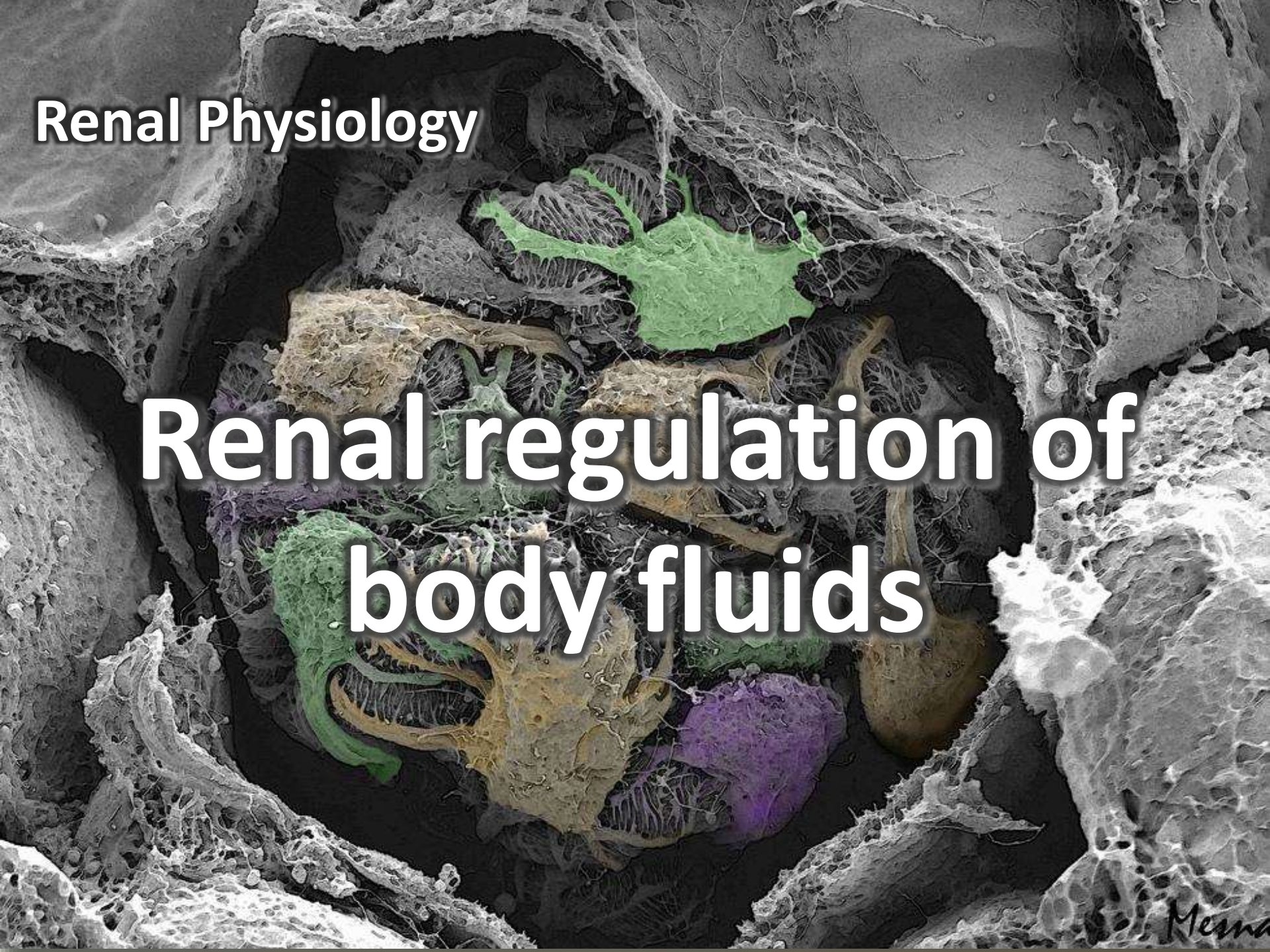
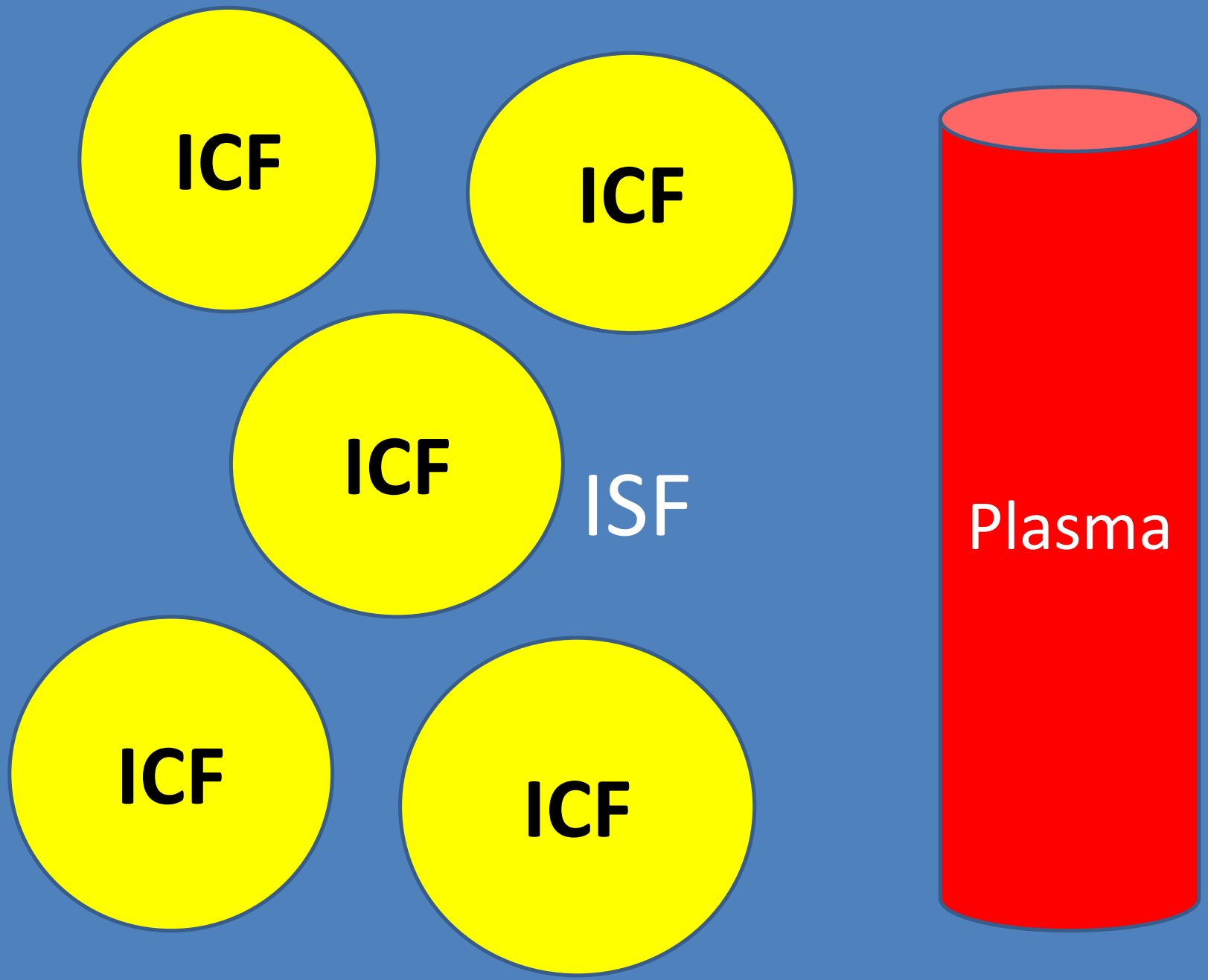

