النادي الطبي

GENITOURINARY SYSTEM

SUBJECT : Physiology

LEC NO. : 5

DONE BY : Fatima murad

وَقُل رَّبِّ زِدْنِي عِلْمًا

تعمل الكلية على الحفاظ على توازن الماء في الجسم من
خلال إما تركيز البول أو تخفيفه حسب حالة ترطيب الجسم

Concentration and Dilution of the Urine

- Kidneys excrete **excess water** by forming dilute urine

- Maximal urine concentration (H2O deficit) البول مركز يعني الجسم ما طلع كميه كافية من الماء
  = 1200 - 1400 mOsm / L
- Minimal urine concentration (high H2O) البول مخفف يعني في كميه ماء كافيه عملت dilution
  = 50 - 70 mOsm / L

- Kidneys can excrete diluted/concentrated urine **without major changes** in rates of excretion of solutes such as Na & K due to their ability to selectively reabsorb these electrolytes
  تزكروا ال pumps

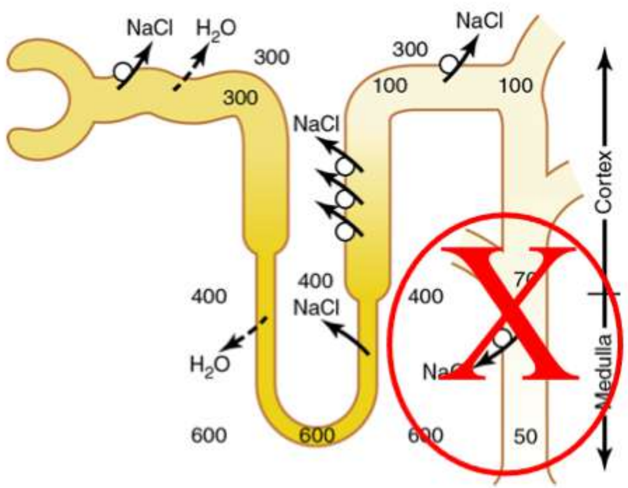
- Obligatory urine volume: is the minimum urine **volume** in which the excreted solute can be dissolved and excreted = 0.5 L/min (*lower than this indicates renal function problem*) الحد الأدنى من حجم البول الضروري لذوبان وإخراج المواد المذابة بشكل كافي

✨ADH العامل الرئيسي اللي بتحكم بتركيز البول هو ال

Juxtamedullary nephrons are responsible for urine concentration

Diluted urine

- LESS (↓) water reabsorption→ By ↓ ADH release

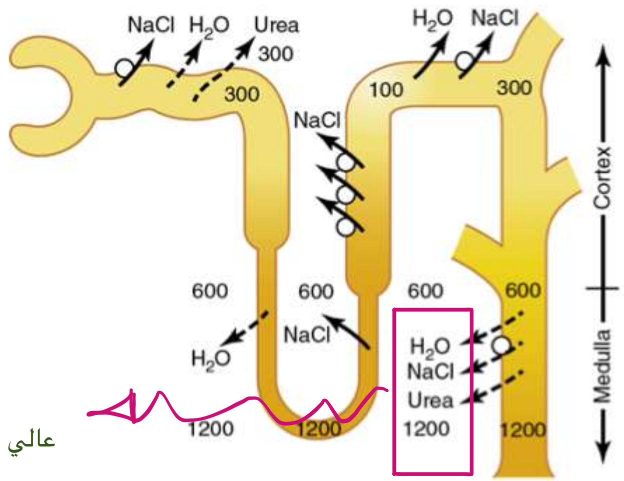


High excreted water compared to salts
Low ADH

Concentrated Urine

More (↑) water reabsorption→ → By ↑ ADH release/High osmolarity of medulla/ Countercurrent flow of tubular fluid

بكون تركيز الاملاح في
medullary interstitium
عالي ليسهل عمليه اعادة امتصاص الماء من
الانابيب باتجاه الدم



Low excreted water compared to salts
High ADH

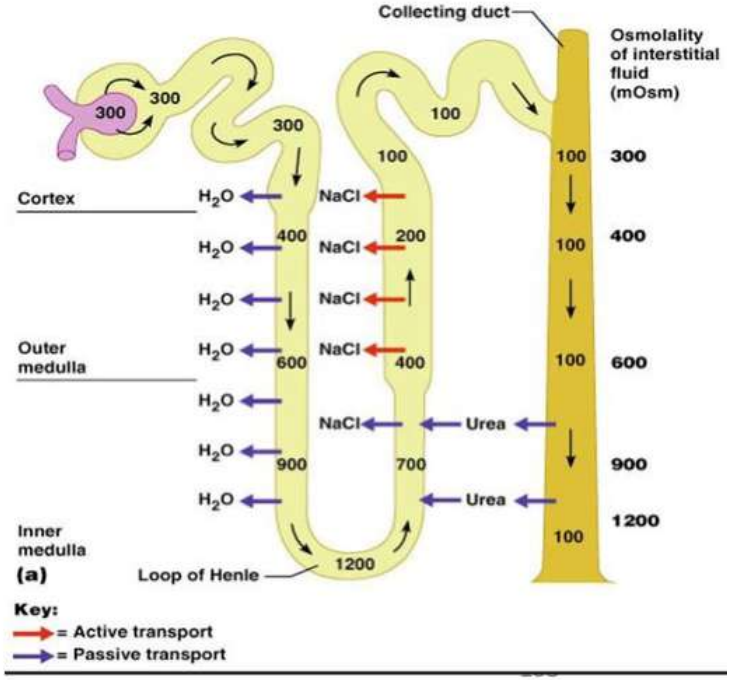
Concentration of urine - Juxatameddullary nephrons

•Juxtamedullary nephron: Special anatomical arrangement of the loops of Henle and vasa recta of renal medulla.

•Requires **<u>hyperosmolar</u>** medullary interstitium –

How?

1. Movements of **electrolytes & urea** from thick ascending loop of Henle & collecting ducts into medullary interstitium
2. Diffusion of **small** amounts of **H_2O** into medullary interstitium -Most of H2O reabsorption occurs in cortex rather than in the medulla



Dr Iman Aolymat

Concentration of urine Juxtamedullary nephrons

Electrolytes & urea reabsorption into medullary interstitium

+

Small amounts of H_2O reabsorption into medullary interstitium

-Most of H_2O reabsorption occurs in cortex rather than in the medulla.

