# 7. Urine Concentration & Dilution

Color index

- Important
- Further Explanation

Physiology Team 434
contact us : physiology434@gmmail.com

# Contents



**Recommended Videos!**

**Please check out this link before viewing the file to know if there are any additions/changes or corrections. The same link will be used for all of our work Physiology Edit**

# Introduction

One of the major function of the kidney is to regulate the osmolality of the blood the normal osmolarity is 290 mOsl/L but for simplicity they always say 300 mOsl/L so the kidney will adjust the osmolality around 300 mOsl/L by making the urine dilute or concentrated depending on the water intake

**Osmolarity = Concentration of solution**


**When a person drink a lot of wate**r the large amount of water tends to make the fluid in the body diluted or **hyposmolarity** meaning the osmolality will be reduce so the kidney will get rid of the extra water and that makes **the urine dilute** and the volume of the urine will be large. Note that the end product and the metabolic waste will be the same .

**In the other hand;**

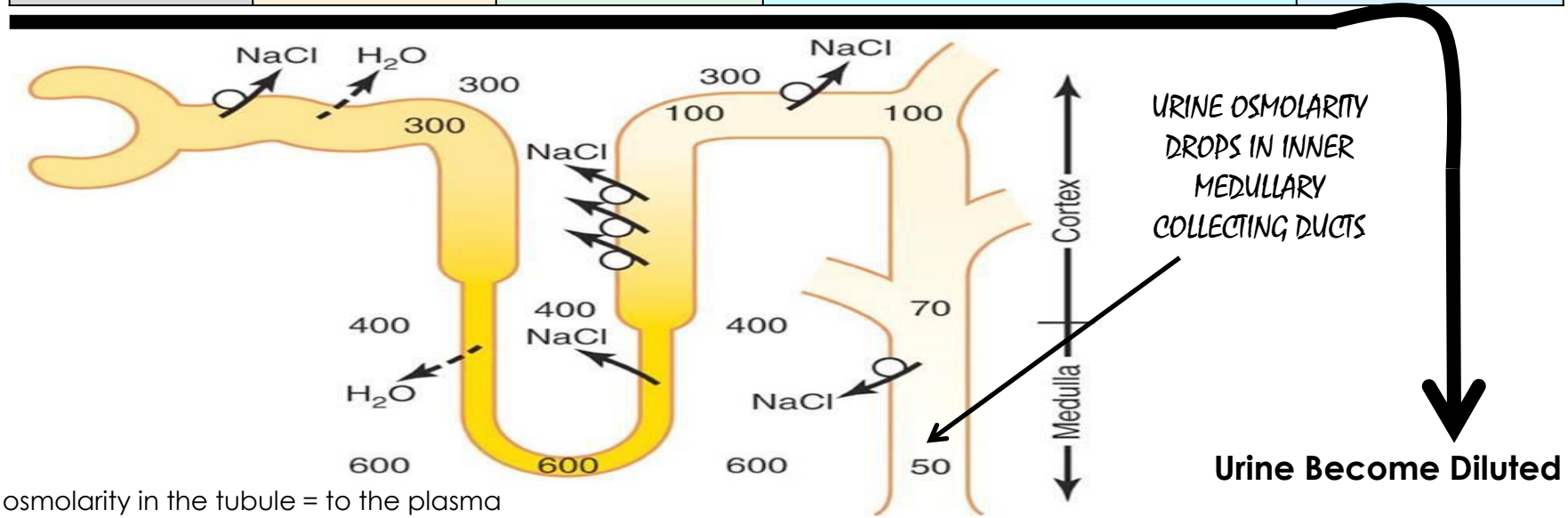
The **urine will be concentrated** when there is **less water intake** that makes the body fluid **hyperosmolar** or concentrated that will increase the osmolality so the kidney reserve the water and get rid of the same end product and metabolic waste so less water in the urine and the same waste but it will be more concentrated because there is no large amount of water.

SAME STORY WILL BE MENTIONED NEXT LECTURE BUT IN MORE DETAILS ☺
SO WE CAN FORGIVE IF YOU SKIP IT JUST FOR NOW!!

