- Renal excretion of water
  - Antidiuretic hormone
  - Hyperosmolar medullary interstitium

Changes in the osmolarity of tubular fluid :

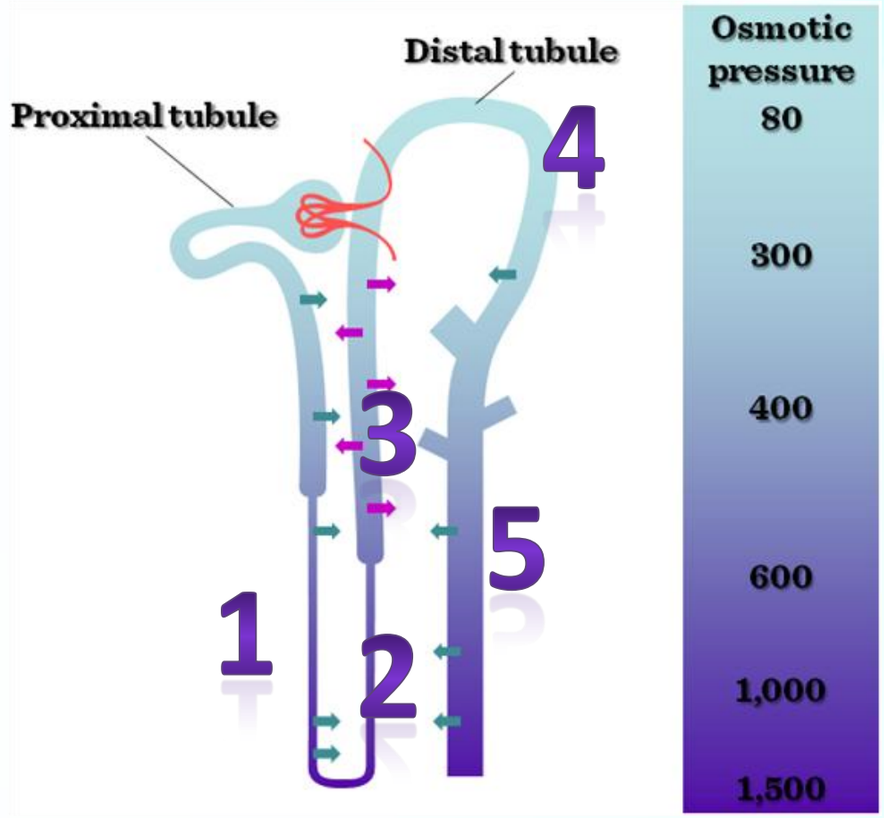
1 — High osmolarity because of the reabsorbation of water

2 — The osmolarity decrease as it goes up because of the reabsorption of NaCl

3 — Low osmolarity because of active transport of Na+ and co-transport of K+ and Cl-

4 — Low osmolarity because of reabsorption of NaCl , also reabsorption of water in present of ADH

5 — High osmolarity because of reabsorption of water in present of ADH , reabsorption of urea



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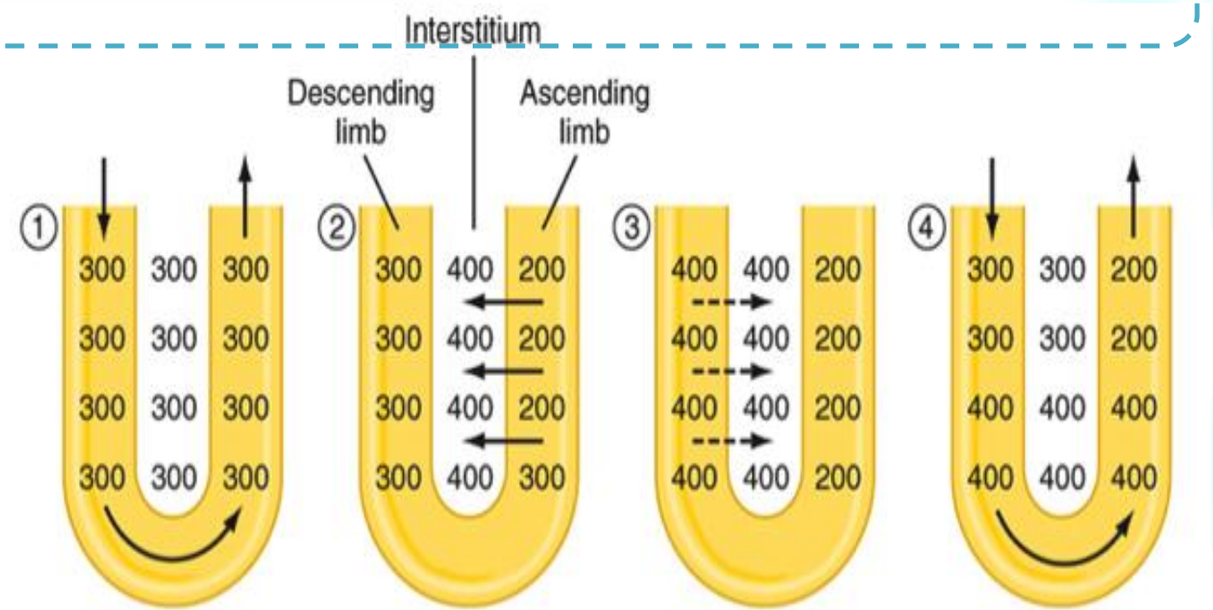
Mechanisms responsible for creation of hyperosmolar medulla:

