بسم الله الرحمن الرحيم

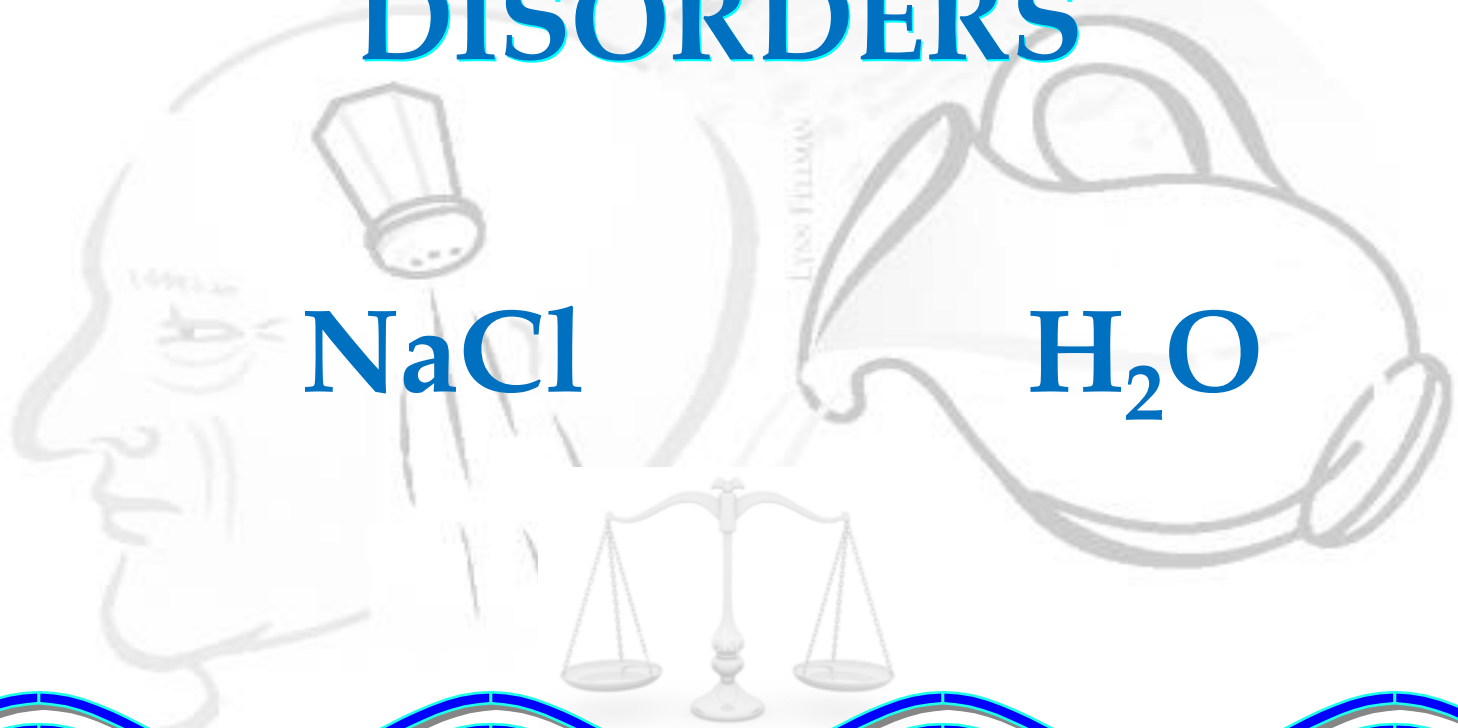
"رب اشرح لي صدري

ويسر لي أمري

واحلل عقدة من لساني

يفقهوا قولي"