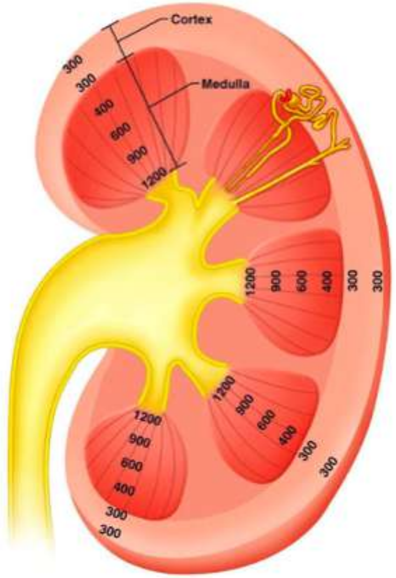
عشان ما يصير في تخفيف بتركيز البول

→ Hyperosmolar medullary interstitium

مقارنة ب
بلازما الدم

يزداد التركيز كل ما مشينا باتجاه ال **medulla**

Hyperosmotic renal medullary interstitium

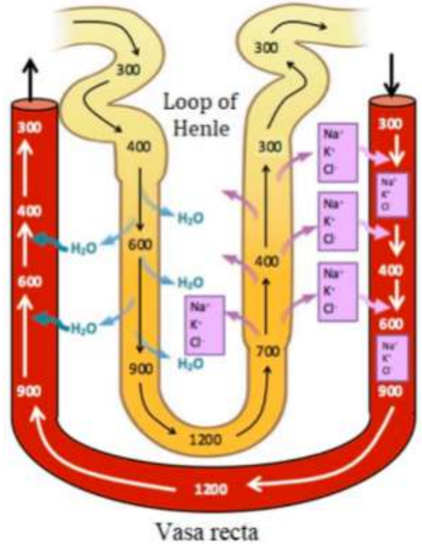


The hyperosmotic renal medullary interstitium:

عكس التيار

- Produced by Counter-Current Multiplayer .
- Maintained by Counter current Exchanger .

vital role in maintaining the concentration gradient necessary for urine concentration and water balance in the body.

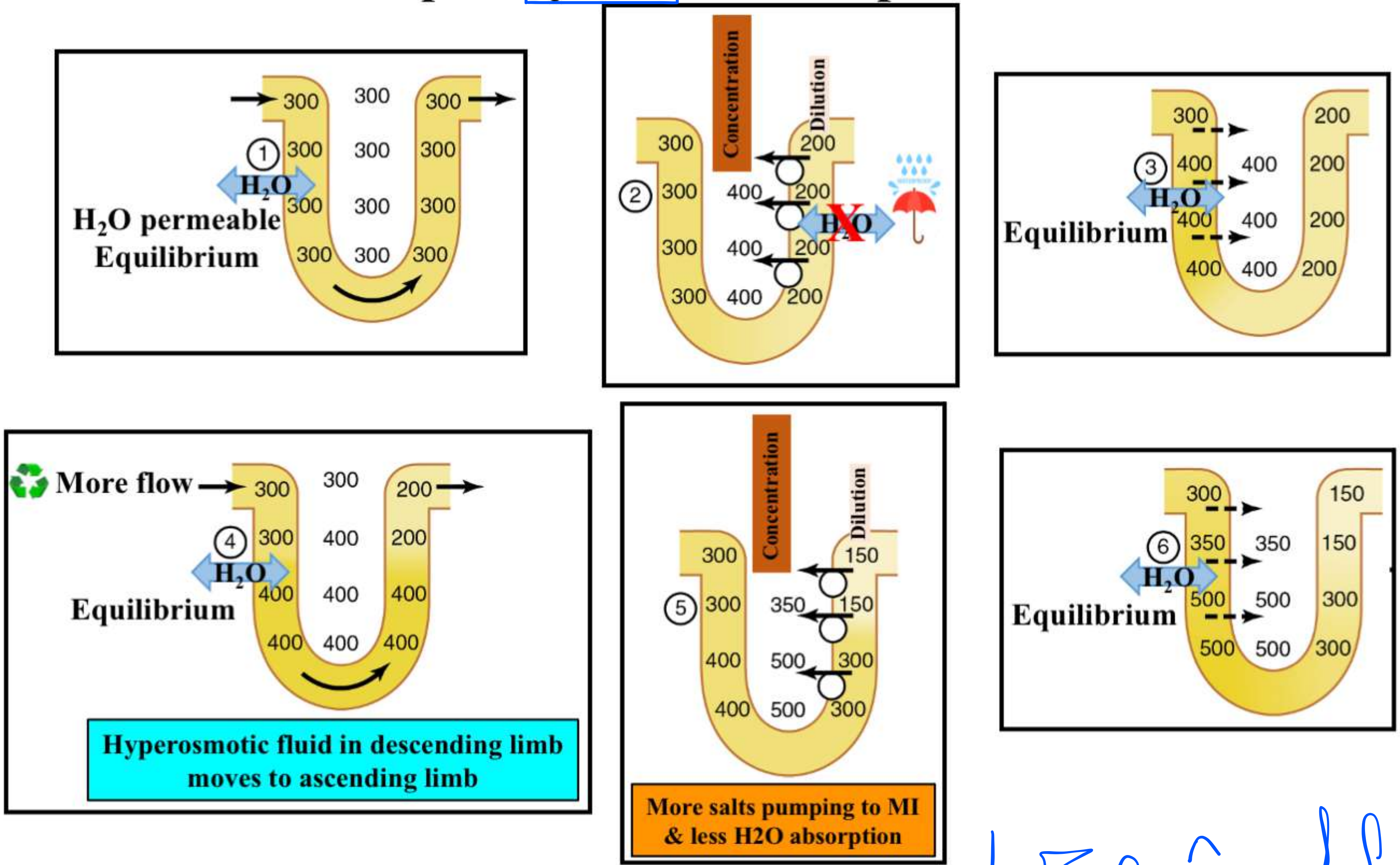


Countercurrent Mechanism: The hyperosmotic renal interstitium is created by the countercurrent multiplier system, which involves the loop of Henle within the nephrons of the kidney. As filtrate moves through the loop of Henle, water is reabsorbed from the filtrate in the descending limb, while solutes (such as sodium and chloride) are actively pumped out into the surrounding interstitium in the ascending limb.