Active transport :	Co-transport :	Facilitated diffusion :	diffusion of :
Na+ ions out of the thick portion of the ascending limb of the loop of henle into the medullary interstitium Of ions from collecting ducts into medullary interstitium like Ca++	K+ , Cl- and other ions out of the thick portion of the ascending limb of the loop of henle into the medullary interstitium No water diffusion to the medulla	Of urea from the inner medullary collecting ducts into the medullary interstitium	Only of small amounts of water from the medullary tubules into the medullary interstitium less than the reabsorption of solutes in to the medullary interstitium

Step no :	Action :
1	Assume that the loop of henle is filled with a concentration of 300mOsm/L the same as that leaving the proximal tubules
2	The active ion pump of the thick ascending limb on the loop of henle reduces the concentration inside the tubule and raises the interstitial concentration
3	The tubular fluid in the descending limb and the interstitial fluid quickly reaches osmotic equilibrium because of osmosis of water out of the descending limb

Counter current multiplier mechanism



This pump capable to establish only a 200mOsm/L concentration gradient

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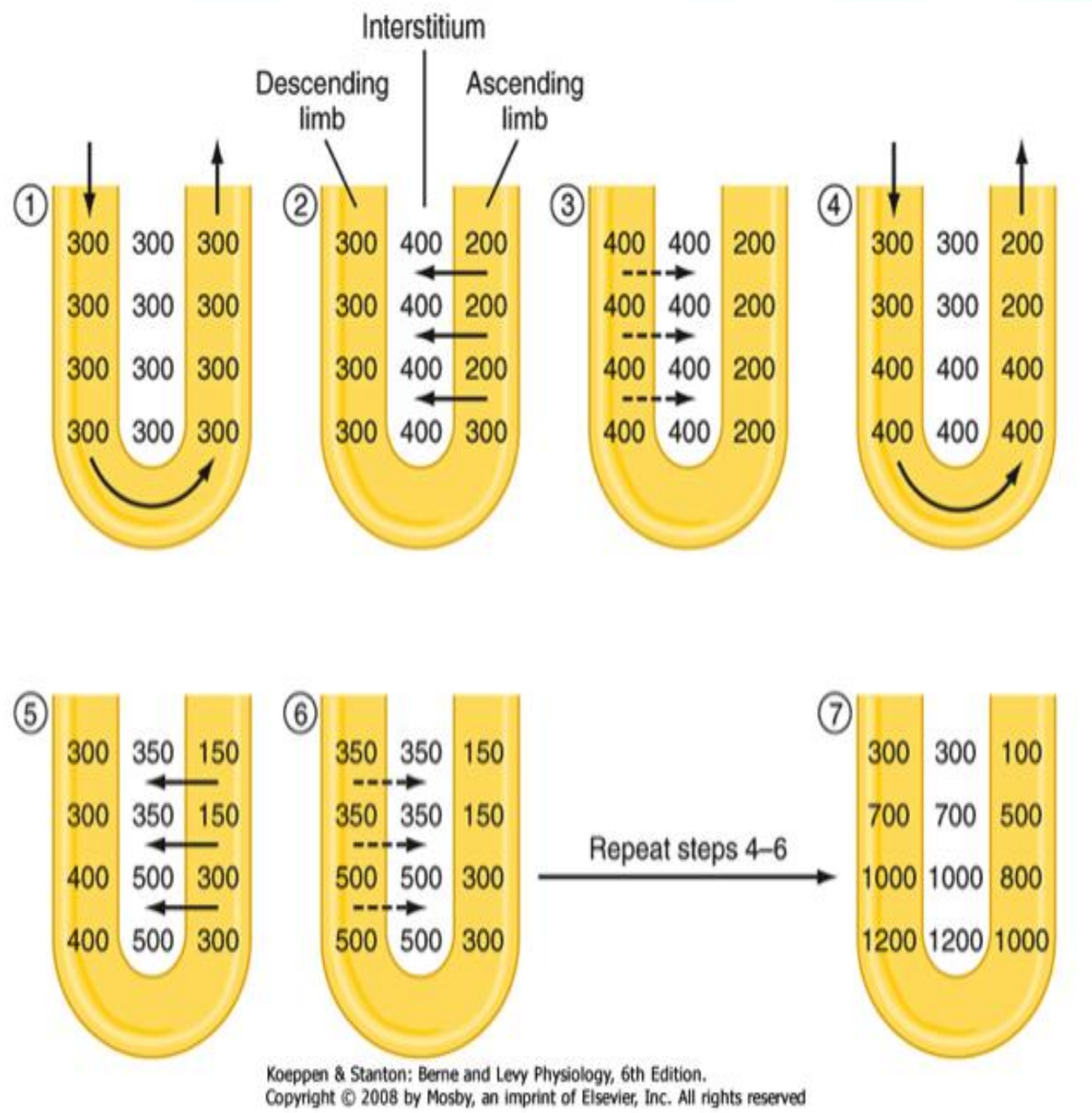
Step no :	Action :