SODIUM AND WATER DISORDERS



NaCl H_2O

SODIUM & WATER DISORDERS

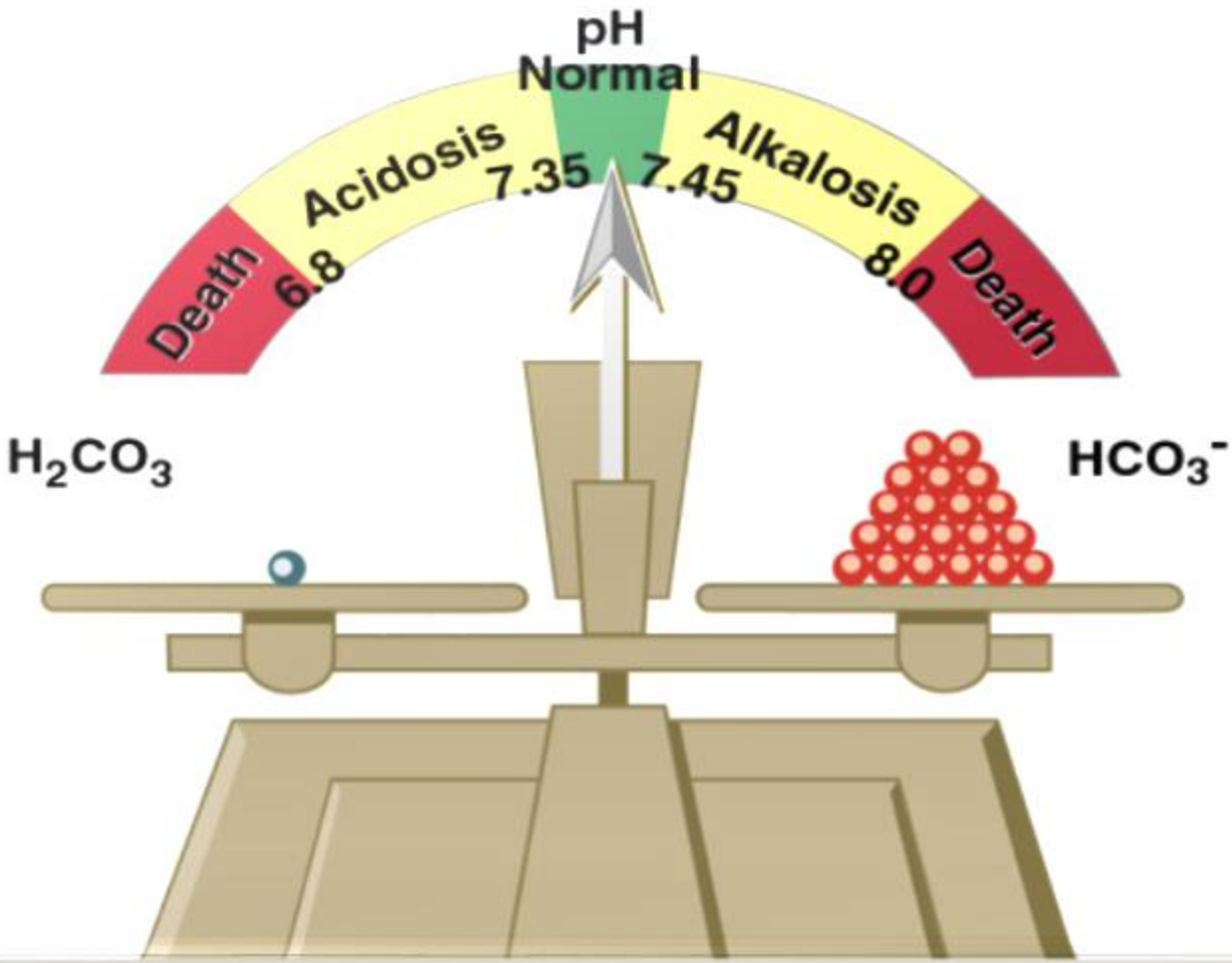
Definitions

- Hypernatremia & hyponatremia (135-145)
- Hypervolemia & hypovolemia (50 meq/Kg)
- Hypovolemia vs. dehydration
- Proportionate and disproportionate disorder
- Hyperosmolar & hypertonic (urea vs. glucose)
- Pseudohyponatremia (Isotonic hyponatremia)
- Translocation hyponatremia (Hypertonic)
- Acute vs. chronic (48 hrs)

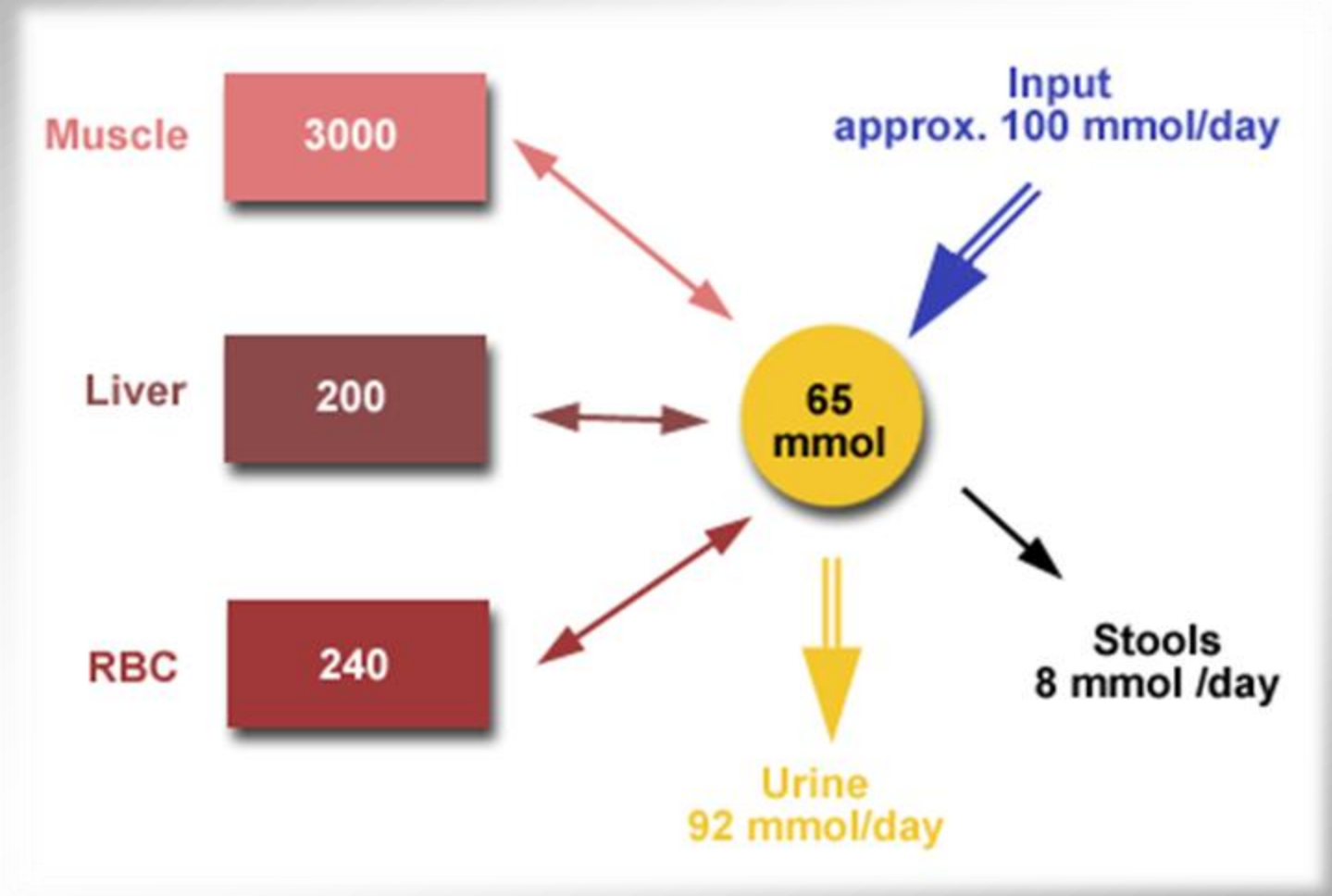
The Concept of Balance and Steady Stat

- Hydrogen ion (acid-base) balance
- Potassium, calcium, phosphorous, magnesium, etc…
- Water balance
- Sodium and volume balance
- Energy (calories) balance

Acid-Base Balance



Potassium Balance (3.5-5.0 mEq)