Henle + Vasa Recta

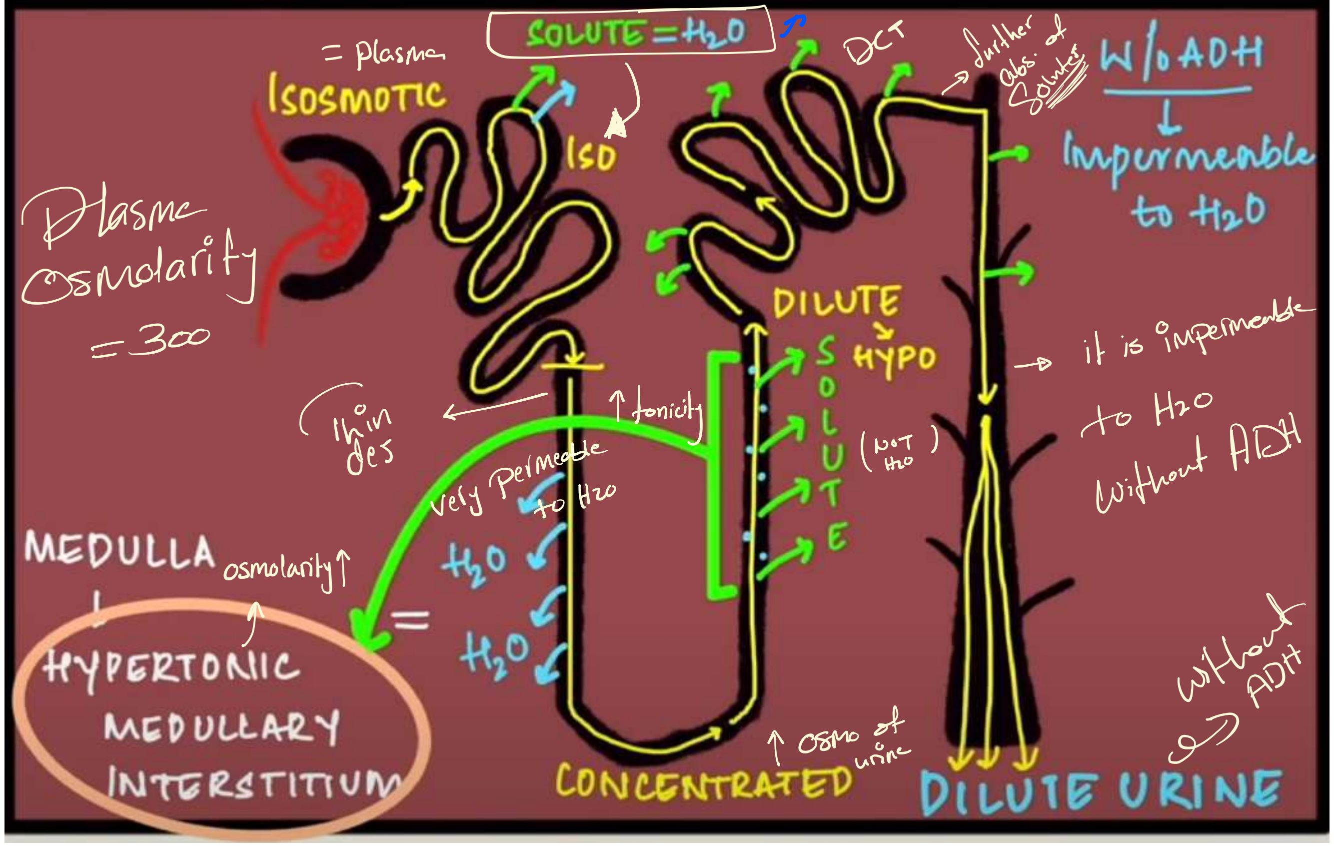
لح اكمل باخط إيدي.. زهقت ☺

Countercurrent multiplier system in the loop of Henle



الشرح ↓

Reabsorbed



Plasma Osmolarity = 300

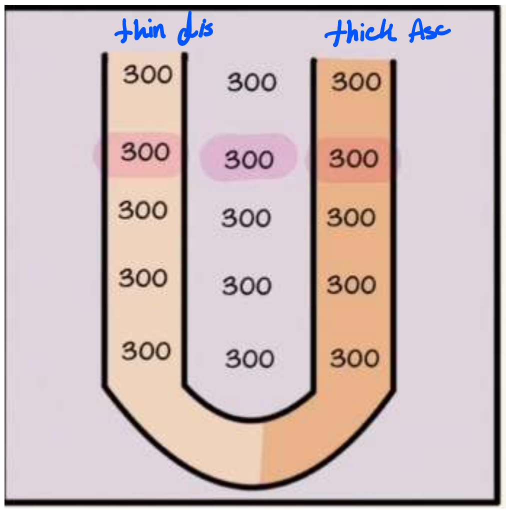
ok .... But we want to Preserve

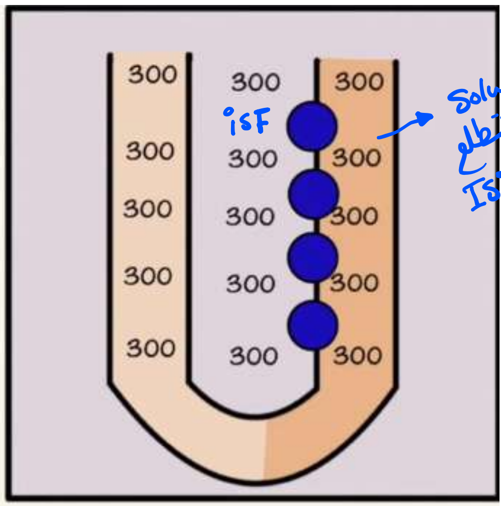
H_2O ⇒

① ADH

② Hypertonic Medulla

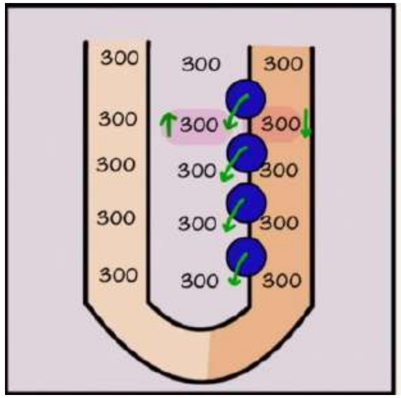
Loop of Henle

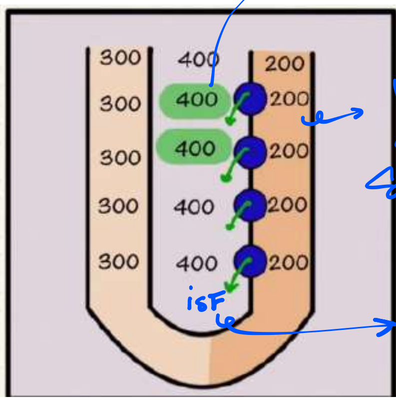




→ Solutes اللي طلع للـ ISF

⟹

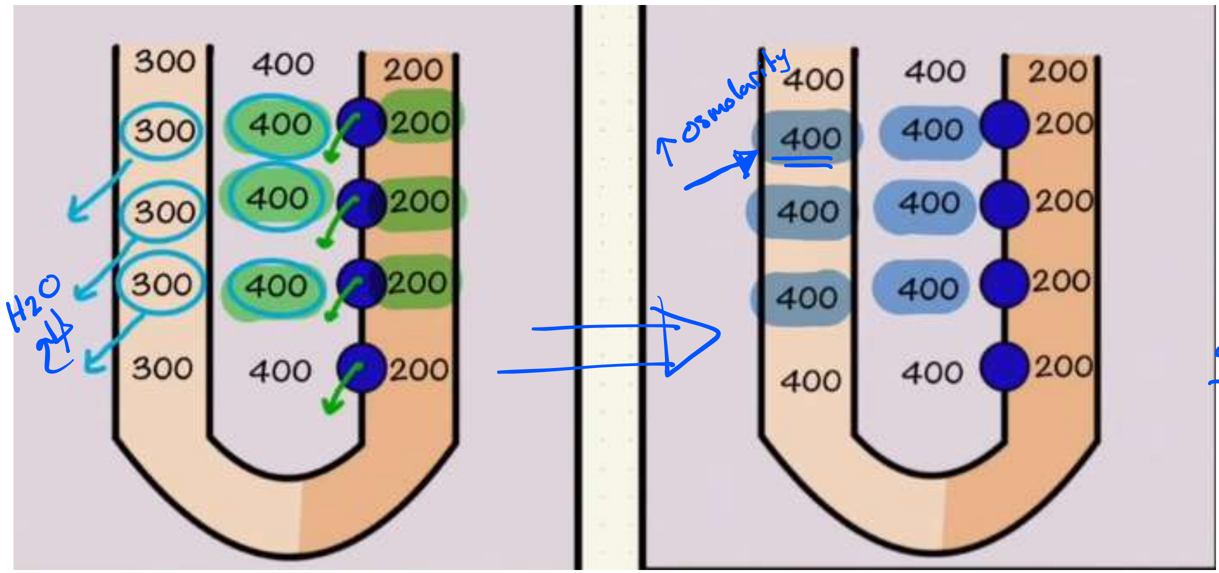


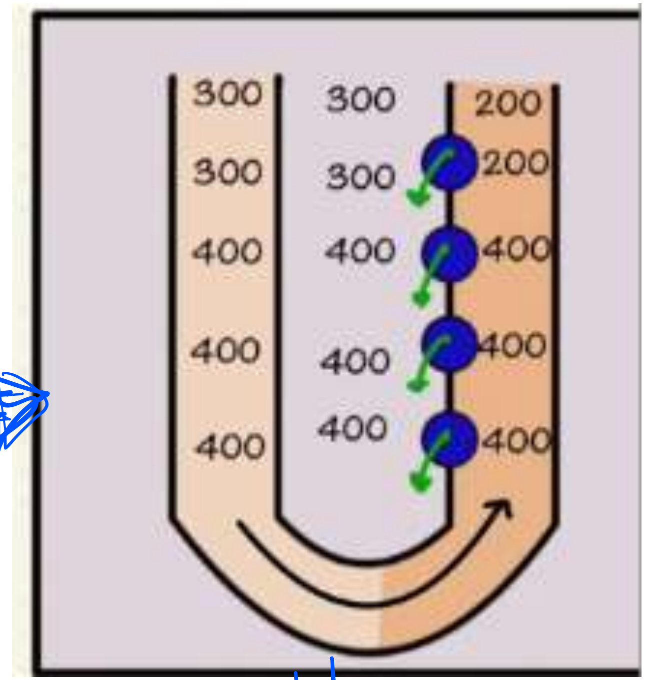


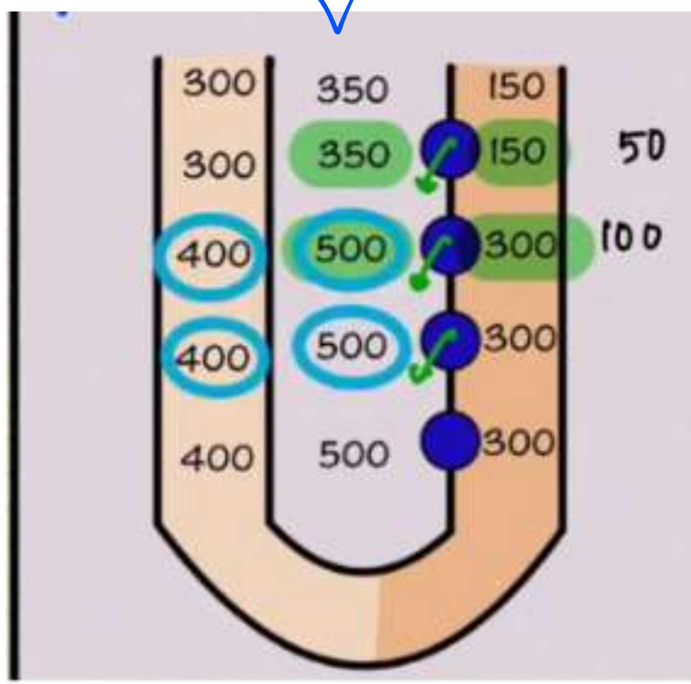
لاحظوا زادت لأنه إجاها كمان Solutes

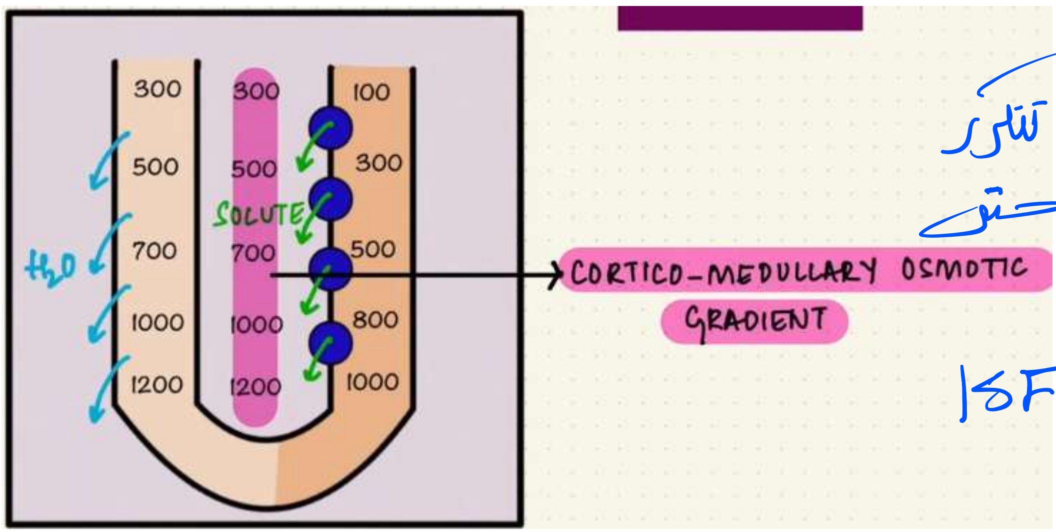
لاحظوا قلت لأنه Solutes طلع برا

→ صار Hypertonic

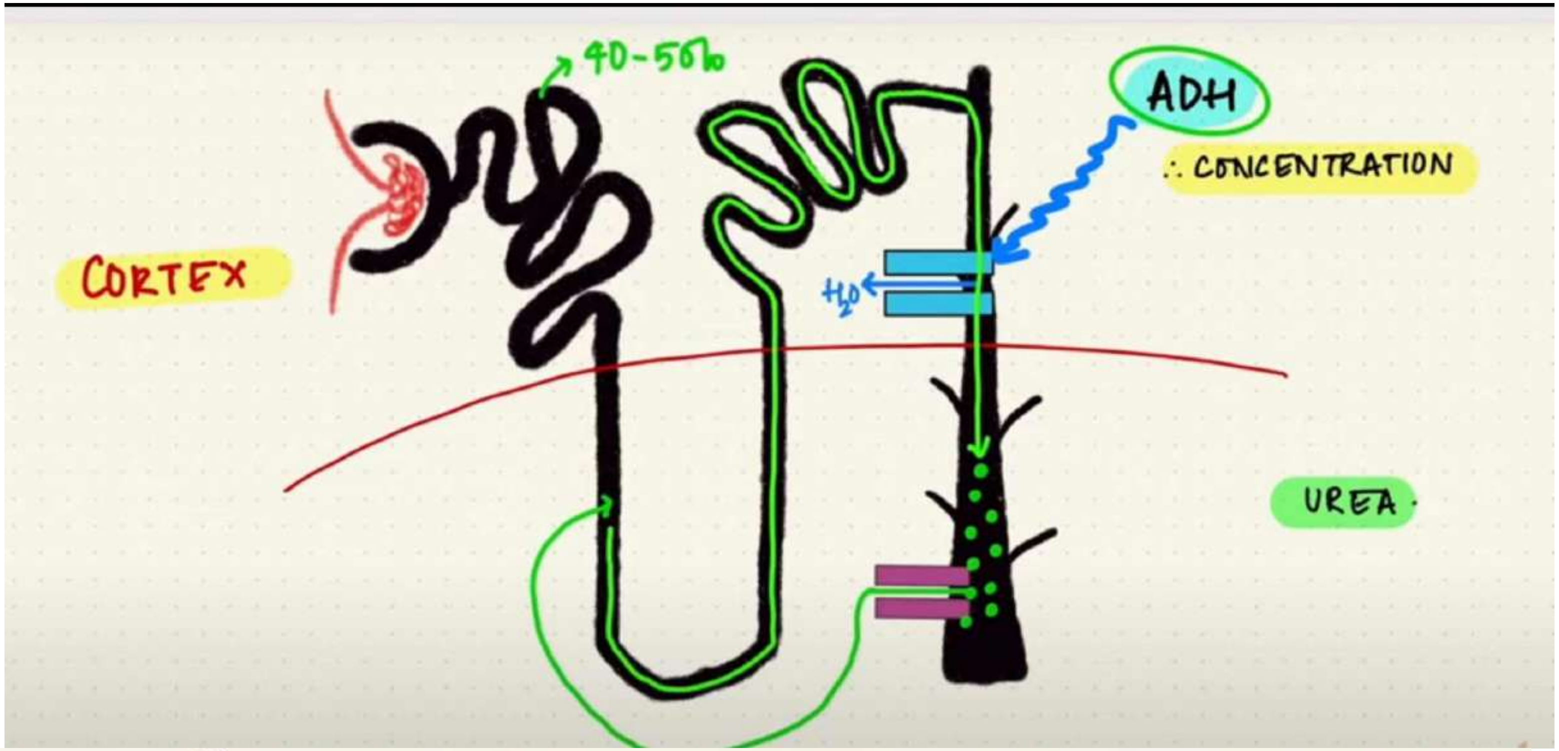




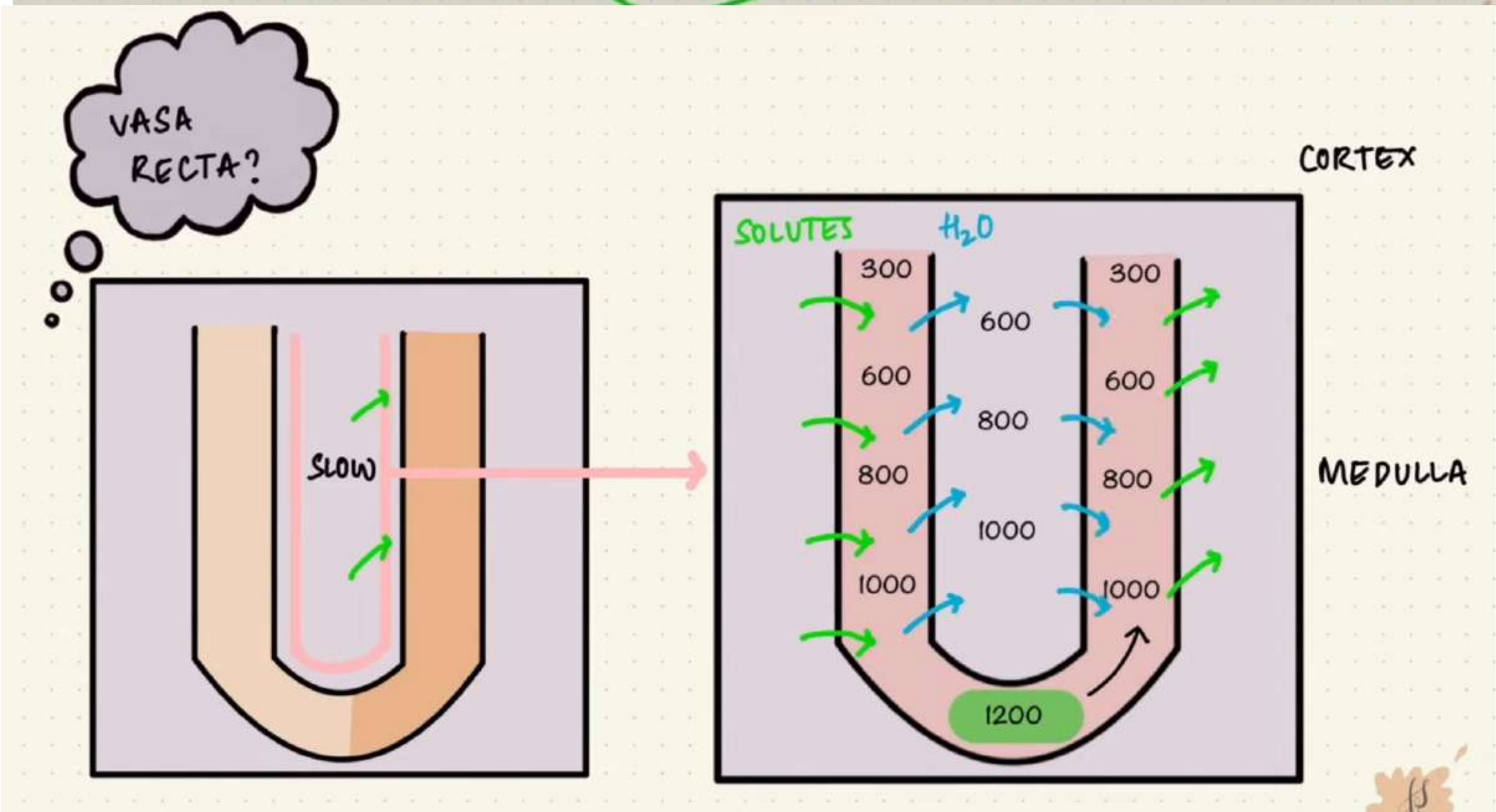