4	Additional flow of the fluid in to the loop of henle from the proximal tubule , which causes the hyper osmotic fluid previously formed in the descending limb to flow into the ascending limb.
5	Additional ions pumped into the interstitium with water remaining in the tubular fluid , until a 200-mOsm/L osmotic gradient is established .
6	Again , the fluid in the descending limb reaches equilibrium with the hyperosmotic medullary interstitial fluid and as the hyperosmotic tubular fluid from the descending limb flows into the ascending limb ,still more solute is continuously pumped out of the tubules and deposited into the medullary interstitium .
7	These steps are repeated over and over , with net effect of adding more and more solute to the medulla in excess of water , with sufficient time, this process gradually traps solutes in the medulla and multiplies the concentration gradient established by the active pumping of ions out of the thick ascending limb , eventually raising the intestitial fluid osmolarity to 1200-1400 mOsm/L .



- Counter current multiplier mechanism helps in creation of hyperosmolar medulla 1200-1400 mOsm/L
- It is maintained by the balanced inflow and outflow of solutes and water in medulla
- In this mechanism the inflow is parallel , close to but opposite to outflow

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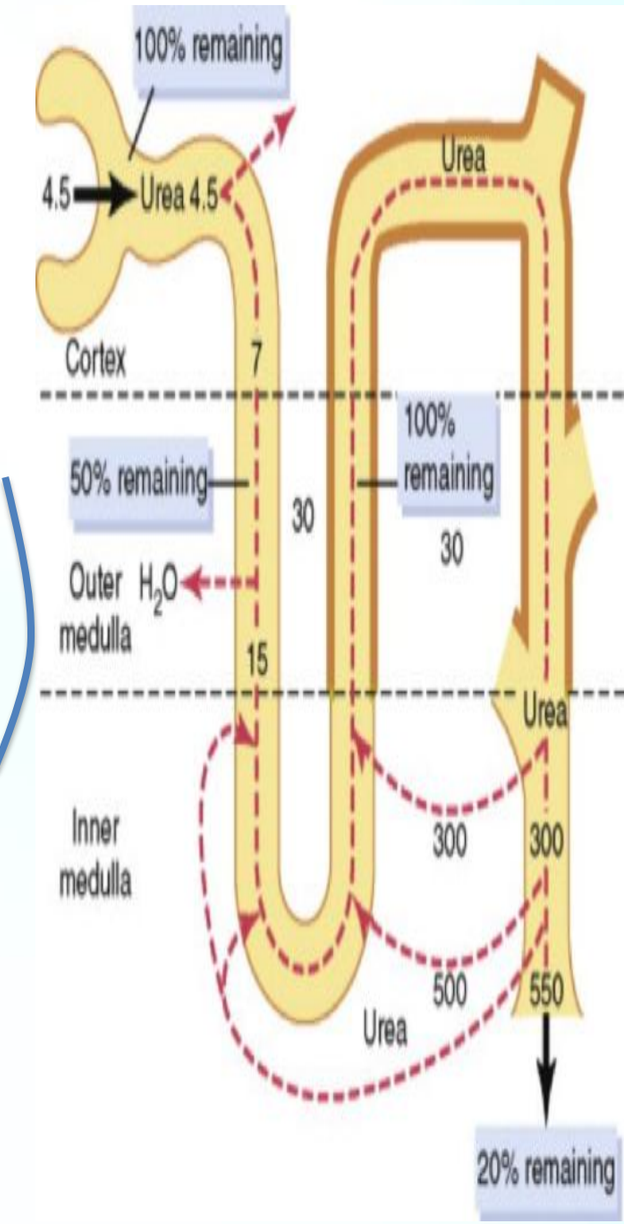
Urea recycling