بسم الله الرحمن الرحيم

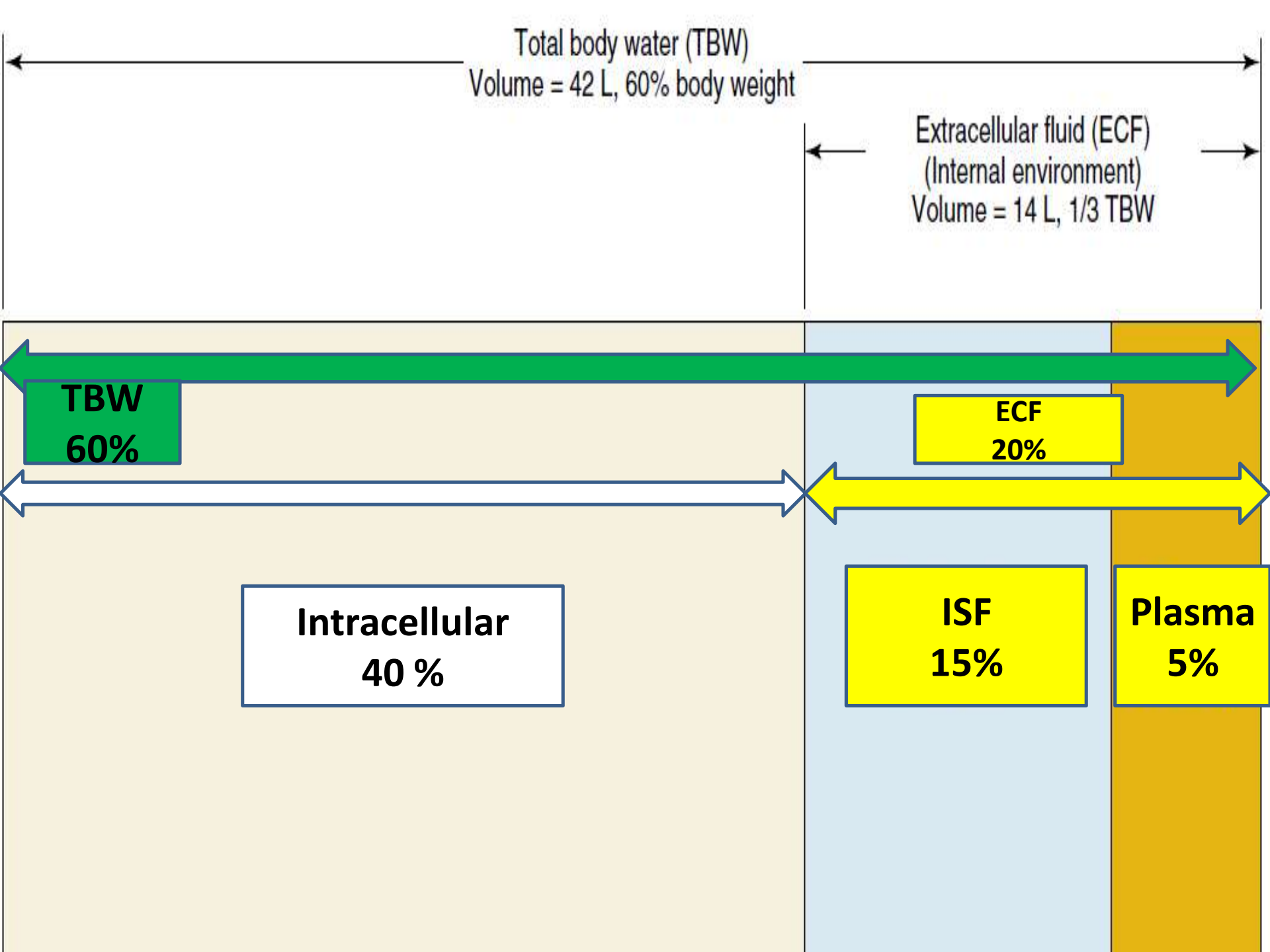
قَالُوا۟ سُبْحَٰنَكَ لَا عِلْمَ لَنَآ إِلَّا مَا عَلَّمْتَنَآ ۖ إِنَّكَ أَنتَ ٱلْعَلِيمُ ٱلْحَكِيمُ ﴿٣٢﴾