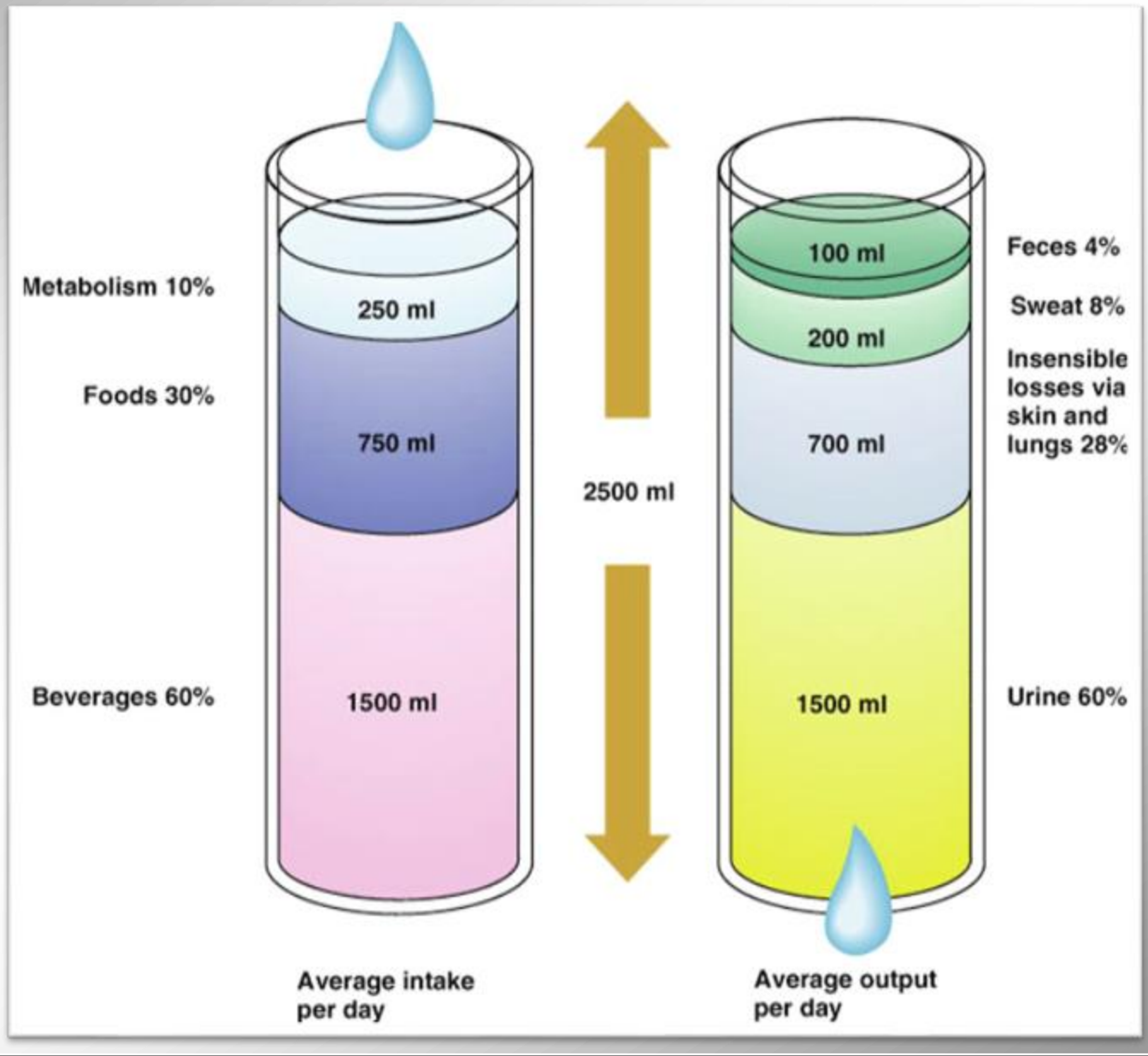


Water Balance

Daily filtration:

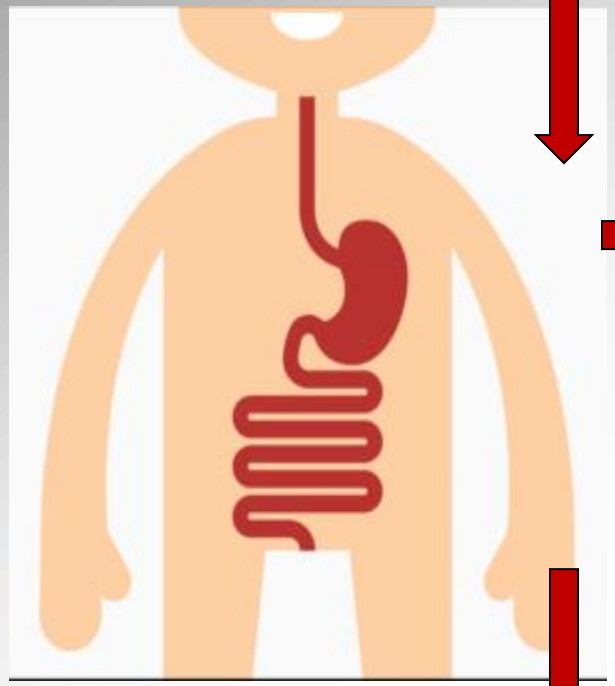
Water 180 Lt

Sodium 25000 mEq



Sodium Balance

Sodium intake
100-300 mmol /day



Sodium Output
5 mmol /day in feces

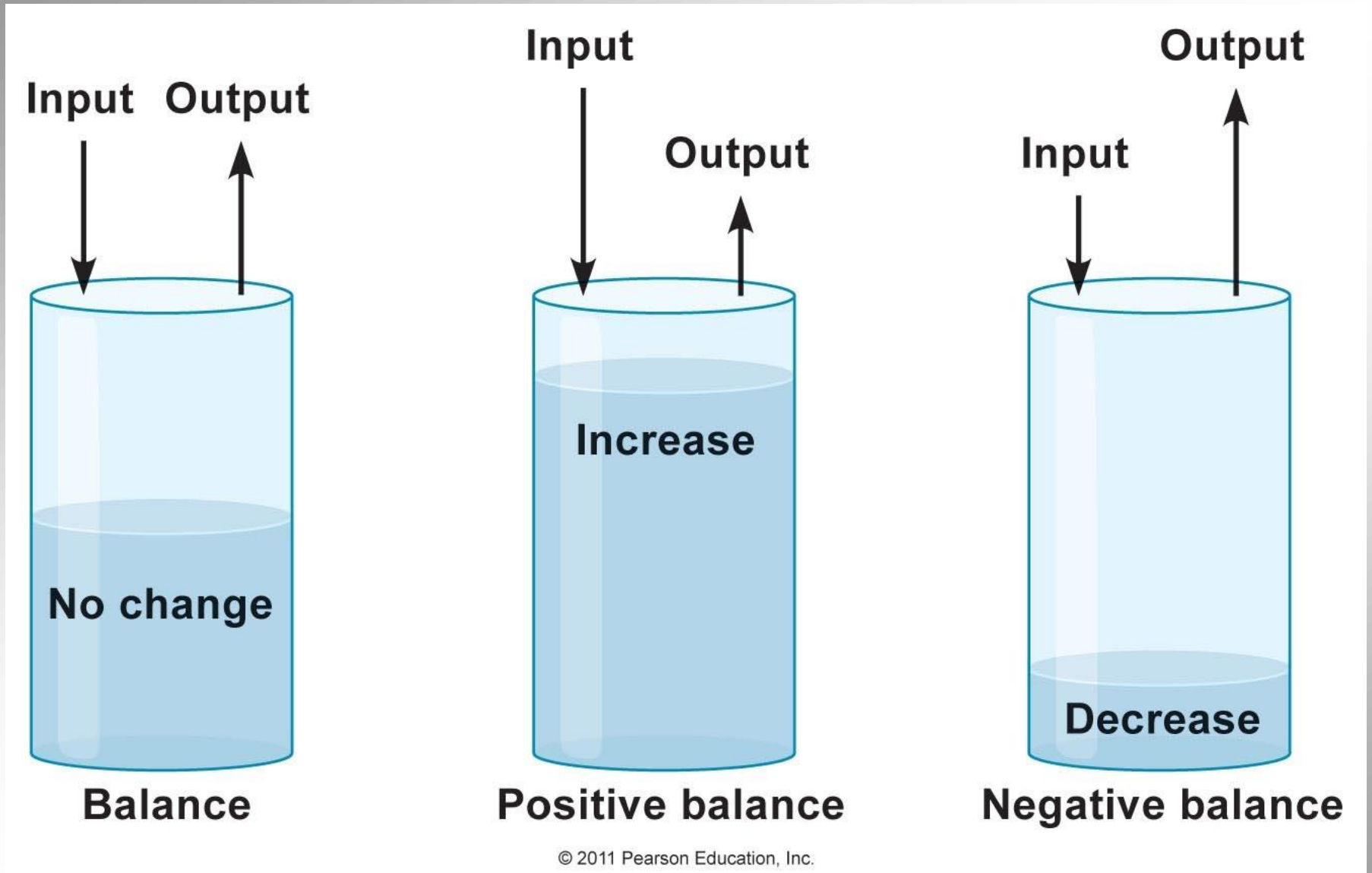
Body distribution
3700 mmol

Bones and tissues