As the fluid flows from the proximal tubule into the thin segments of the loop of henle urea is more and more concentrated because of water reabsorption out of the descending limb and passive secretion of urea from medullary interstitium in to the thin loops of henle

This urea recirculation provides an additional mechanism for forming a hyper osmotic renal medulla . Because urea is one of the most abundant wastes products that most be excreted by the kidney



The thick limb of the loop of henle , the distal tubule and the cortical collecting tubule are all relatively impermeable to urea → the kidney forms concentrated urine and high levels of ADH → reabsorption of water → urea is more concentrated → as the urea flows intramedullary collecting duct, the high concentration of urea and specific urea transporter causes diffuse of urea in to the medullary interstitium

Moderate share of urea that moves into medullary interstitium eventually diffuses into thin loops of henle passes upward through the ascending limb, distal tubule , cortical collecting tubule and back down into the medullary collecting duct again

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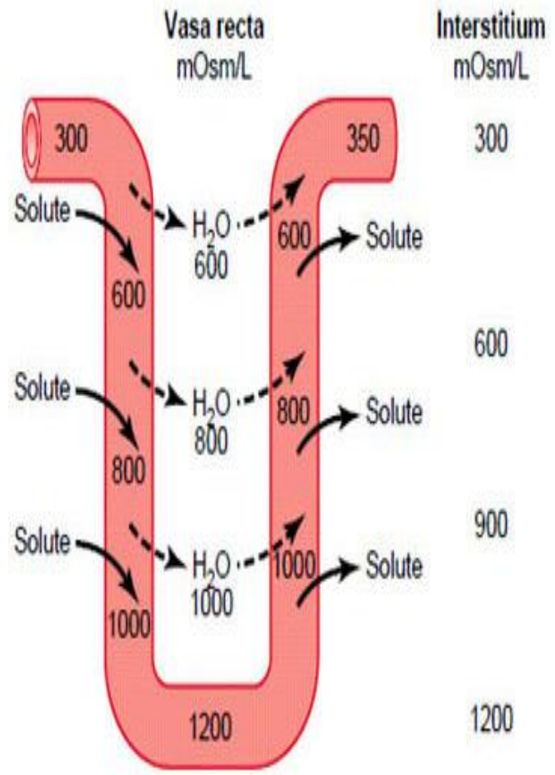
Counter current in exchanger vasa recta

Functoin Maintain the hyperosmolarity of the renal medulla

How it works ?	Descending limb of vasa recta	Ascending limb of vasa recta
	Water pass out into hyperosmolar medulla carrying O_2 and nutrient NaCl will enter the blood increasing its osmolality.	Water will be reabsorbed back to the hyperosmolar blood carrying water, CO_2 and waste product NaCl will leave the blood and become deposited in the medulla