# Urinary Dilution Mechanism

(Low or no ADH)

| Structure | 1- PCT | 2- Thin descending limb | 3- Thin ascending limb | 4- Thick ascending limb | 5- Collecting duct |
|---|---|---|---|---|---|
| Permeability | To Both | To water | **Impermeable to water,** Permeable to NaCl | | **Absence of ADH** |
| Reabsorption | NaCl & H2O | Water (osmosis) | NaCl (passivly) | NaCl (actively) | ++NaCl |
| **Osmolarity of Tubular Fluid** | **Isoosmotic *** 300 mOsm/L | **Hypertonic ↑** 1200 mOsm/L | **↓Hypotonic** 100 mOsm/L | | **↓↓Hypotonic** 100 mOsm/L |



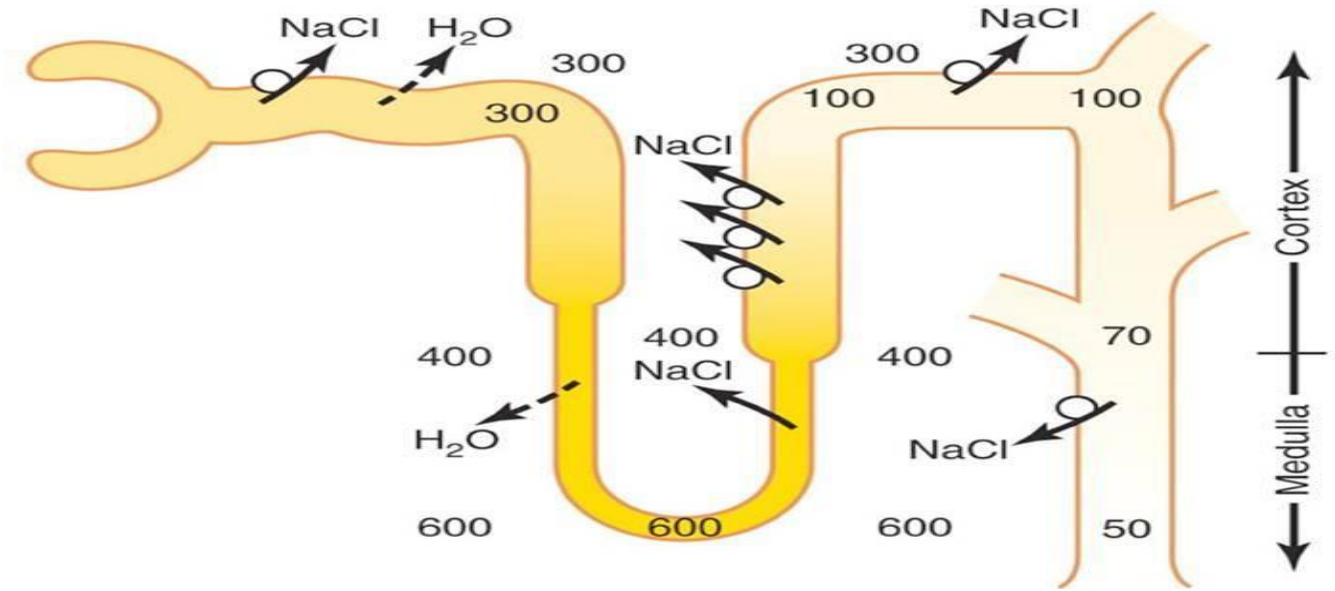

e osmolarity in the tubule = to the plasma

# Urinary Concentration Mechanism

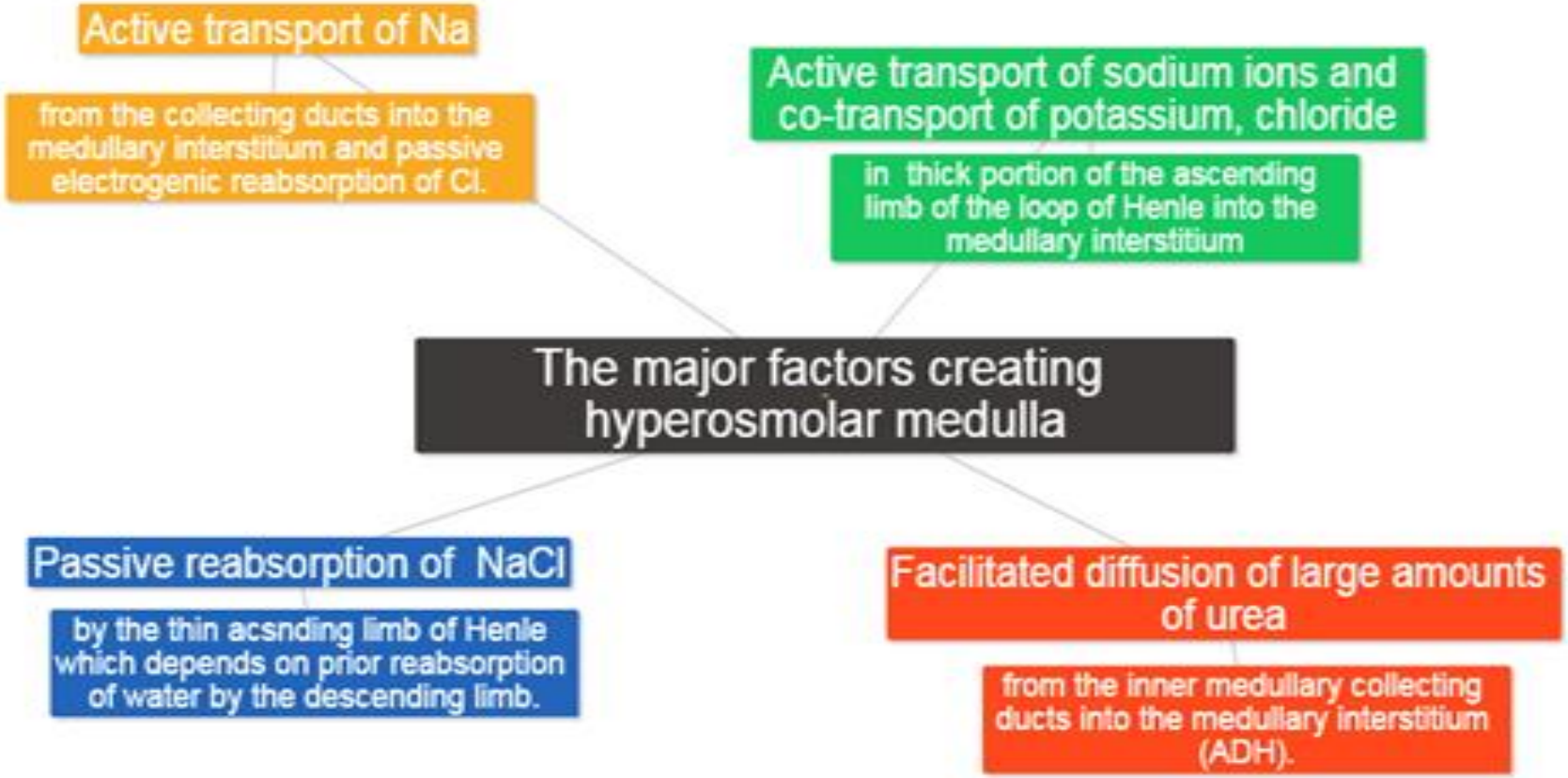
(ADH dependent)

From PCT to TAL[1] in the figure same as the diluted but differ in the late distal tubule and cortical collecting tubule and the inner medullary collecting ducts

| Late Distal Tubule and The Cortical | Inner Medullary Collecting Ducts |
|---|---|
| Highly permeable to water in presence of ADH so water are reabsorbed | Osmolality of medullary tissue high up to 1200 (Will explain next ) |




1: Thick Ascending Limb


Active transport of Na
from the collecting ducts into the medullary interstitium and passive electrogenic reabsorption of Cl.
Active transport of sodium ions and co-transport of potassium, chloride
in thick portion of the ascending limb of the loop of Henle into the medullary interstitium
The major factors creating hyperosmolar medulla
Passive reabsorption of NaCl
by the thin acsnding limb of Henle which depends on prior reabsorption of water by the descending limb.
Facilitated diffusion of large amounts of urea
from the inner medullary collecting ducts into the medullary interstitium (ADH).