وبتضل تتكرر
العملية حتى
يوصل
ISF = 1200

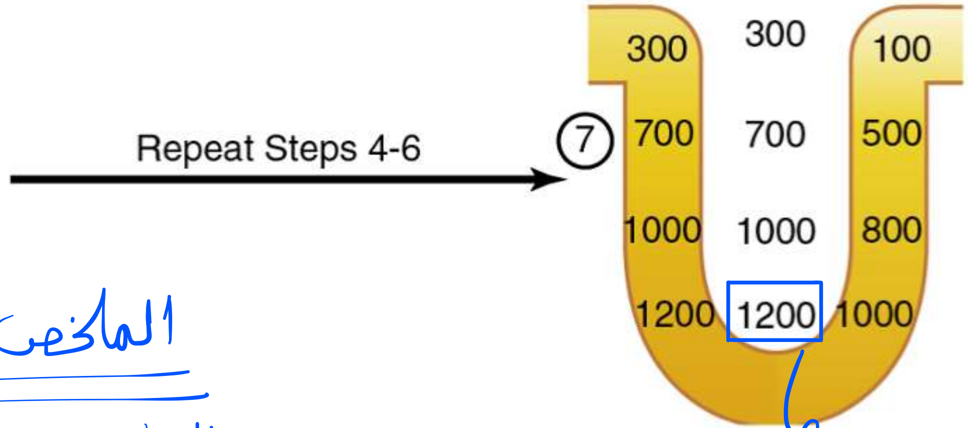


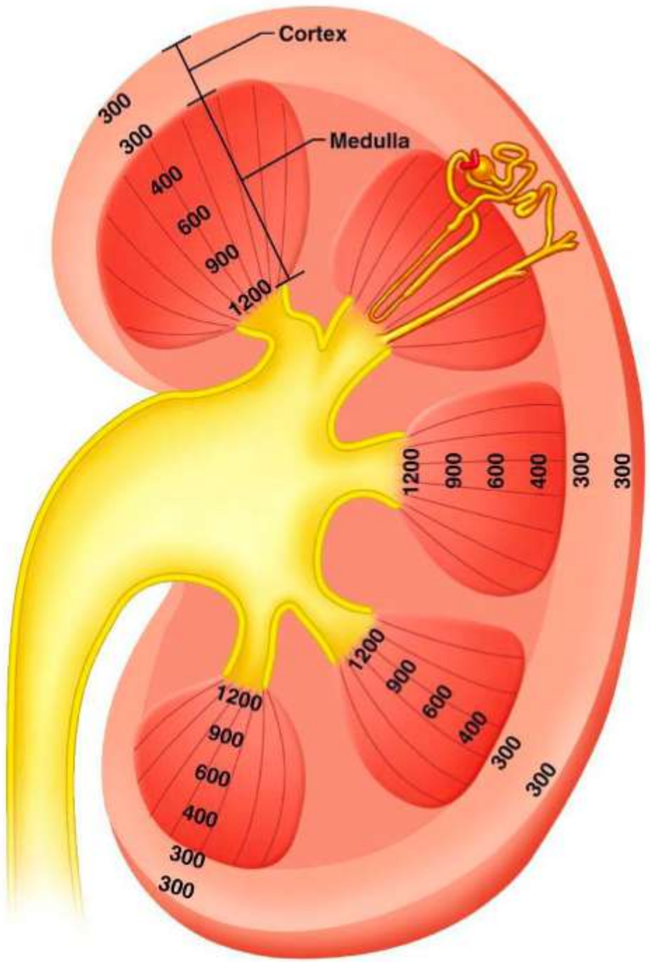
40-50%
ADH
∴ CONCENTRATION
CORTEX
UREA



VASA RECTA?
SLOW
CORTEX
SOLUTES
H_2O
300
600
800
1000
300
600
800
1000
300
600
800
1000
1200
MEDULLA

Countercurrent multiplier system in the loop of Henle





الملخص

Thin des → بطلع ماء برا
→ بركز الملح داخل الأنبوب → ↑ interstitium osmolarity.

Thick Asc → بطلع الملح
→ تخلي الماء.

انتقال الماء من ال distal part الى medullary بفعل ال ADH

الهدف من الخطوات اللي رح تقرأوها هو رفع
medullary ISF osmolarity
من 300 الى1200

Countercurrent multiplier system in the loop of Henle

1. Loop of Henle is filled with fluid having a concentration of 300 mOsm/L, the same as that leaving the proximal tubule.

Type your text