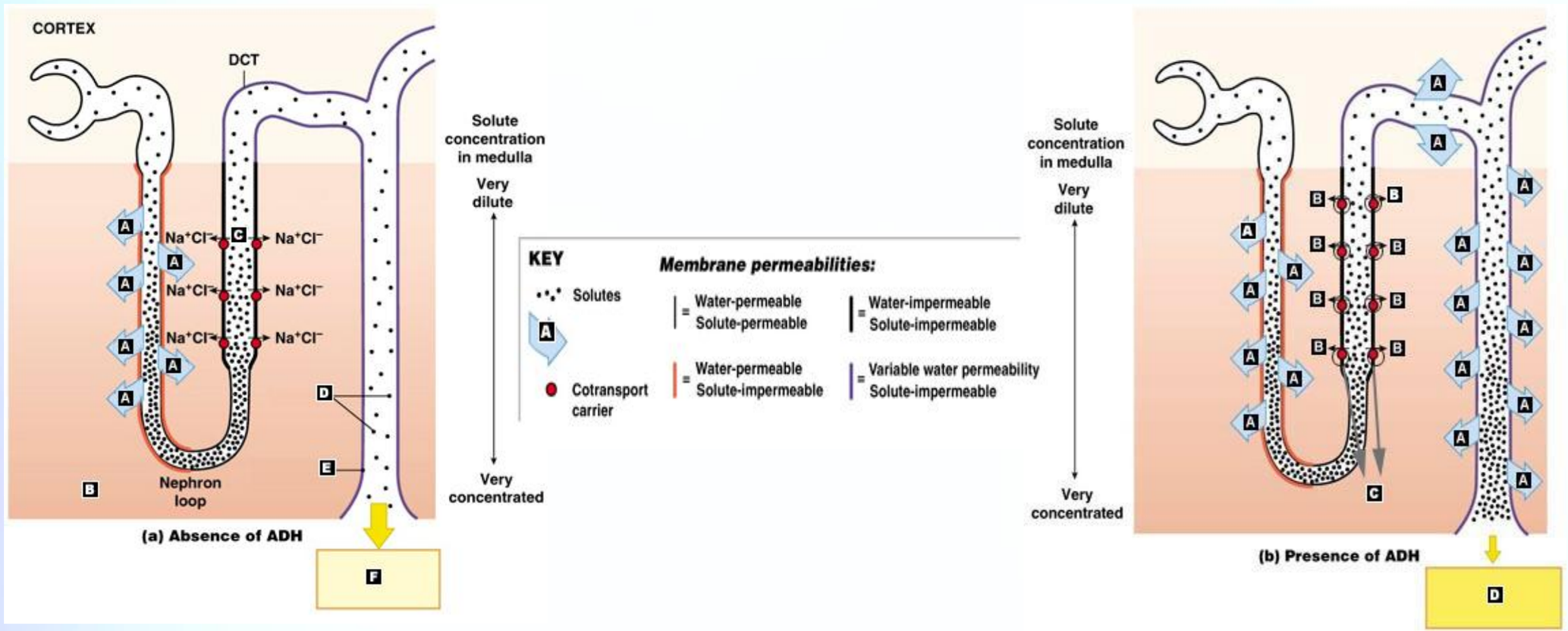


features	The medullary blood flow is slow (1-2% of total renal blood flow) For metabolic demand Helps to minimize solute loss from the medullary interstitium .	Vasa recta serve as counter current exchangers : To minimize washout of solutes from medullary interstitium . This due to U shape of vasa recta .

Role of ADH

Water reabsorbed from collecting duct (by osmosis) is determined by the hormone ADH (anti-diuretic hormone)

1. Osmoreceptors in the hypothalamus detect the low levels of (high water osmolarity)
2. the hypothalamus sends an impulse to the pituitary gland
3. which releases ADH into the bloodstream.
4. ADH makes the wall of the collecting duct more permeable to water.
5. In the present of ADH more water is reabsorbed and less is excreted.



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Diuresis

Is an increase of urine output. It has two types :

Water diuresis:	Osmotic diuresis:
Drinking large quantity of water → dilute ECF→↓ADH→ no water reabsorption in collecting duct→ large of "diluted" urine. volume	**Filtration of excessive osmotic active substances → Drag water with it → Large volume of hyperosmolar "concentrated " urine. Like in diabetic patients we will find an amount of glucose in their urine.**

Disorders of urinary concentrating ability

Diabetes insipidus: is a condition characterized by excessive thirst and excretion of large amounts of severely diluted urine.		Diabetes mellitus:
1/ cranial diabetes inspiduse : Cause : inability to produce or release ADH Urine : low fixed specific gravity (diluted urine) Polyuria Polydypsia	2/ Nephrogenic diabetes insipidus: Cause : inability of kidney to respond to ADH Urine : low fixed specific gravity (diluted urine)	High specific gravity urine (concentrated urine)