# Mechanisms Responsible for Maintaining a Hyperosmolar Medulla:

**Counter current exchange**
**(Vasa Recta mechanism)**

**The medullary blood flow is very low**

1-2% of the total blood of the kidney.
Minimum Removal of solutes because It is **very small** and the **sluggish flow**.

| Conditions Decrease Medullary Blood Flow | Conditions Increase Medullary Blood Flow |
|---|---|
| 1- **Volume depletion**.<br>2- **Improve urine concentrating ability.**<br>3- **Efficiency of countercurrent exchanger** by allowing more time for blood in the ascending vasa recta to loose solutes and achieve osmotic equilibration | 1- **Osmotic diuresis.**<br>2- **Decrease urine concentrating ability.**<br>3- **Impair the efficiency of countercurrent exchange.** |

# Counter Current Multiplayer

Produce the **hyperosmotic medullary interstitial** due to solute deposition on medullary interstitial.

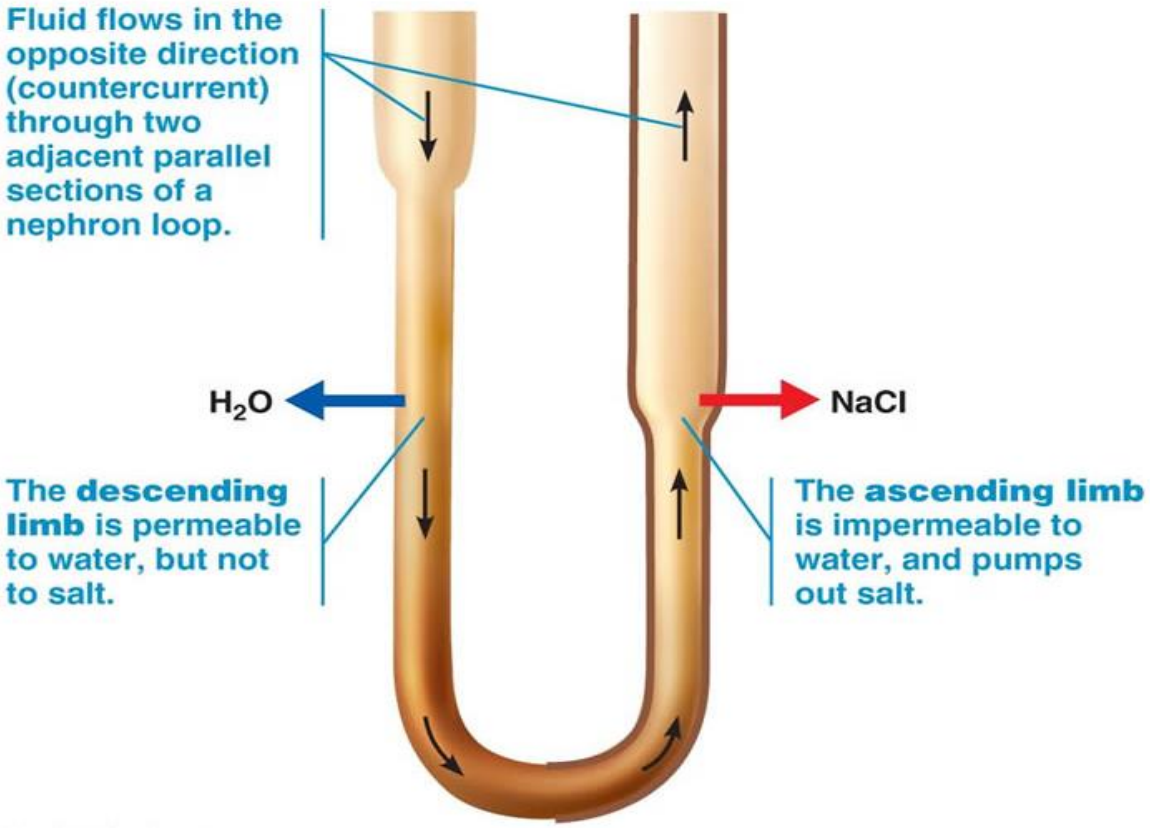
NaCl that reabsorbed from the *Thick ascending loop* of henle is deposited on medullary interstitial.
Also the **Urea** that reabsorbed from the **Collecting duct** to medullary interstitial will contribute to medullary hyperosmotic .

**REMEMBER :** Wherever the solutes go water will follow it.

So, as result of hyperosmotic medullary interstitial the **descending loop of Henle** will release **water by osmosis** into the interstitial to reach the **equilibration** between osmolarity in the tubule and in medullary interstitial.