25%

ECF
75%

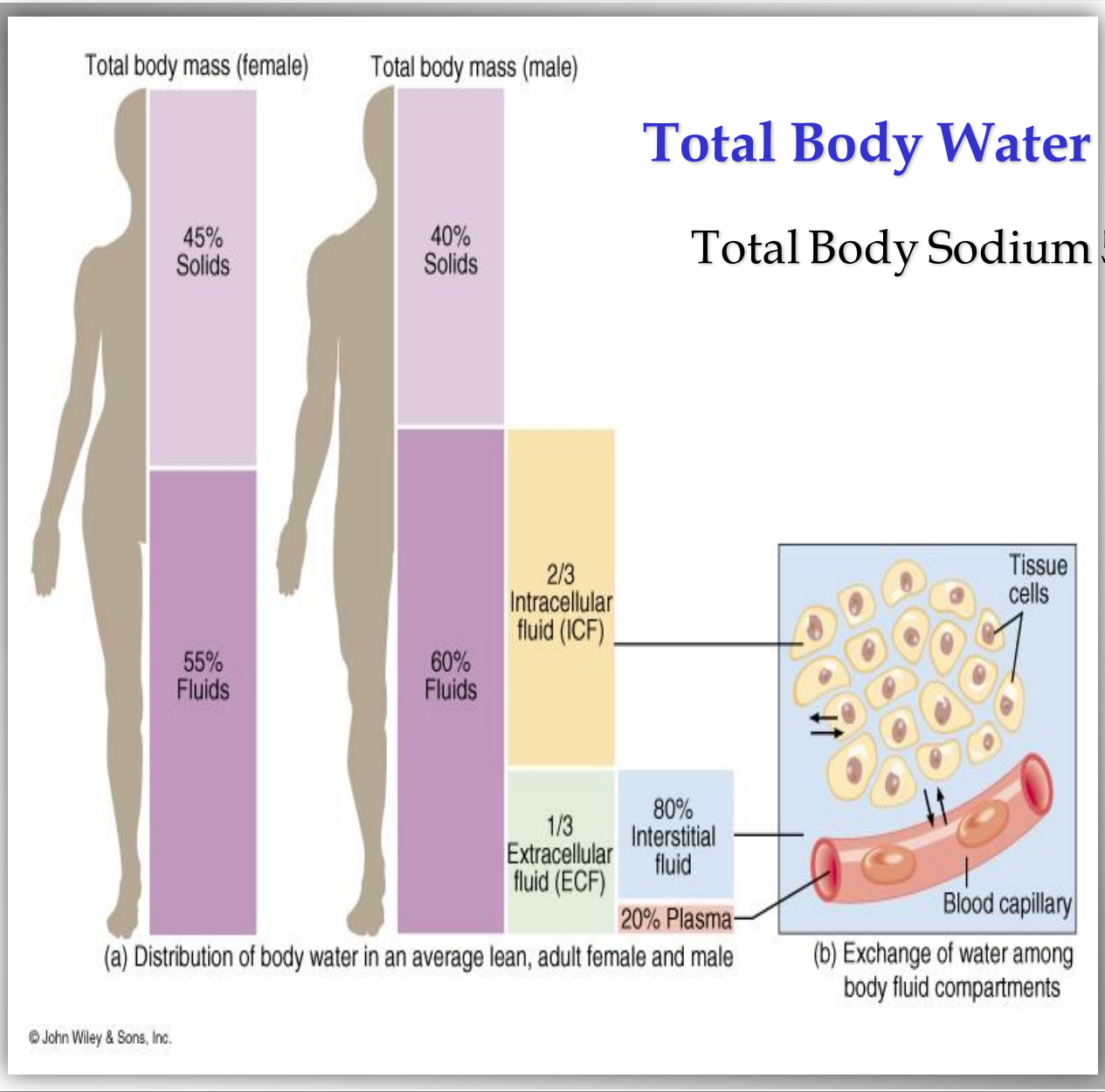
Renal losses
match intake

Sweat
5 mmol/day



Total Body Water (sex & age)

Total Body Sodium 50 meq/Kg



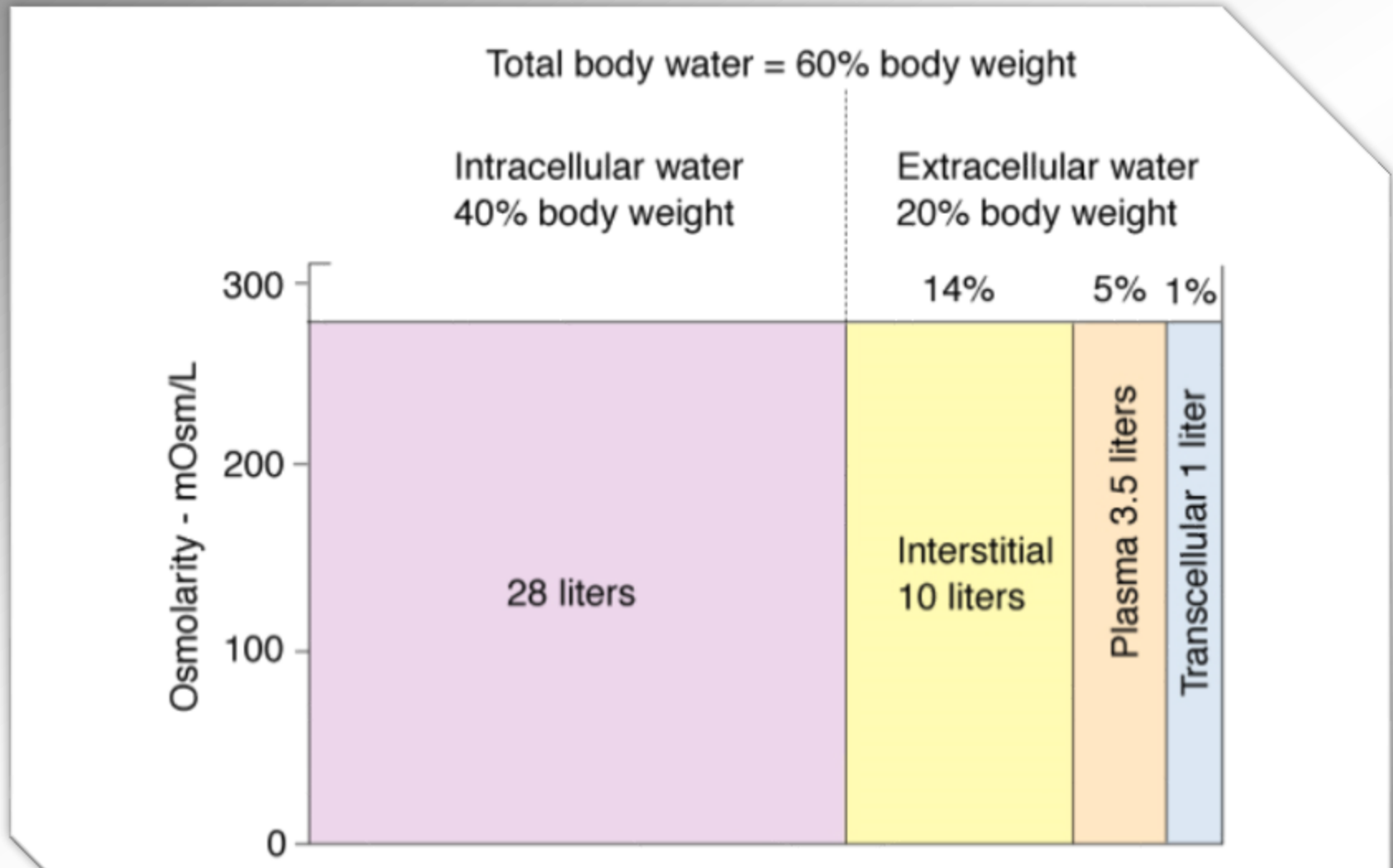
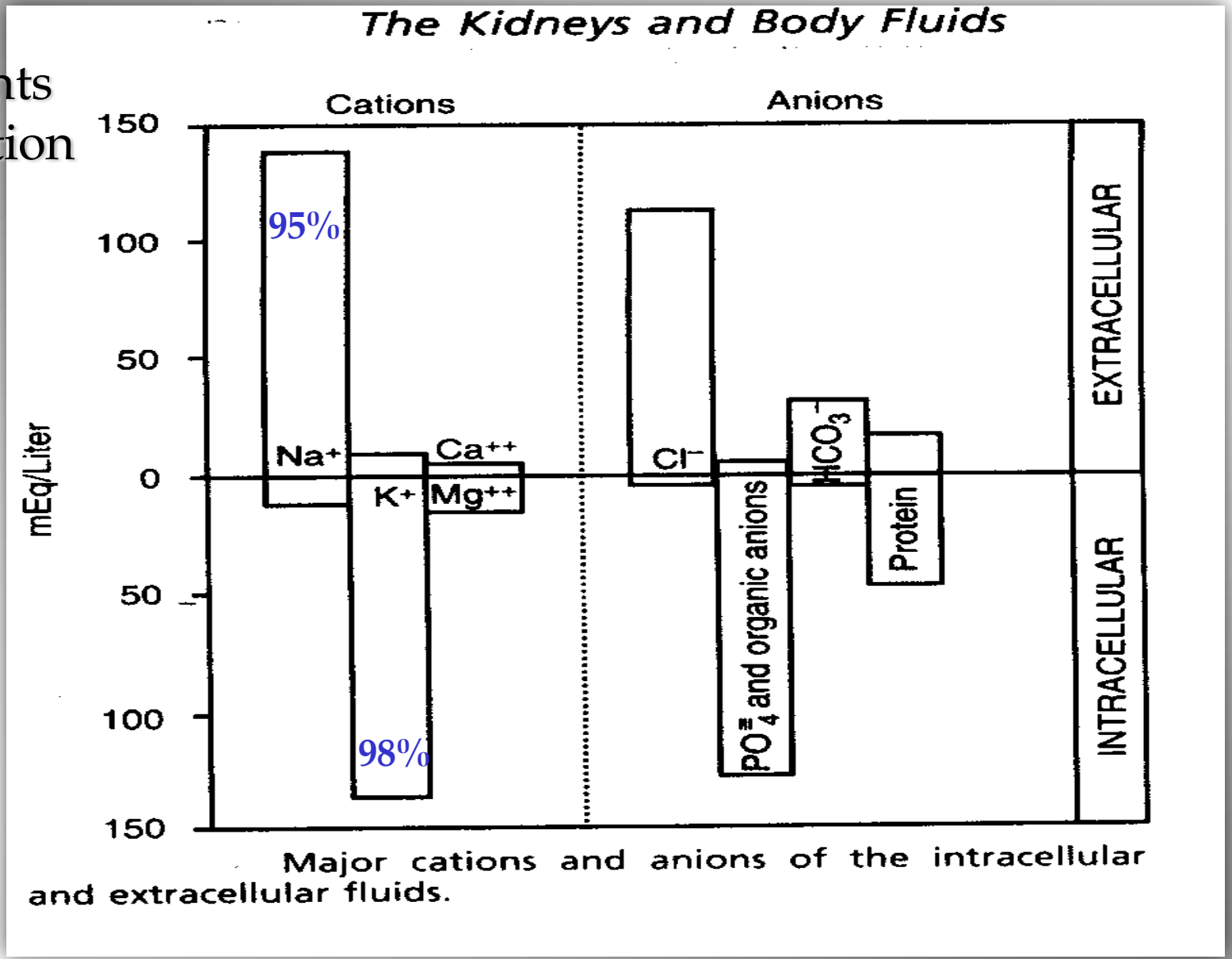