SUMMARY

- The kidney can excrete urine as dilute as 50 mOsm/L and as concentrate as high as 1200-1400 mOsm/L depends on water intake .
- The kidney can excrete large volume or small volume of urine without affecting the rate of solute excretion.
- Counter current multiplier mechanism is a function of the loops of henle . Its role in formation of the hyperosmotic medula .
- Urea recycling frome the inner medullary collecting duts is the process that contributes to establishment of hyperosmotic medulla .
- Counter current exchanger " vasa recta " is for blood supplying to the medulla and for maintaining hyperosmolar medulla.
- Vasa recta has two main features :

•Slow blood flow

•The vasa recta act as a counter current exchanger to minimize washout of solutes from the medullary interstitium. This is due to the U shape of vasa recta capillaries.

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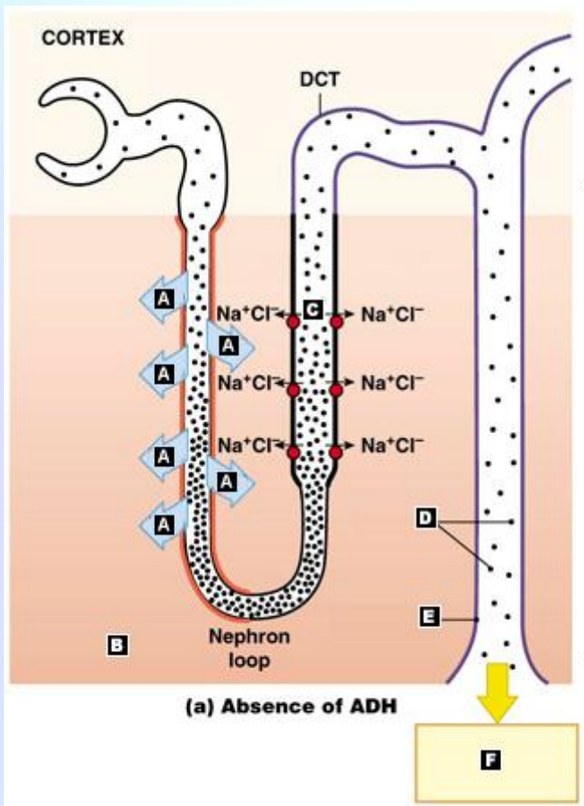
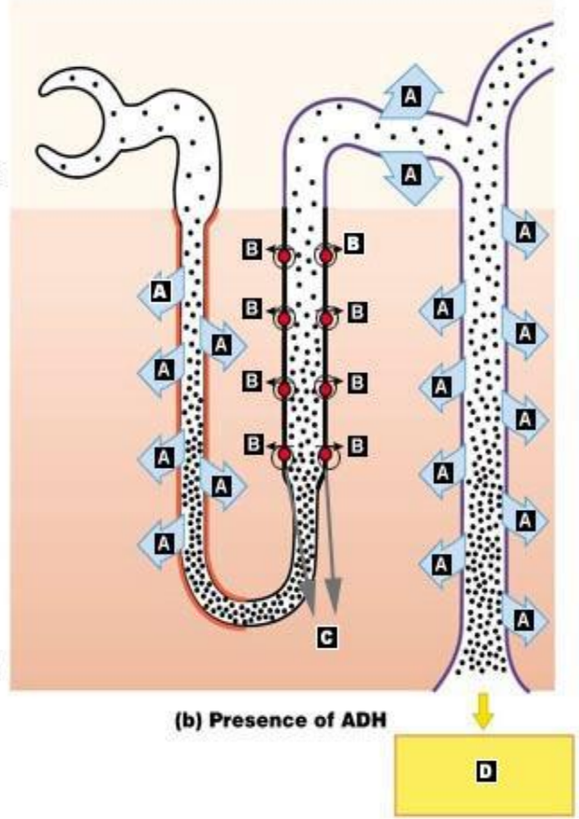
SUMMARY

- There is a powerful feedback system for regulating plasma osmolarity and sodium concentration that operates by altering renal excretion of water independently of the rate of solute excretion. A primary effector of this feedback is antidiuretic hormone (ADH), also called vasopressin.
- Tha mian difference between water diuresis and osmotic diuresis is the concentration of the urine .
- **Water diuresis : diluted urine**
- **Osmotic diuresis : concentrated urine**