# Counter Current Multiplayer cont.

**The countercurrent multiplier depends on three properties of the nephron loop to establish the osmotic gradient.**



# Counter Current Exchanger

Found in the **vasa recta.** ✧

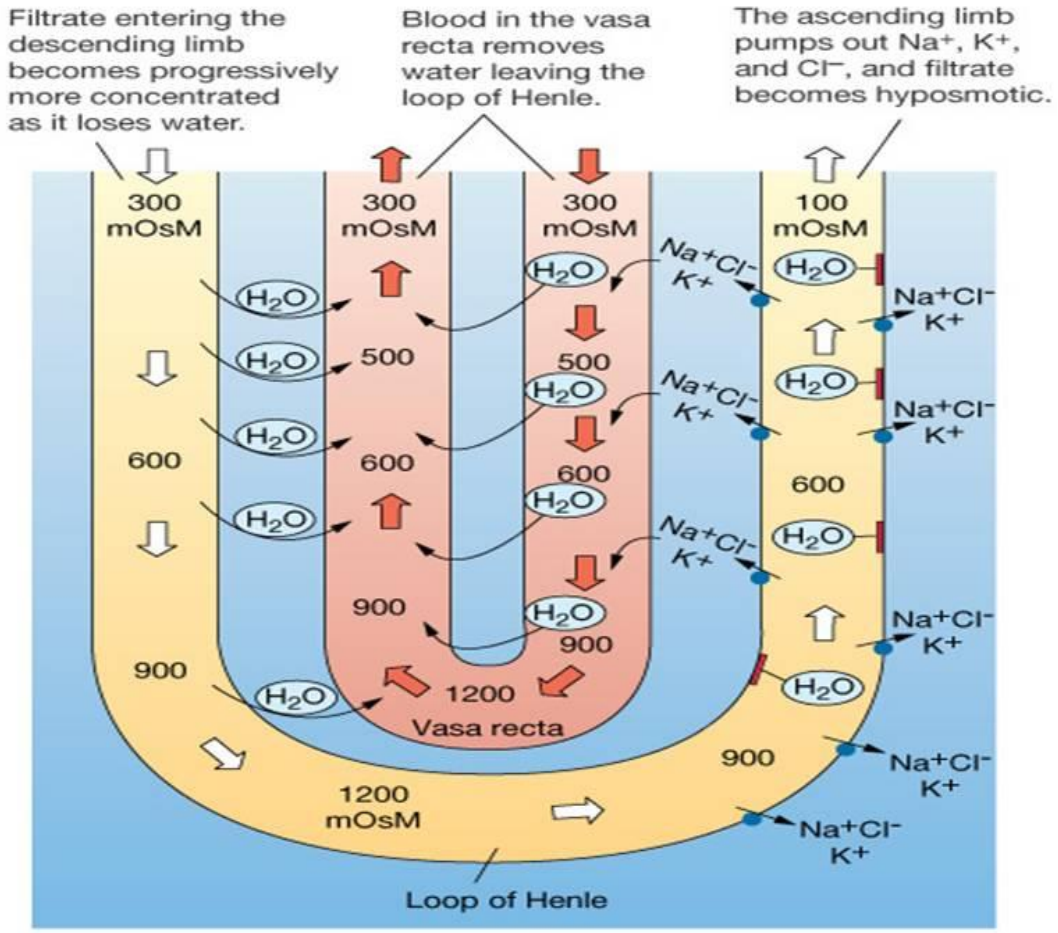
**Maintain** hyperosmolar medulla ( passive process) ✧

The exchange of solutes and water between ascending and descending vasa recta and he interstitium is called **Countercurrent exchange.** ✧