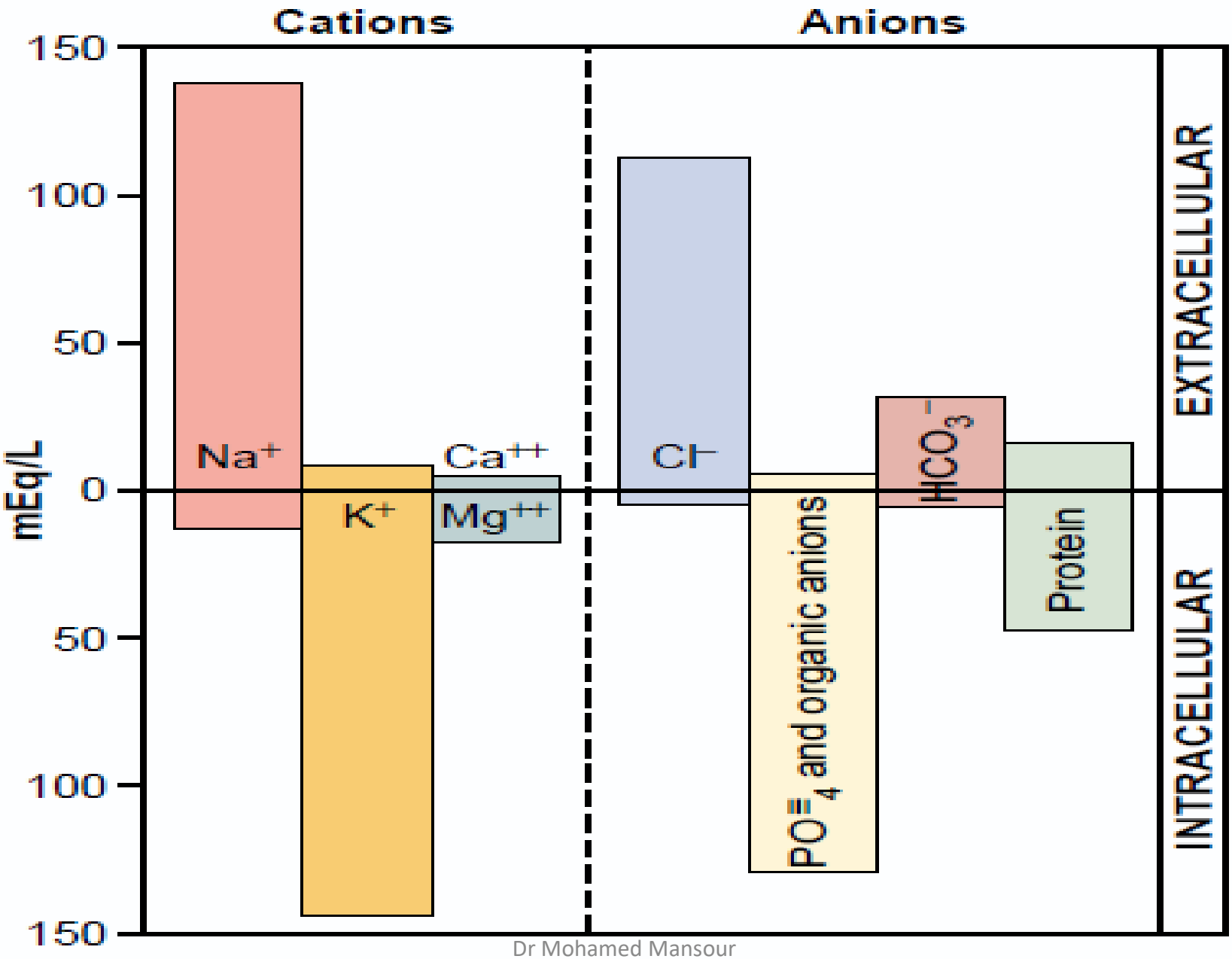
Renal Physiology

Renal regulation of body fluids



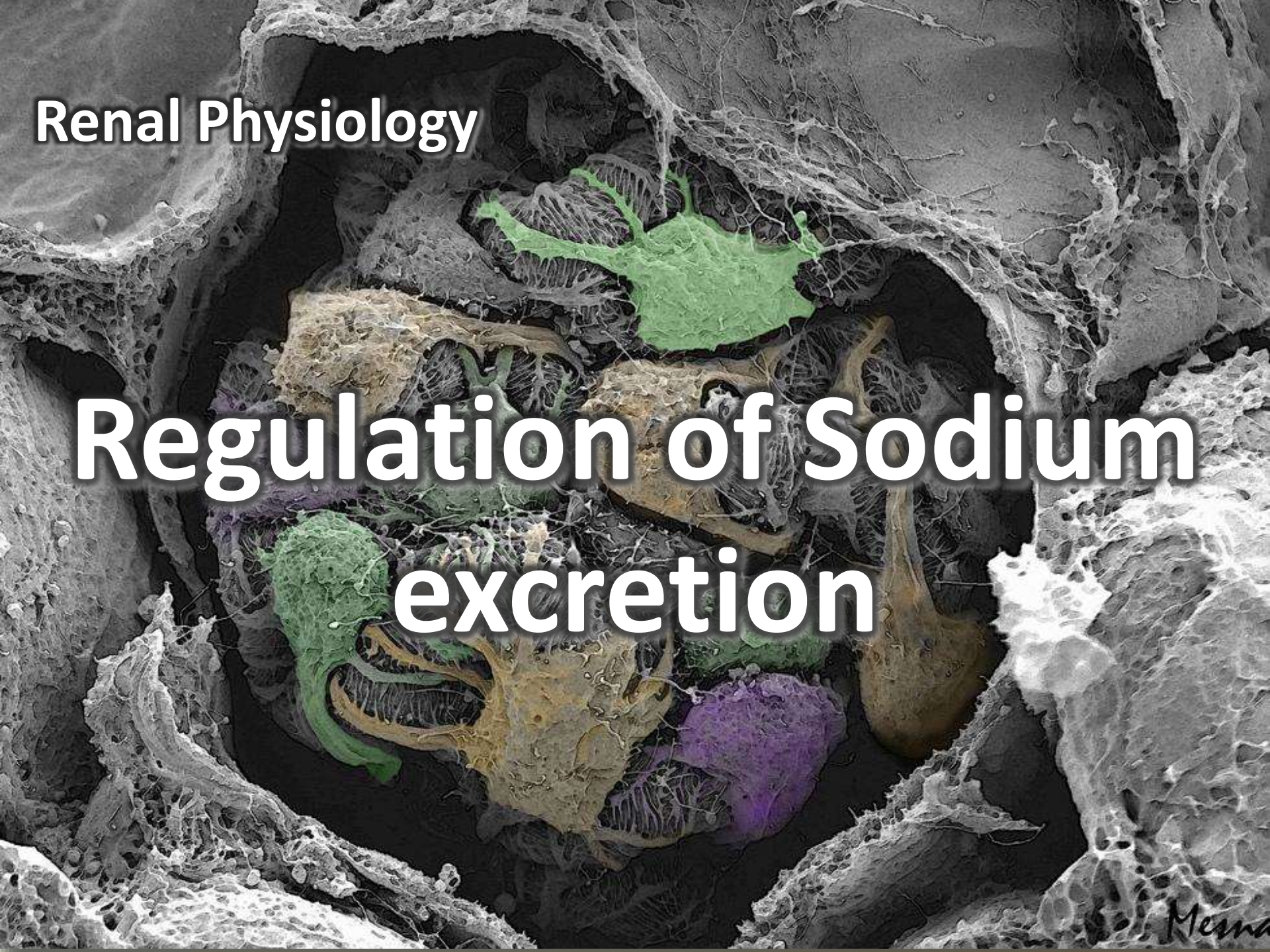

ICF
ICF
ICF
ISF
Plasma
ICF
ICF


Total body water (TBW)
Volume = 42 L, 60% body weight
Extracellular fluid (ECF)
(Internal environment)
Volume = 14 L, 1/3 TBW
TBW
60%
ECF
20%
Intracellular
40 %
ISF
15%
Plasma
5%

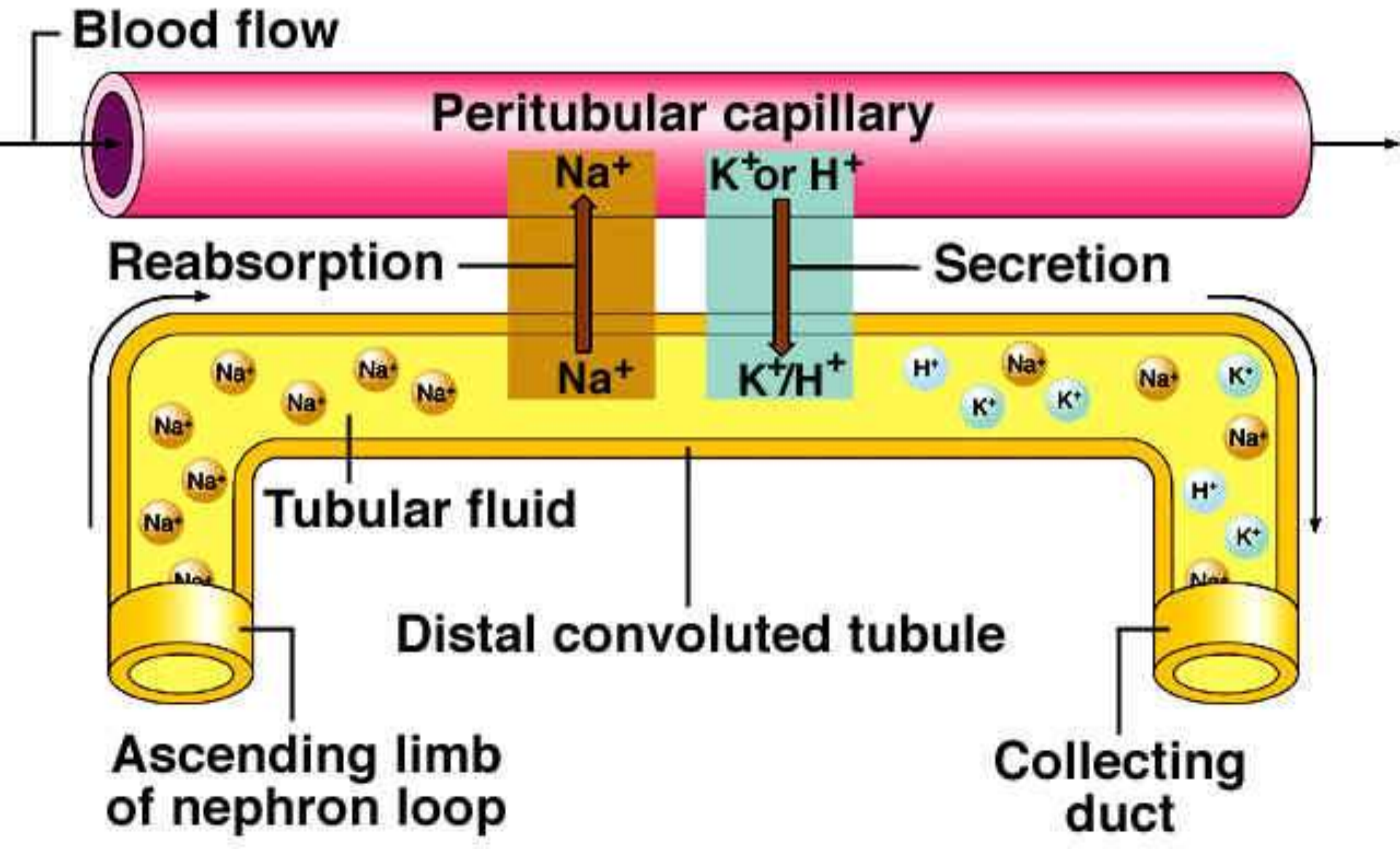

Cations
Anions
150
100
50
0
50
100
150
mEq/L
Na+
K+
Ca++
Mg++
Cl−
PO≡4 and organic anions
HCO−3
Protein
EXTRACELLULAR
INTRACELLULAR

Renal Physiology

Regulation of Sodium excretion



Tubular Reabsorption and Secretion



Regulation of Na^+ Excretion.

Na^+ is the main extra cellular cation.

The amount excreted is adjusted to equal amount ingested.