Role of ADH





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MCQS

Q1.When the water concentration in body fluids increases the secretion of ADH increases. A. T B. F	Q4.The ADH promotes water reabsorption through the walls of the: A. Thick Ascending limb of loop of Henle. B. Distal convoluted tubule and collecting duct. C. Vasa recta.	Ans: 1.B 2.A 3.A 4.B 5.C 6. B
Q2.The countercurrent mechanism takes place in: A. Juxtamedullary nephron B. Cortical nephrone C. Both.	Q5.Which one of the following produces the hyperosmotic Medullary interstitium? A. NaCl reabsorbed from the thick ascending limb of loop of henle to medullay interstitum B. Urea reabsorbed from collecting duct to medullary interstitum C. Both A and B	
Q3.The function of the countercurrent multiplier is to: A. Produces the hyperosmotic Medullary Interstitium B. Maintains hyperosmolar medulla C. Secretes ADH	Q6.When a persons dehydrated. His extracellular fluids osmolality is high ; so hir kidney will excrete diluted urine. A. T B. F	

MCQS

Q7.Reabsorotion of urea will occurs in present of ADH : A. T B. F	Q10.In water diuresis the urine will be concentrated : A. T B. F	Ans: 7.A 8.A 9.B 10. B 11.B 12.B
Q8.Excreton of large volume or small volume of urine wont affect the rate of solute excretion. A. T B. F	Q11.Nephrogenic diabetes insipidus patients will have : A. No production or releasing of ADH B. No response from the kidney to ADH C. High specific gravity urine	
Q9.If the ECF is hypo-osmotic the excreted urine will be: A. Concentrated B. Diluted C. Non	Q12.The function of the Counter current exchanger “vasa recta “ : A. Produces the hyperosmotic Medullary Interstitium B. Maintains hyperosmolar medulla C. Secretes ADH	

GOOD LUCK

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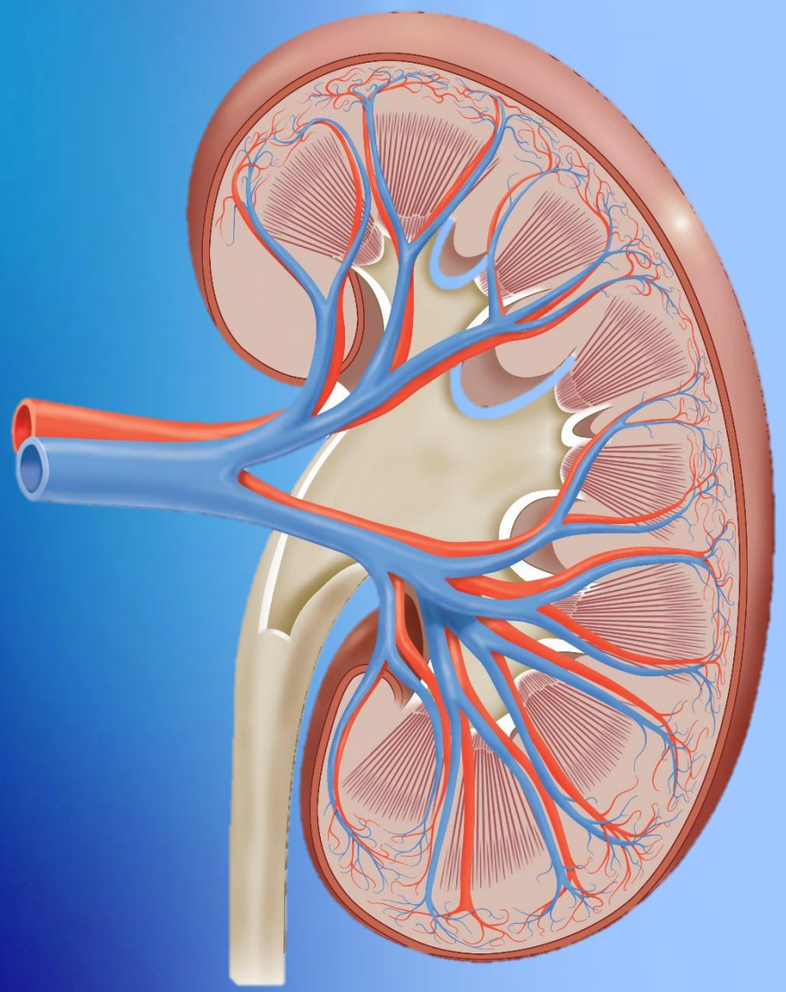

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