Figure 33-4 Approximate size of body compartments in a 70-kg adult.

Compartments Ions Distribution



Major cations and anions of the intracellular and extracellular fluids.

Concepts of:

1- FS forces

2- Diffusion

3- Osmosis

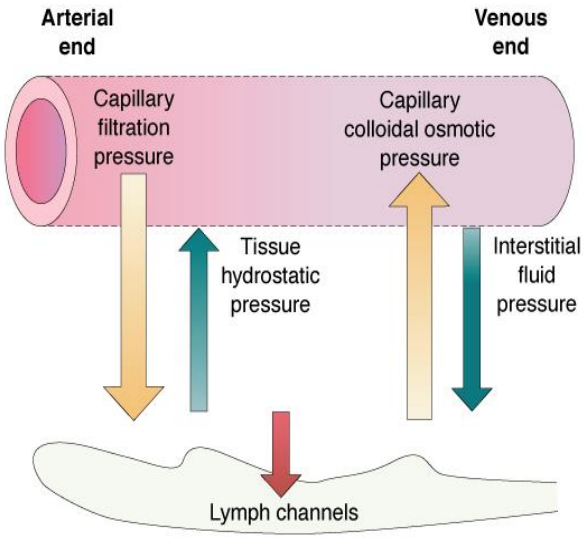


Figure 33-5 Exchange of fluid at the capillary level.

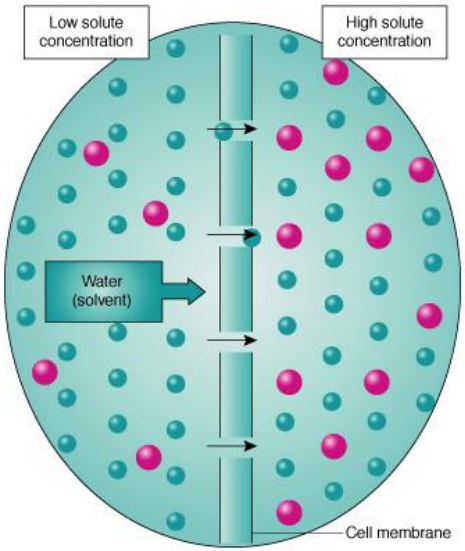


Figure 46-3 Body fluids are transported through cell membranes through the process of osmosis. Water, a solvent, moves from an area of lesser solute concentration to one of greater solute concentration, until equilibrium is established.

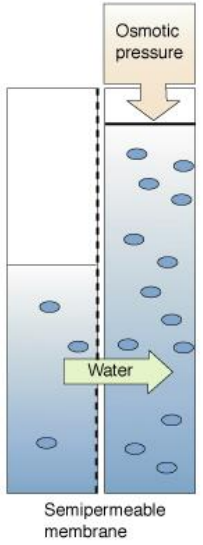


Figure 33-2 Movement of water across a semipermeable membrane. Water moves from the side that has fewer nondiffusible particles to the side that has more. The osmotic pressure is equal to the hydrostatic pressure needed to oppose water movement across the membrane.