2. Active ion pump of **thick ascending** limb on the loop of Henle **reduces** the concentration inside the tubule and raises the interstitial concentration; this pump establishes a 200-mOsm/L concentration gradient between the tubular fluid and interstitial fluid.

3. Tubular fluid in the **descending limb** of the loop of Henle and interstitial fluid quickly reaches osmotic equilibrium due to **osmosis of water out of the descending limb**. The interstitial osmolarity is maintained at 400 mOsm/L because of *continued transport of ions out of the thick ascending loop of Henle.*

4. Additional flow of fluid into the loop of Henle from the proximal tubule, which causes the *hyperosmotic fluid previously formed in the descending limb to flow into the ascending limb.*

Countercurrent multiplier system in the loop of Henle

5. Once fluid is in the ascending limb, *additional ions are pumped into the interstitium* and **water remains** in the tubular fluid. The interstitial fluid osmolarity rises to 500 mOsm/L.

6. Fluid in the descending limb reaches equilibrium with the hyperosmotic medullary interstitial fluid..

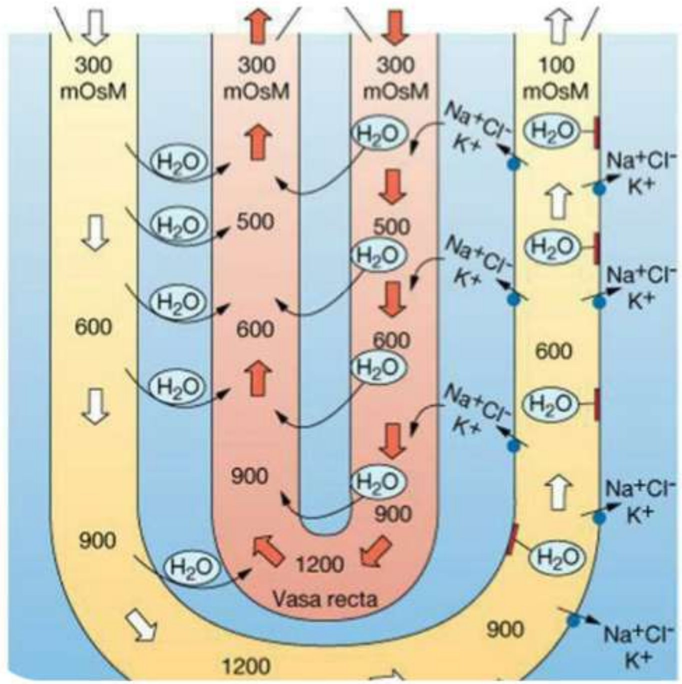
These steps are repeated over and over, with the net effect of adding more and *more solute to the medulla in excess of water*. With sufficient time, this process gradually traps solutes in the medulla and multiplies the concentration gradient established by the active pumping of ions out of the thick ascending loop of Henle, eventually raising the interstitial fluid osmolarity to 1200 to 1400 mOsm/L, as shown in step 7.