Urinary Na^+ output ranges between

1-400 mEq/d depending on intake.

Na^+ excretion is affected by:

Amount filtered.

Amount reabsorbed.

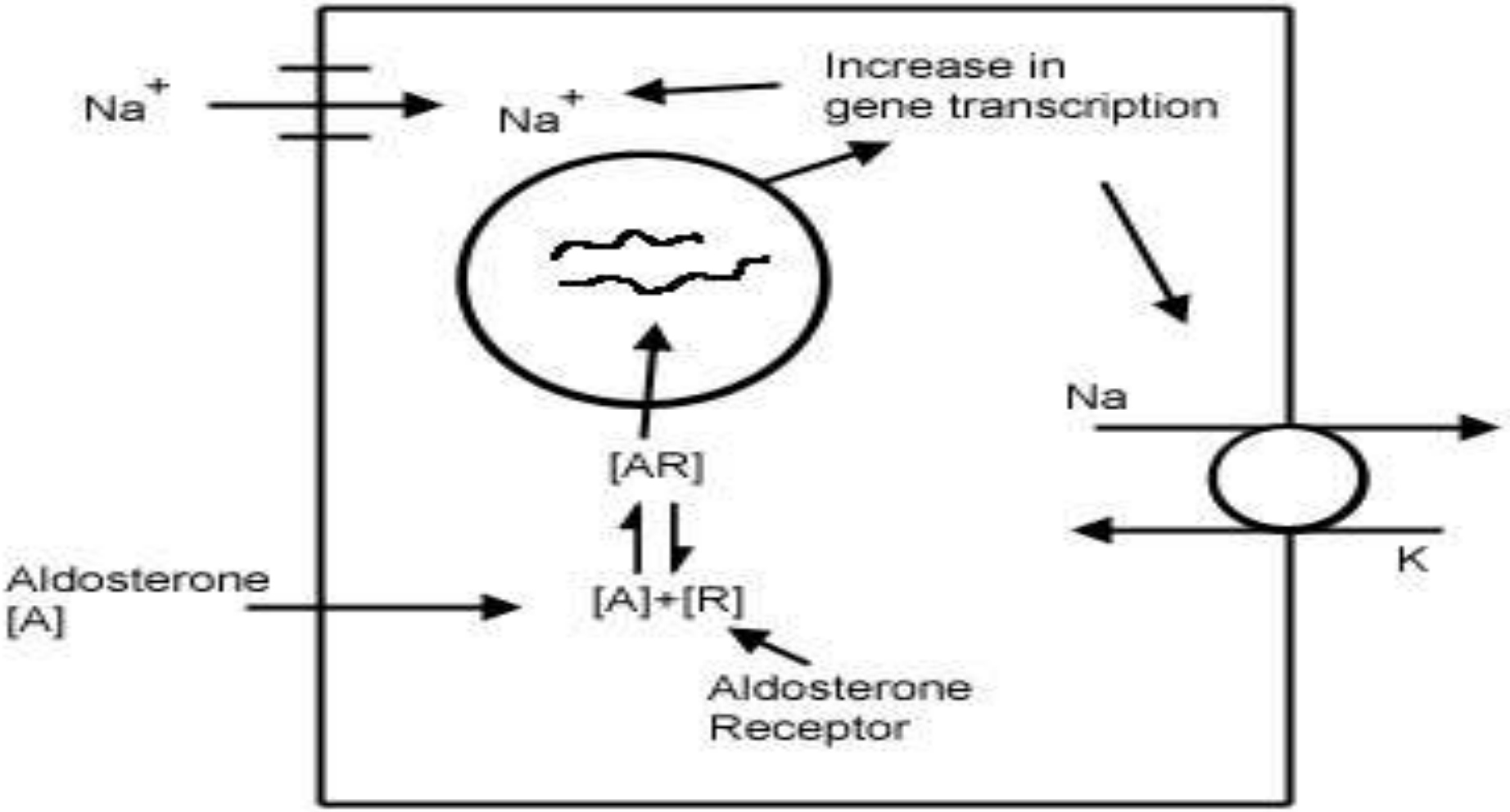
So, factors influencing GFR and tubular reabsorption will affect renal Na^+ excretion.

1- Hormonal control of Sodium reabsorption.

a) Mineralocorticoids (Aldosterone).

- ↑ Na^+ reabsorption in exchange with K^+ or H^+ excretion at the P cells of DCT & CD.
- **Mechanism:**
- ↑ Number of Na^+ channels at the apical membrane of P cells.
- Stimulate Na^+-K^+ pump at basolateral membrane.

Mechanism of Action of Aldosterone.



b) Glucocorticoids

- Have weak mineralocorticoid activity.

c) Angiotensin II

- Most powerful Na^+ retaining hormone.
- Mechanism:

1-↑ Aldosterone secretion.

2- Direct action on PCT through:

- Stimulation of Na^+-K^+ ATPase.
- Stimulation of Na^+- H^+ counter transport.

d) Sex hormones

- **Estrogen↑ Na^+ reabsorption.**

e) ANP

- **↑Na^+& H_2O excretion under conditions of marked expansion of ECF.**

Systemic Regulation by Hormones

Renin-Angiotensin System (RAS)

- Hypovolemia & hypotension.
- Renal ischemia (e.g. renal artery stenosis).
- Decreased Na+ delivery to distal tubule of the nephron.
- Sympathetic stimulation (via β1 adreno-receptors).