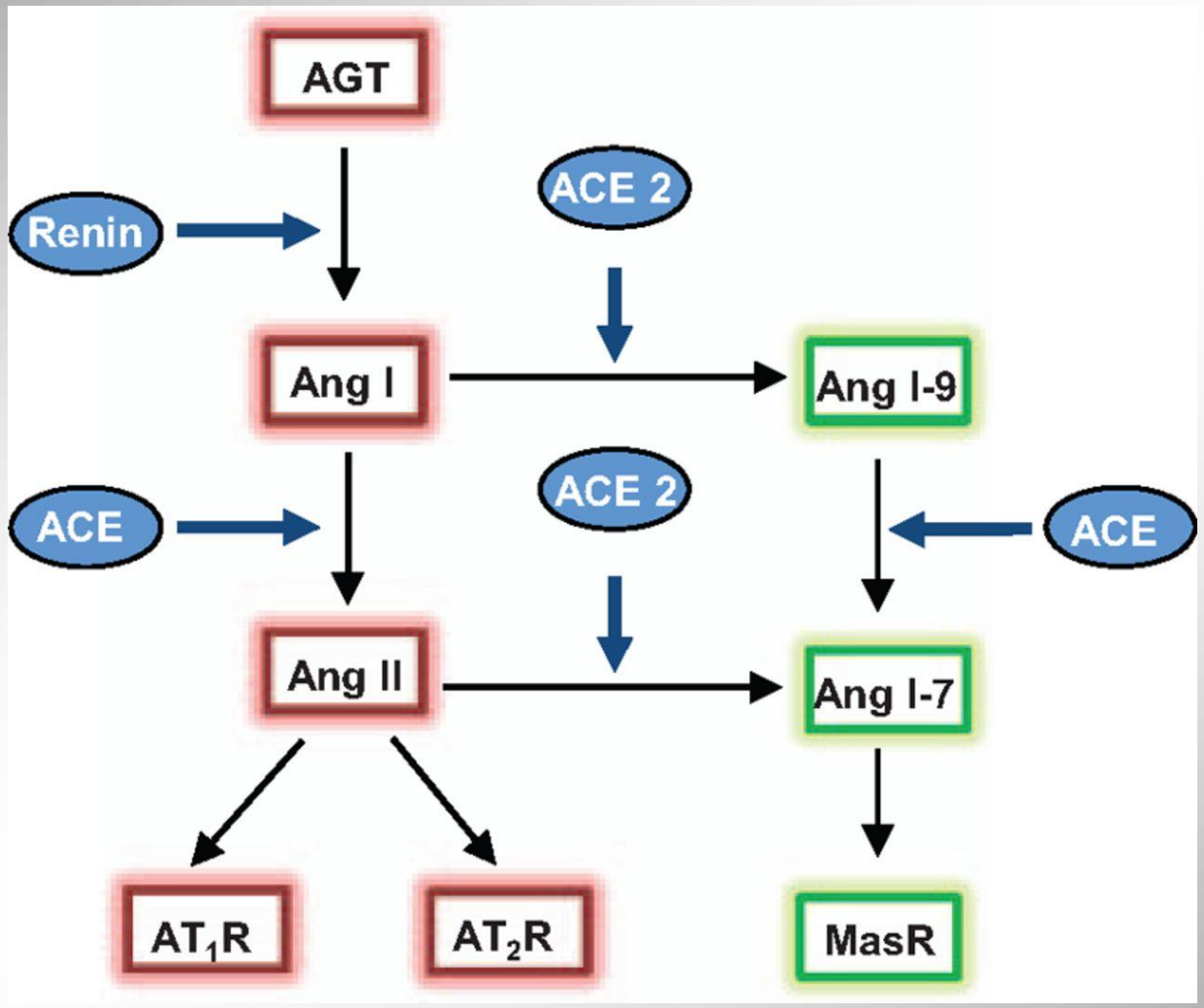

LYNN FELLMAN

Calculated Serum Osmolality= 2Na+urea+glucose

Measured Serum Osmolality= (Nl: 280-290 mOsm/l

Normal Serum Osm Gap (Measured-Calculated)= (-14 to +10)