The Vasa Recta Preserve Hyperosmolarity of Renal Medulla

- Vasa recta blood flow is **<u>low</u>** (only 1-2 % of total renal blood flow) **minimizing washout of solutes** from the medullary interstitium.

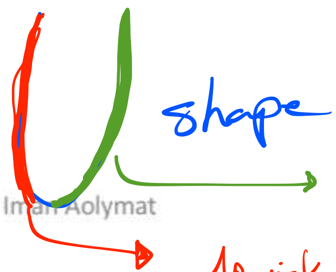
- The vasa recta serve as **countercurrent exchangers**:
- Descending limb→ **hyperosmotic** (water out & solutes in)
- Ascending limb →solutes out and water in

Large amounts of solutes would be lost from the renal medulla without the U shape of the vasa recta capillaries.



Vasa Recta
→ لو كان مش
straight الوعاء الدموي
→ Diffusion of salts from Medulla to Vasa recta (wash out of salts)

But



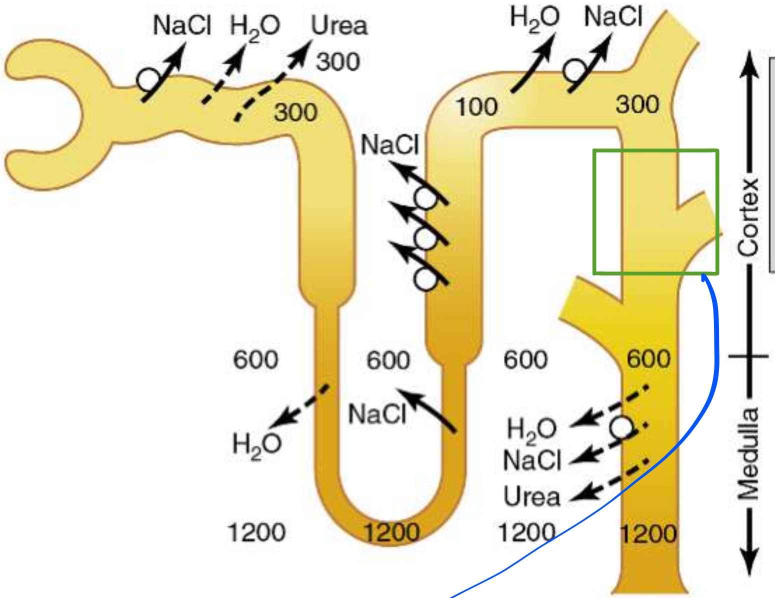
shape

باخذ ملح منه ISF

بطلع ملح ع ISF وباخذ ماء

Role of distal T & collecting ducts in excreting concentrated urine

Distal tubule **→dilutes tubular fluid**
Active reabsorption of NaCl
Impermeable to H2O



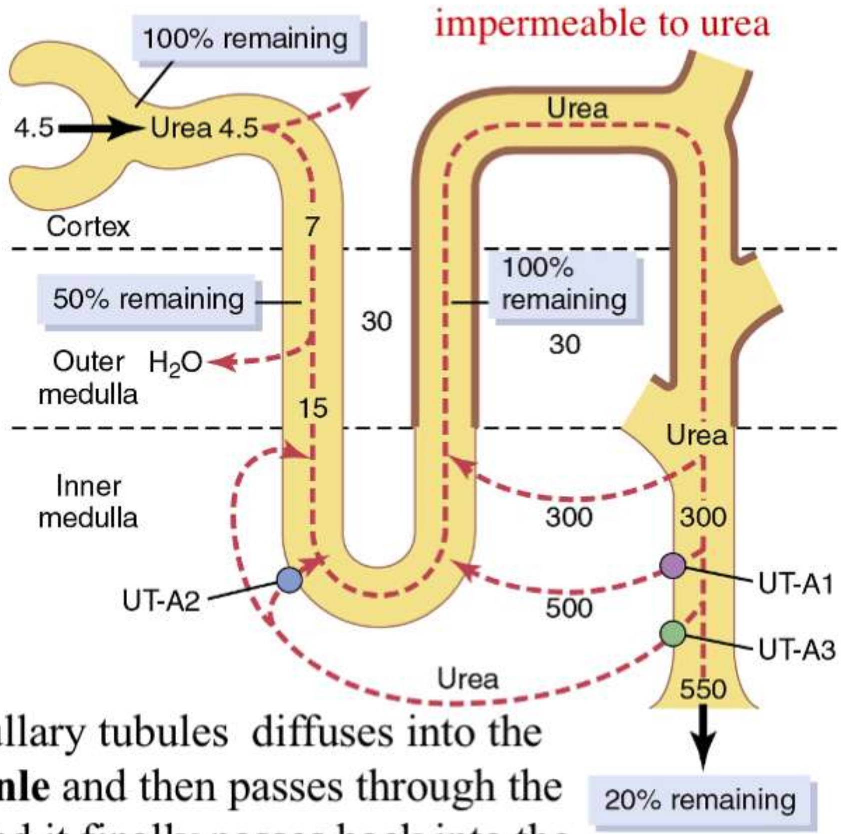
Cortical collecting tubule
ADH dependent H2O reabsorption **TO CORTEX NOT MEDULLA→** maintain hyperosmolar medulla
Continues to reabsorb solutes

Medullary collecting ducts
ADH dependent H_2O reabsorption → carried away by **vasa recta** into venous blood.
Urea passive reabsorption- UT-A1 and UT-A3.

Permeability of water depends on ADH

Urea Recirculation

- 50% of urea is **passively** reabsorbed in **proximal tubule**
- Distal and collecting tubules →impermeable to urea
- Medullary collecting tubule **highly permeable** to urea → diffuses into medullary interstitium
- ADH increases urea permeability of medullary collecting tubule by activating urea transporters (UT-A)



Urea from medullary tubules diffuses into the **thin loop of Henle** and then passes through the distal tubules, and it finally passes back into the collecting duct.