Angiotensinogen

↓ **Renin** ← JGA+

Juxta Glomerular Apparatus of Kidney

Angiotensin I

↓ ACE

Angiotensin converting enzyme

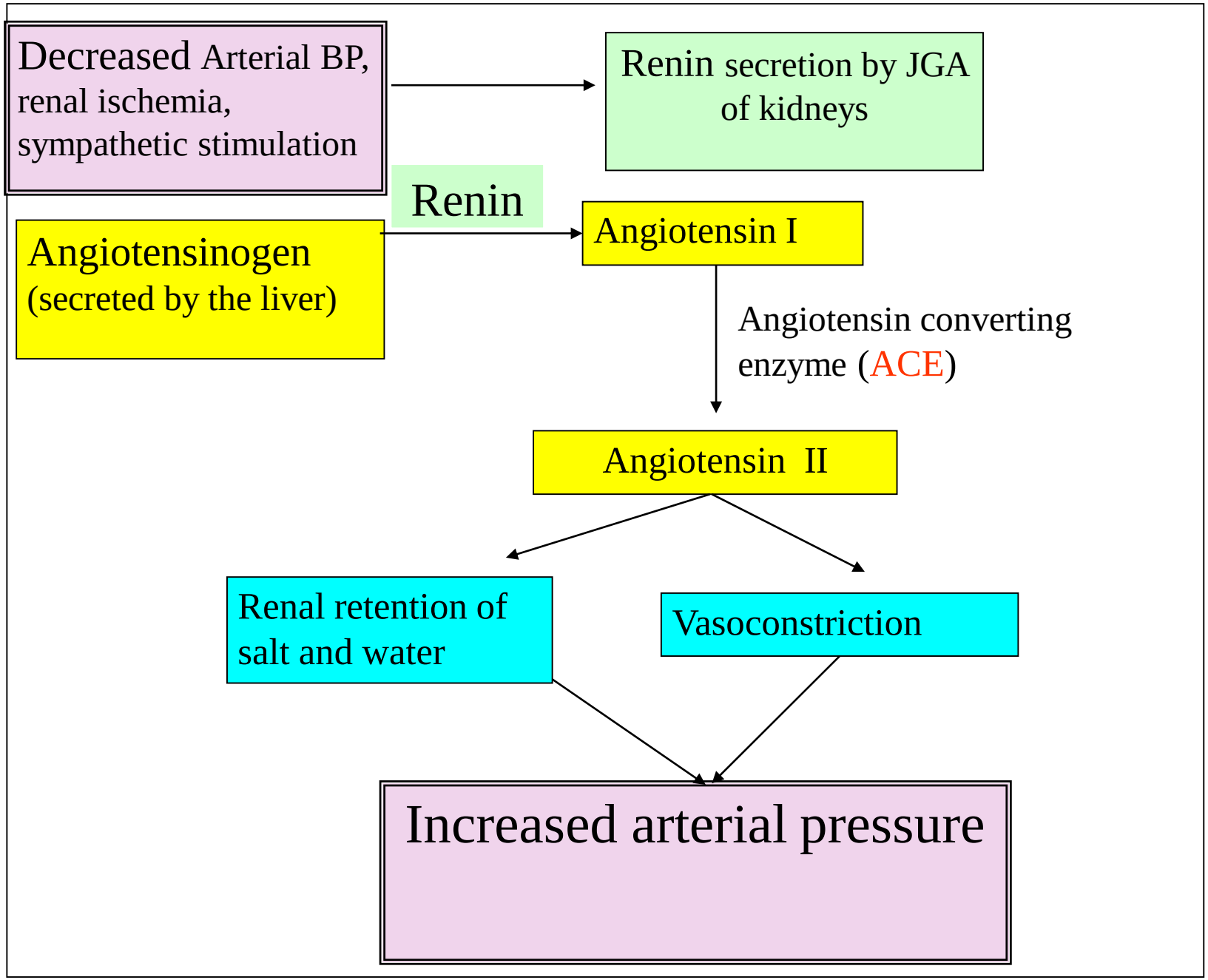
Angiotensin II

Systemic Regulation by Hormones

Renin-Angiotensin System (RAS)

