Formation of dilute and concentrated urine
Water transport:

- Normally, 180 L is filtered / day, average daily urine volume is about 1 L, this mean that 99% of water will be reabsorped
- The kidneys have the ability to regulate water excretion independently of solute excretion by the effect of ADH
- Urine output can range between 0.5 L with a concentration of 1400 mOsm/kg to a volume of 23 L with a concentration of 30 mOsm/kg .

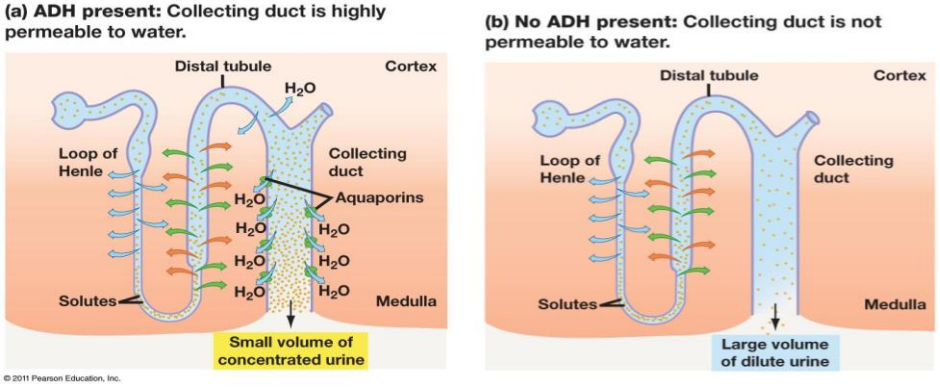
	GFR ml/min	Urine volume	% of reab.	Urine conc. mosm/l
Max ADH	125	0.5 L	99.7 %	1400
No ADH	125	23.3 L	87.1%	30

There is Obligatory and facultative reabsorption of water :

1. Obligatory (must occur) reabsorption : about 85% of the filtered water is always reabsorbed,. it occurs by osmosis .
2. Facultative(optional) reabsorption :15% of the water may or may not be absorbed depending upon the body water balance. it occurs in late DCT and collecting tubule under the control of ADH.

- Reabsorption in PCT (~ 65%) by the osmotic gradient created by reabsorption of Na^+.
- Thin descending loop of Henle LH (20%): it is permeable to water while the ascending limb and early DCT is impermeable to water.
- Collecting ducts (CD) : two portions

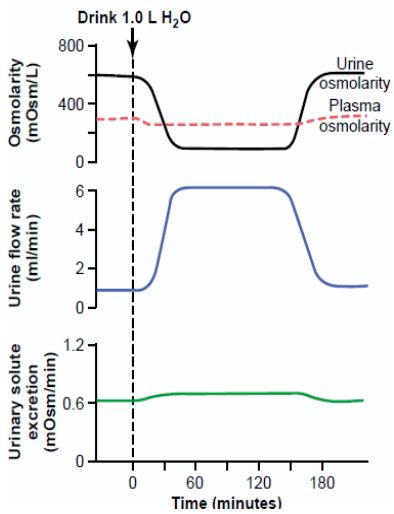
- cortical CD : 10% reabsorbed by ADH which ↑ the permeability of the CD by insert aquaporin 2 in Principal cells, changing the tubular fluid osmolarity from hypotonic to isotonic
- medullary CD :4.7 %is reabsorbed also under the effect of ADH to excrete concentrated urine .

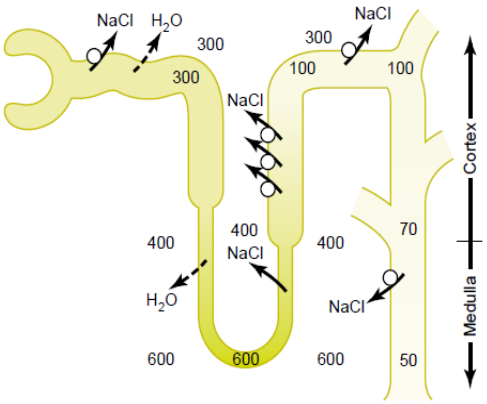


Note :-

- In case of absence of ADH→ excretion of dilute urine (30-50 mosm/L).
- ***Obligatory urine volume*** *:* minimal volume of urine that must be excreted per day = 600/1200 mOsm/l =0.5 L .

Renal Mechanisms to excrete a Dilute Urine When there is a large excess of water in the body, the kidney can excrete a dilute urine, with a concentration as low as 50 mOsm/L by ↓ADH →↓ reabsorption of large amounts of water in the distal parts of the nephron (late DCT and CD)





Renal mechanism to excrete concentrated urine:

- requirements for forming a concentrated urine are
  1) High level of ADH
  2) High osmolarity of the medullary interstitium. it provides the osmotic gradient necessary for water reabsorption in the presence of ADH.
- Medullary hyperosmolarity is mediated by countercurrent mechanism and urea recycling .