**It will prevent wash out of solutes in medulla due to the U shape of vasa recta.**

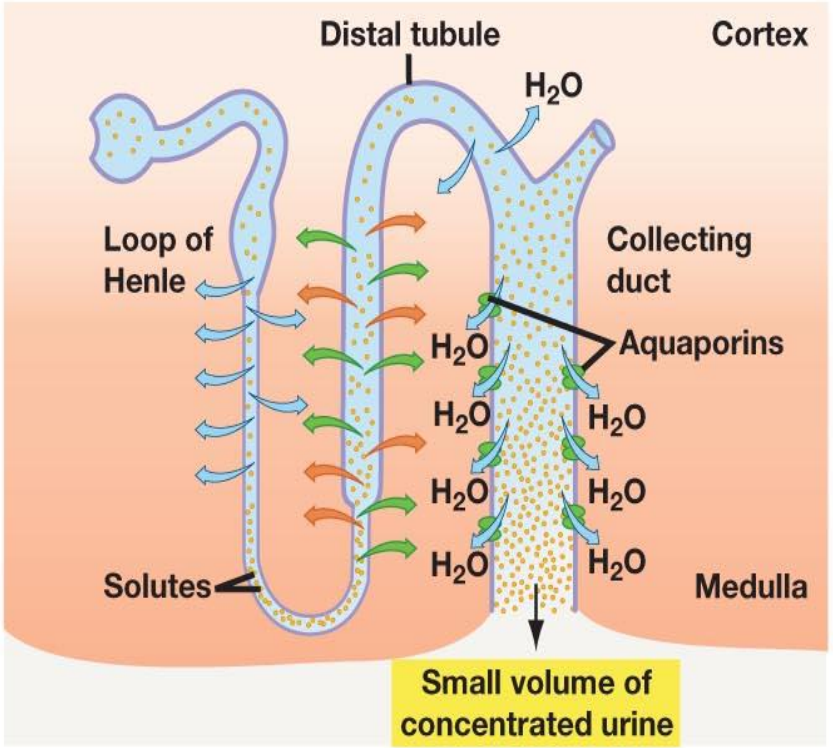
| Vasa Recta | |
|---|---|
| Descending vasa recta | Ascending vasa recta |
| Gain solutes. ○<br>Loose water. ○<br>So, it will be more concentrated at end. ○ | Gain water. ○<br>Loose solutes. ○<br>So, It will be less concentrated at end. ○ |

# Counter Current Exchanger cont.

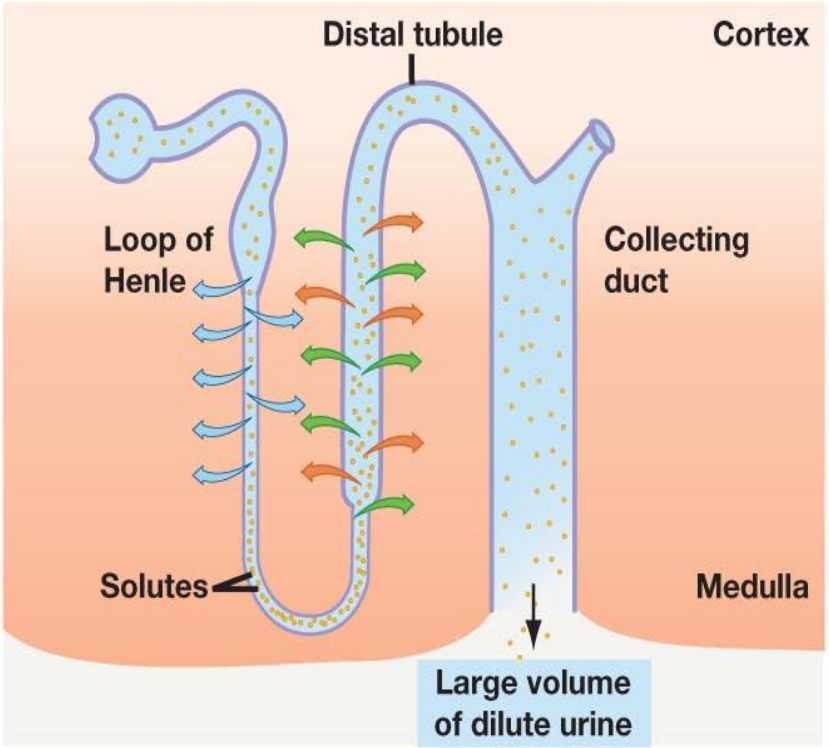


# Role of ADH

**(a) ADH present:** Collecting duct is highly permeable to water.




**(b) No ADH present:** Collecting duct is not permeable to water.



# Water Diuresis & Osmotic Diuresis

**Diuresis mean increase urine output**

Has two ways:

| Water diuresis | Osmotic diuresis |
|---|---|
| Increased urine flow rate (No change in urine excretion of solutes | Increased the flow with a change in the excretion of solutes |
| **Causes:**<br>Excess ingestion of water<br>Lack of ADH<br>Defect in ADH receptors in Distal segment of nephron (nephrogenic Diabetes Insipidus) | **Causes:**<br>- Increase plasma glucose level (DM)<br>- Increase level of poorly reabsorbed solutes/ anions<br>- Diuretic drugs (Lasix) |
| Diuresis is mainly due to decrease in water reabsorption in distal segment of nephron. No change to the water reabsorbed proximally | Diuresis is mainly due to decrease reabsorption of solute in PCT or LOH. Decrease solute reabsorption results in decrease in water reabsorption proximally as well as distally |

# Cont.

| | |
|---|---|
| Increase urine volume results from increased excretion of pure water. | Increase urine volume results from increased excretion of osmotically active solutes which pulls water with it. |
| Urine osmolality falls far below plasma osmolality | Urine osmolality falls but remains above plasma osmolality. |
| Only about 15% filtred load of water reaching distal segments may remain unabsorbed and excreted in urine (maximum urine volume 20 ml/min) | Due to decreased water reabsorption in all segments of nephron, a much greater fraction of filtered water may be excreted volume more than 20 ml/min |
| ADH administration will stop diuresis if it is due to lack of ADH or excess ingestion of water. ADH administration will not be effective in Nephrogenic Diabetes Insipidus. | ADH administration will not stop diuresis. |

# Disorders of Urinary Concentrating Ability

| Diabetes Insipidus | Nephrogenic Diabetes Insipidus | Diabetes Mellitus |
|---|---|---|
| **Cause** | | High specific gravity urine (concentrated urine ) |
| Inability to produce or release ADH | Inability of kidney to respond to ADH | |
| • Urine : low fixed specific gravity (diluted urine)<br>• Polyuria[1]<br>• Polydypsia[2] | Urine : low fixed specific gravity (diluted urine) | |

1: is a condition usually defined as excessive or abnormally large production or passage of urine.

2 : excessive thirst.

Mentioned in Females' slides of Lecture 11

**ADH controls water permeability in the last portion of DCT and Collecting duct.**

| | |
|---|---|
| ADH ⬇ | Dilute urine, Excess water is excreted, Solutes concentration is low. |
| ADH ⬆ | Concentrated urine, Most water is reabsorbed, Solutes concentration is high. |

| Counter-Current Multiplier | Counter-Current Exchanger |
|---|---|
| Produces Hyperosmotic Renal Medulla. | Maintains Hyperosmotic Renal Medulla. |
| Loop of Henle | Vasa Recta |

| Disorders of Urinary Concentrating Ability | | |
|---|---|---|
| **Diabetes Insipidus** | **Nephrogenic Diabetes Insipidus** | **Diabetes Mellitus** |
| Inability to produced or release of ADH, urine will be diluted. | Inability to respond the ADH, urine will be diluted. | Urine will be concentrated. |

Summary

# MCQs

**1- The countercurrent mechanism happens in?**

A. Cortical nephron
B. Juxtamedullary nephron
C. Non of them

**2- In the thin ascending limb the NaCl transmuted from the tubule by:**

A. Active transport
B. Passive transport
C. The TAL is impermeable to NaCl

**3- In which of the following conditions the urine will be concentrated:**

A. Nephrogenic diabetes insipidus
B. Diabetes insipidus
C. Diabetes mellitus

# SAQs

**4- The cause of Nephrogenic diabetes insipidus is ?**

No response from the kidney to ADH

**5- Mention tow conditions that increase medullary blood flow**

1- Osmotic diuresis
2- Decrease urine concentrating ability

**6- Mention three factors that create the hyerosmolar medulla**

*Active transport of Na
*Facilitated diffusion of large amounts of urea
*Passive reabsorption of NaCl

1.B
2.B
3.C

Questions

THANK YOU FOR CHECKING OUR WORK!

# BEST OF LUCK

## Done By:

- Abdulaziz Alsolimi
- Bandar Alsarani
- Hadeel Alsulami
- Nouf Almasoud