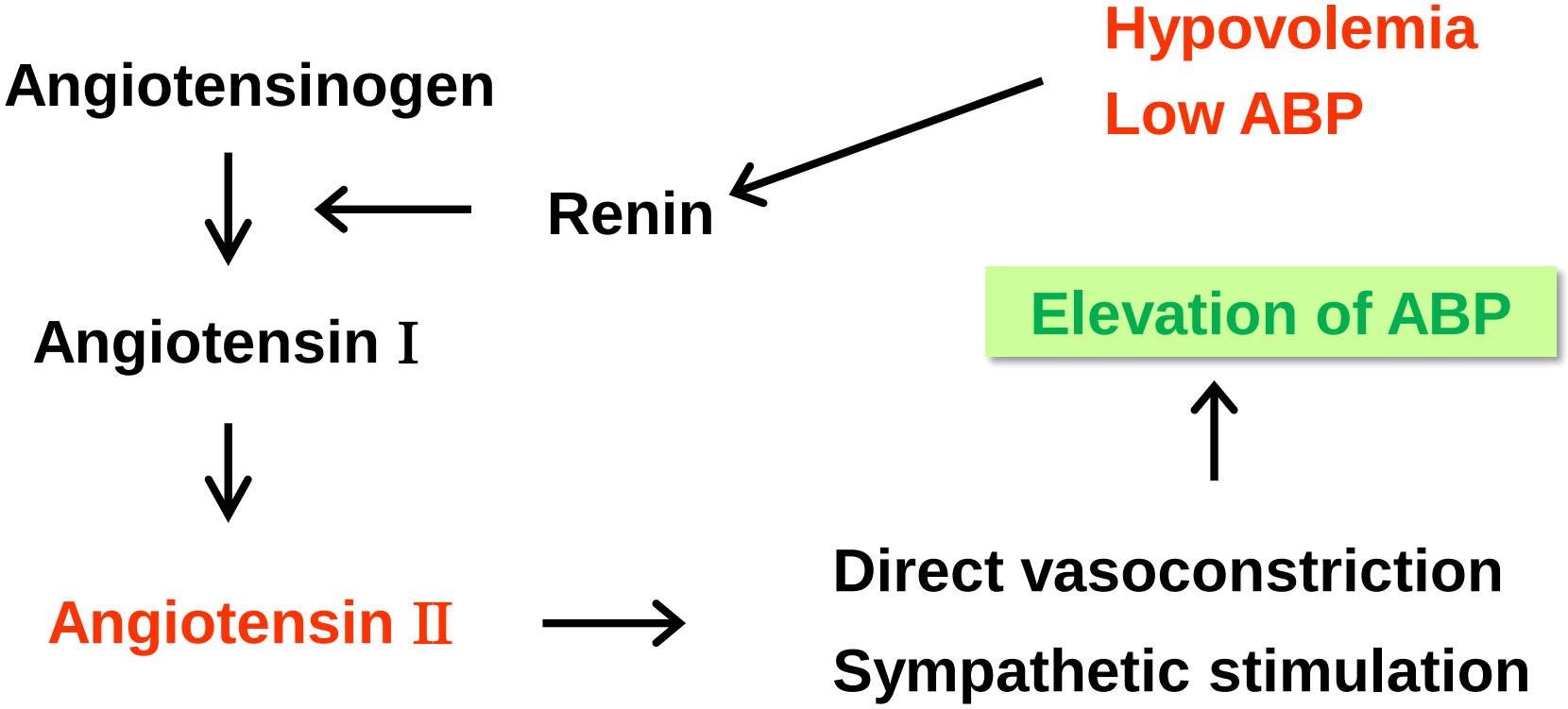
Actions of angiotensin II via AT_1

1. Vasoconstriction
2. Aldosterone secretion from adrenal cortex.
3. reabsorption of Na^+ by distal renal tubules.


Decreased Arterial BP, renal ischemia, sympathetic stimulation
Renin secretion by JGA of kidneys
Renin
Angiotensinogen (secreted by the liver)
Angiotensin I
Angiotensin converting enzyme (ACE)
Angiotensin II
Renal retention of salt and water
Vasoconstriction
Increased arterial pressure

Long Term Regulation of Arterial Pressure
Renal-Body Fluids Mechanism

Renin-Angiotensin System vasoconstriction

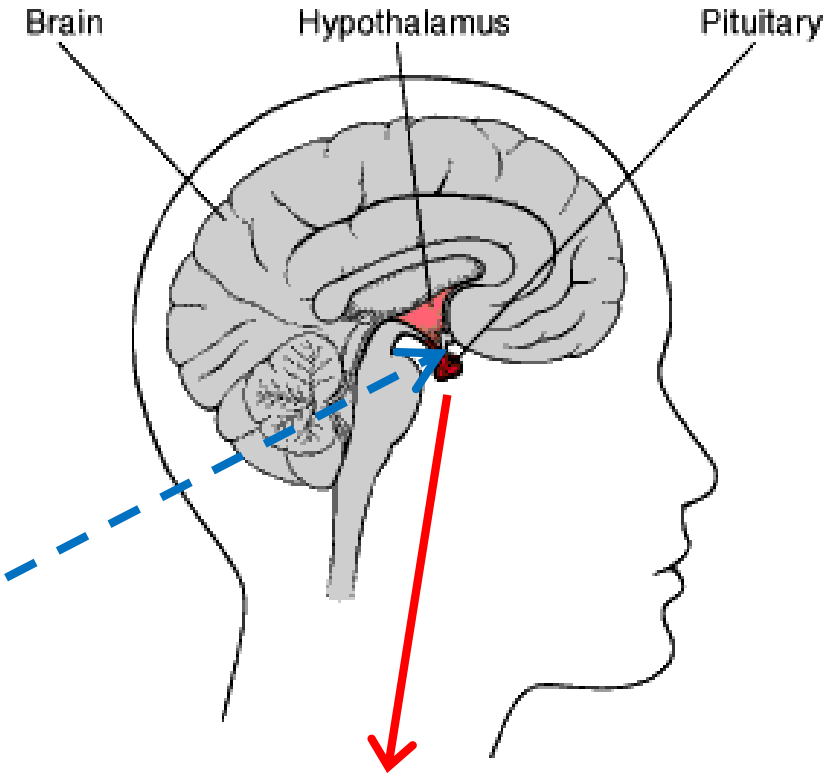


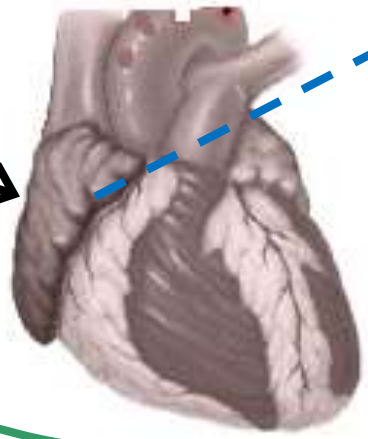
ADH hormone (Vasopressin)

Vasopressin secretion

Decreased ECF volume

\+





Vasopressin

↓

Decrease water excretion by Kidneys

Osmolarity

Volume

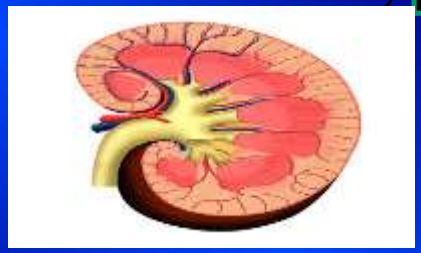
Osmolarity

Volume

Hypothalamus (Osmoreceptors)

Posterior Pituitary gland

ADH



V2 receptors
Antidiuretic action
Water retention Via
Aquaporin II channels

Vasopressor action (VC)
V1 receptors

H_2O permeability

H_2O permeability in distal tubule is variable, which means that sometimes it is high and sometimes it is low.

Examples:

- H_2O diuresis with increased H_2O intake – this causes distal tubule to decrease permeability and produce dilute urine
- Dehydration causes increased H_2O reabsorption resulting in concentrated urine (max of 1200 mOsm)

The permeability of the distal tubule to H_2O is regulated by "antidiuretic hormone" (ADH) or Vasopressin.