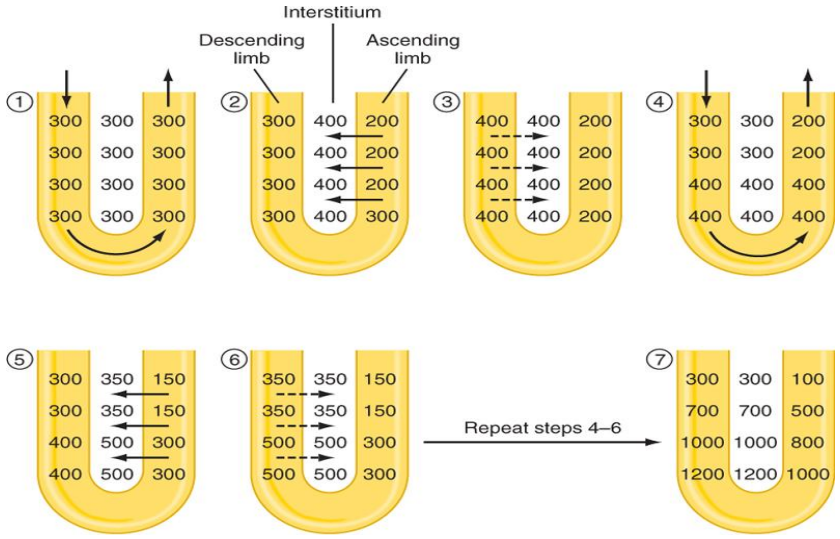
Counter current Mechanism :

is a system in which the inflow runs parallel to, counter to, and in close proximity to the outflow for some distance. It consist of :

1) Counter current multiplier (loop of Henle)
2) Counter current exchanger (vasa recta).

Counter current multiplier mechanism :

1- The loop of Henle is filled with fluid with a concentration of 300 mOsm/L
2- The active pump of the thick ascending limb establishes a 200-mOsm/L conc. gradient between the tubular fluid and interstitium.
3- Tubular fluid in the descending limb reach osmotic equilibrium with interstitium because of osmosis of water out of the descending limb.
4- The next flow of fluid from the proximal tubule causes the hyperosmotic fluid previously formed in the descending limb to flow into the ascending limb .
5- ions are pumped again into the interstitium, until a 200-mOsm/L osmotic gradient is established and the interstitial fluid osmolarity ↑ to 500 mOsm/L
6- The fluid in the descending limb reaches equilibrium with the hyperosmotic medulla and the cycle is repeated again .
7- This process gradually traps solutes in the medulla and multiplies the concentration gradient →↑interstitium osmolarity to 1200- 1400 mOsm/L.

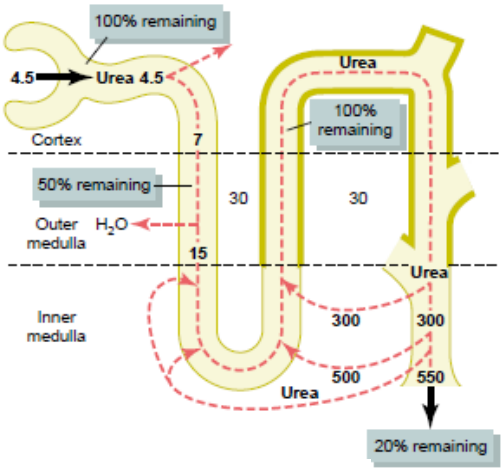


Countercurrent exchangers

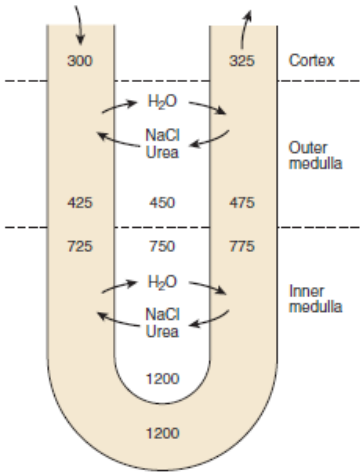
Mechanism mediated by the U shape of the vasa recta capillarie:

- The vasa recta serve as countercurrent exchanger to maintain the hyperosomlar medullary interstitium.
- In the descending limb of the vasa recta → diffusion of water out of the blood and diffusion of solutes from the renal interstitial fluid into the blood .

- In the ascending limb of the vasa recta (flow towards cortex) , solutes diffuse back into the interstitial fluid and water diffuses back into the vasa recta.
- The medullary blood flow is slow , < 5 %of the total renal blood flow. This sluggish blood flow is sufficient to supply the metabolic needs of the tissues and minimizing washout of solutes from the medullary interstitium.
- If the blood flow in the vasa recta is straight (not U shape)→ all the solute in the interstitium will be removed and the hyperosmolar interstitium can not be maintained.



Urea recycling



Countercurrent exchanger

Role of urea in the hyperosmolarity of the renal medulla

- it contributes about 40 -50 %of the osmolarity of the medullary interstitium.
- 50% of filtered is reabsorbed from the tubules ,the remaining is excreted (waste product)
- is passively reabsorbed in the P.C.T.
- Distal and cortical collecting tubules are impermeable to urea →↑urea conc due to water is reabsorbed from the cortical collecting tubule .
- In the inner medullary collecting ducts →urea to diffuse out of the tubule into the renal interstitium by **UT-AI** channels (activated by ADH) then diffuses back into the thin loop of Henle .
- It passes in the distal tubules and the medullary CD to be reabsorped again into the interstitium.

- This recirculation →trap urea in the renal medulla and contributes to the hyperosmolarity of the renal medulla.
- A high protein diet increases the ability of the kidneys to concentrate the urine and a low-protein diet reduces the kidney's ability to concentrate the urine.

Osmotic Diuresis :

- It is an increase in urine volume due to presence of large quantities of unabsorbed solutes in the renal tubules **(** They hold water in the tubules)

Water dieresis :

- It is an increase in urinary output following excessive intake of water or hypotonic solution. It occurs due to ↓ of ADH in the plasma.

	Osmotic dieresis	Water dieresis
Urine volume	>20L/day	Max 16ml/min
Osmolarity	>300 mosm/l	50 mosm/l
Causes	Large quantity of unabsorbed solute ex Diabetes mellitus ,mannitol	↓ or absence ADH ex: diabetes insipidus or excessive water intake
Water reabsorption In PCT and Loop of Henle	Decreased	Normal
In DCT and CD	↓due to increase osmotic load	↓ (low ADH)