Micturition

Emptying urinary Bladder

Transport of urine to urinary bladder

Collecting duct لأنه طلع منه

- No change in composition
- Urine from Collecting Duct→ Calyces (↑Pacemaker activity → peristalsis) →Pelvis→ Ureter →Urinary Bladder

Sympathetic stimulation: → تثبيط لل Non-vital organ

↓Peristalsis

Parasympathetic stimulation: → بحالات الراحة Rest and digest

↑Peristalsis

RF ← ارتداد البول باتجاه الكلية ينتهي ب

- Oblique course U+ compressed by detrusor muscle tone→ Prevents Vesicoureteral Reflux

as a valve

- Reflux →enlargement of ureters+ ↑pressure in renal calyces & medulla →damage

Pain sensation in Ureters

- Well supplied with pain nerve fibers
- Irritation/ block (e.g. stone) → intense stimulation of pain nerve fibers → Intense contraction of ureters (severe pain)

↓

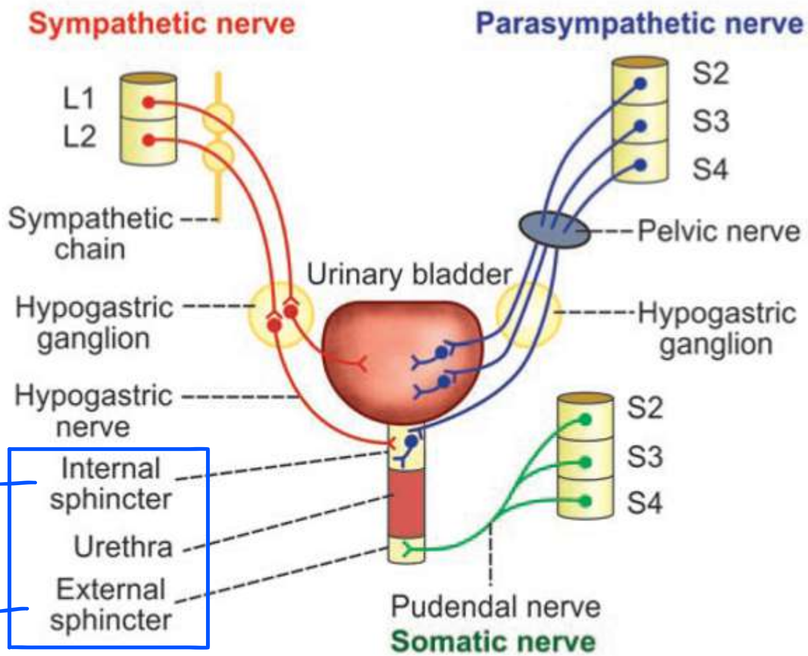
Sympathetic reflex back to kidney→ vasoconctriction of renal arterioles→ ↓the urine output =**Ureterorenal reflex→ preventing excessive flow of fluid into pelvis**

لأنه نشاط sympathetic

لأنه في stones والجسم 2L

يقلل urine flow من خلال تقليل Peristalsis

Innervation of urinary bladder



لا ارادي ← Internal sphincter

ارادي ← External sphincter

Pelvic nerve has sensory fibers→ impulses from stretch receptors in urinary bladder and urethra →CNS

لو صار مشكلة بصير urinary retention.

Nerve	On detrusor muscle	On internal sphincter	On external sphincter	Function
Sympathetic nerve (L1-L2)	Relaxation	Constriction	Not supplied	Filling of urinary bladder
Parasympathetic nerve (S2-S4)	Contraction	Relaxation	Not supplied	Emptying of urinary bladder
Somatic nerve (S2-S4)	Not supplied	Not supplied	Constriction	Voluntary control of micturition

لو صار في مشكلة بصير urinary incontinence

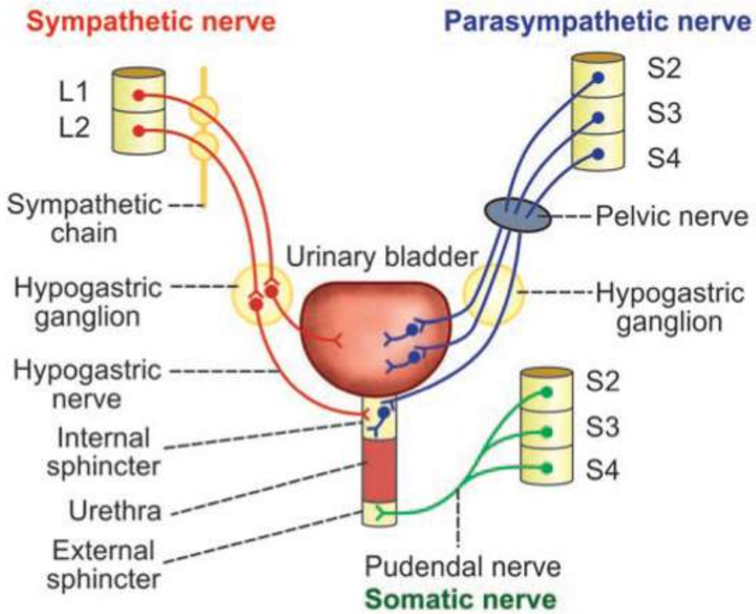
* Urethra + Detrusor Muscle (pressure لو زاد) → Sensory Receptors → Sacral area → Micturation

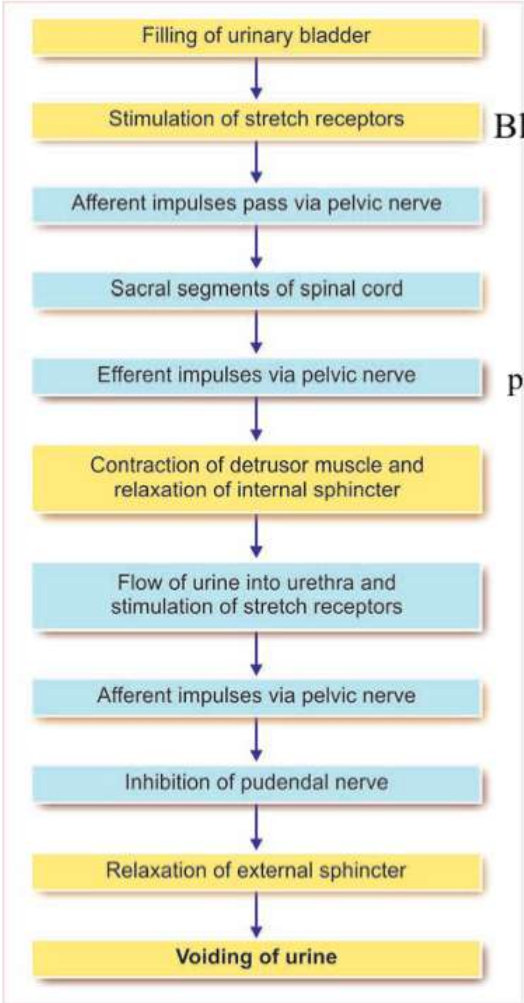
Micturition

- Emptying urinary bladder when it becomes filled →tension in its walls > threshold level→ **micturition reflex**
- Contraction of detrusor muscle→↑pressure in bladder to 40-60 mm Hg → emptying the bladder
- Internal sphincter→ prevents emptying of bladder until pressure in bladder > threshold level
- External sphincter→ voluntary skeletal muscle, used to consciously prevent urination

Micturition Reflex

- Autonomic spinal cord reflex
- Contraction of Detrusor muscle
- Inhibited / facilitated by brain





Bladder wall/posterior urethra

parasympathetic nerve fibers

Control by Higher Centers

Higher centres normally exert final control of micturition

- Pon & cerebral cortex
- Partial **inhibition of micturition reflex→** Prevent micturition, even if micturition reflex occurs by **tonic contraction of external urinary sphincter** until a convenient time presents itself.
- Cortical centers can facilitate sacral micturition centers to initiate micturition reflex & relax external sphincter

Voluntary urination