Control of Water Intake

- Drinking is largely by habit! That is, we drink enough which, under normal conditions, does not make us thirsty. Thirst is an emergency mechanism when there is a lack of water.
- Stimuli for thirst is similar to osmoreceptors which produce and release ADH.
- Major mechanism for causing sensation of thirst is an ‘intracellular dehydration’ – mainly due to ↑ Osmolality of extracellular fluid

Long Term Regulation of Arterial Pressure
Renal-Body Fluids Mechanism

Atrial natriuretic peptides secretion

Increased ECF volume → Elevation of ABP

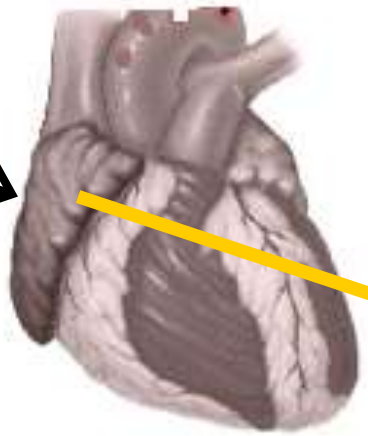
Decrease ABP

↑

Decreased ECF volume

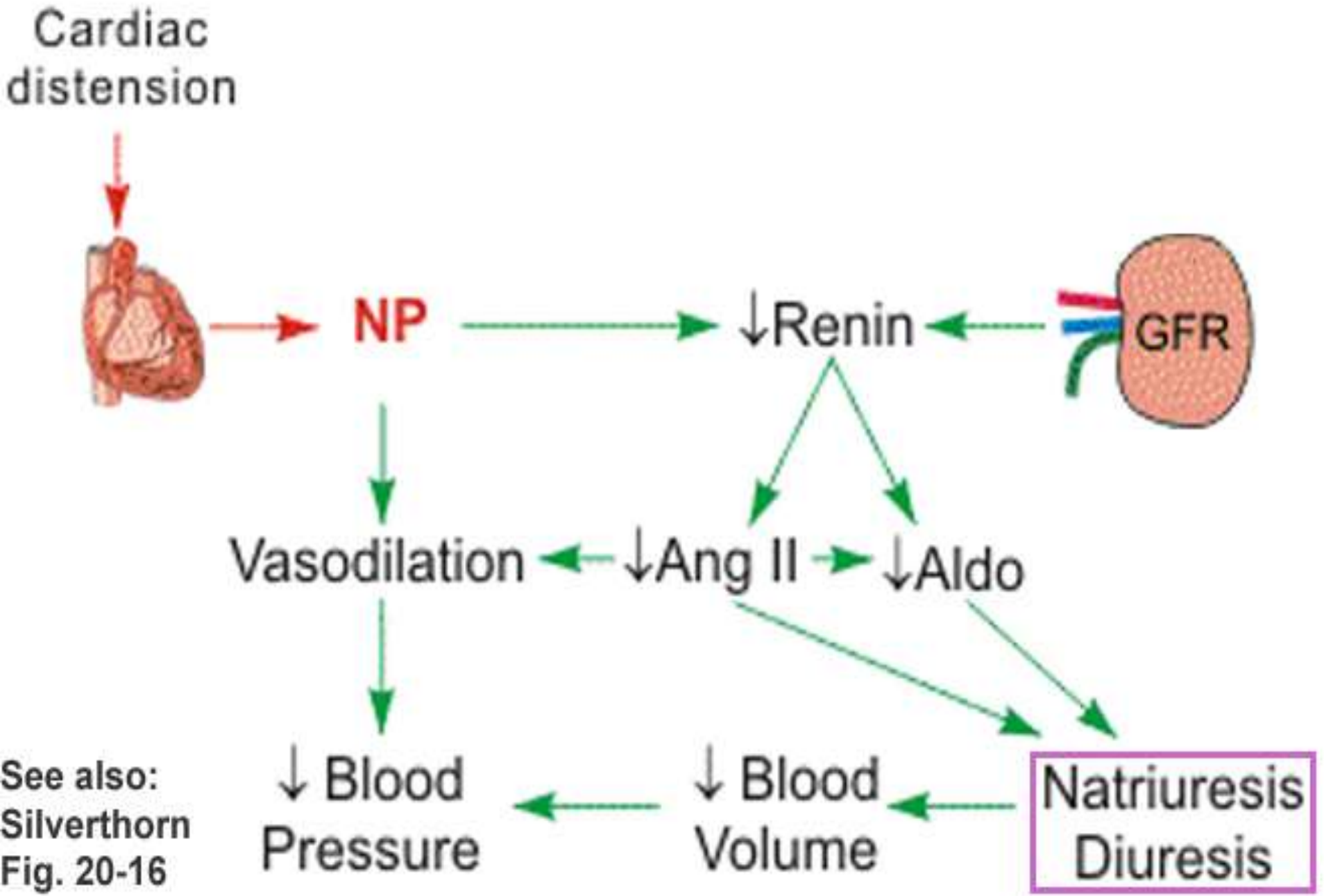
↑

Na^+ & Water excretion ← A N P ← Atrial stretch



- **Mechanism of action of ANP:**
- **↑ GFR by relaxation of mesangial cells & VD of afferent arteriole.**
- **↓ Renin secretion.**
- **↓ Na^+ reabsorption at CD directly by:**
- **Inhibition of Na^+ channels at apical membrane.**
- **Inhibition of Na^+-K^+ ATPase at basolateral membrane.**

Actions of the Natriuretic Peptides (NP)



See also: Silverthorn Fig. 20-16

f) PGE_2 ↑ Na^+ excretion through:

- **Inhibit apical Na^+ channels.**
- **Inhibit Na^+-K^+ ATPase.**

(Action similar to ANP and opposite to aldosterone).


Thank
You!

Diabetes Insipidus (*Disorders of urinary concentration*)

1. **Central diabetes insipidus**:

- Deficiency of ADH secretion due to lesion of the hypothalamus, hypothalamo-hypophyseal tract or posterior pituitary.

2. **Nephrogenic diabetes insipidus**:

- Inability of the kidney to respond to ADH e.g. congenital defect in the V_2 receptors in the collecting duct.

Diabetes Insipidus (Symptoms)

1) **Polyuria** : Passage of large amounts of dilute urine. (with NO glucose in urine)

2) **Polydipsia** : Drinking of large amounts of fluid.

It is the polydepsia that keeps these patients healthy. If the sense of thirst is depressed by loss of consciousness, these patients develop fatal dehydration.

	Central DI	Neprogenic DI
ADH level	Low	Normal or high
Treatment	ADH (Desmopressin)	Drugs to increase ADH sensitivity (Thiazide diuretics)

Thank you