RAAS System


AGT
Renin
ACE 2
Ang I
Ang I-9
ACE
ACE 2
ACE
Ang II
Ang I-7
AT1R
AT2R
MasR

H2O= 1000 ml

NaCl= 9000 mg

Na= 154 mmol

Cl= 154 mmol

Osm= 308 mOsmol

S. Osm= 2Na+Glu+Urea+X

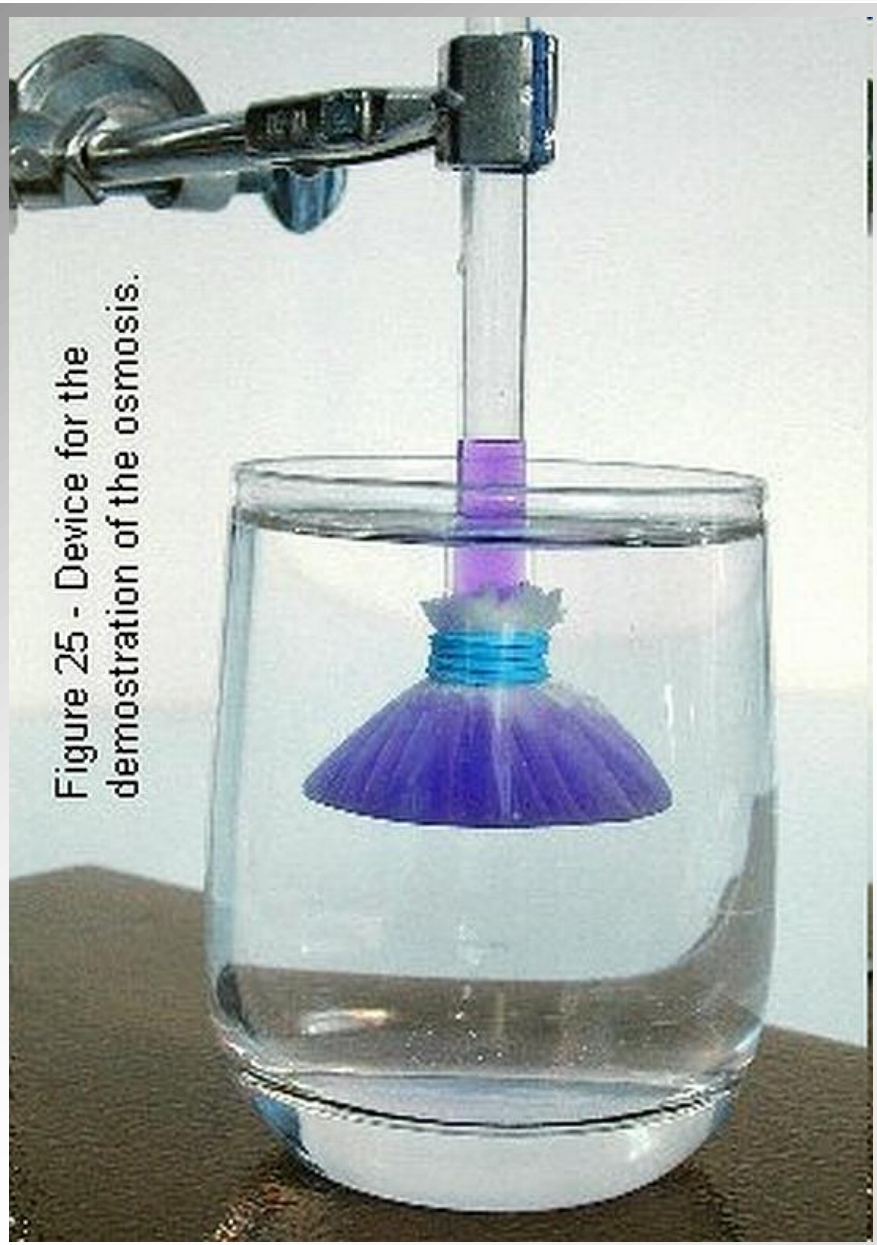
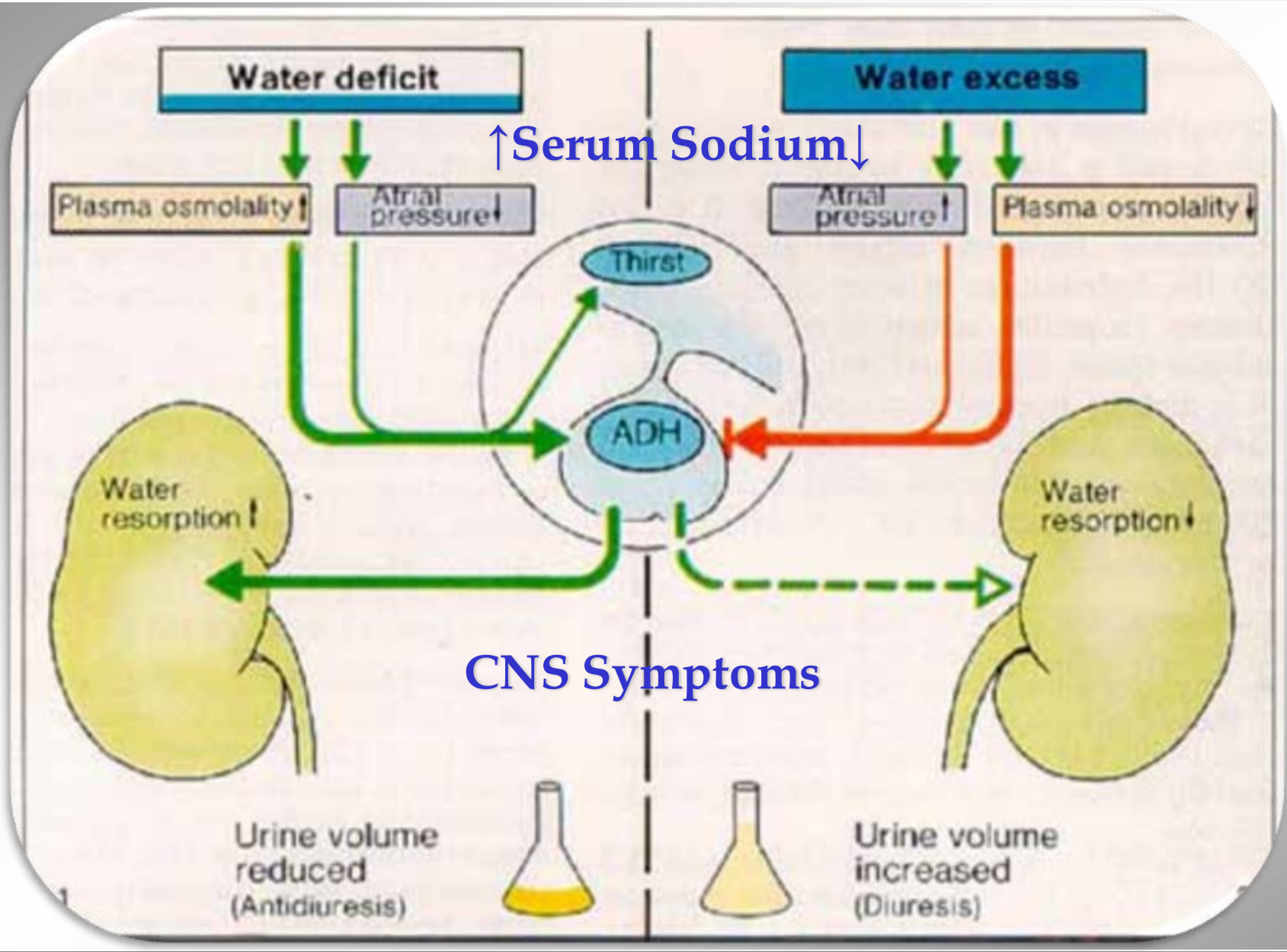


Figure 25 - Device for the demostration of the osmosis.

Two Systems

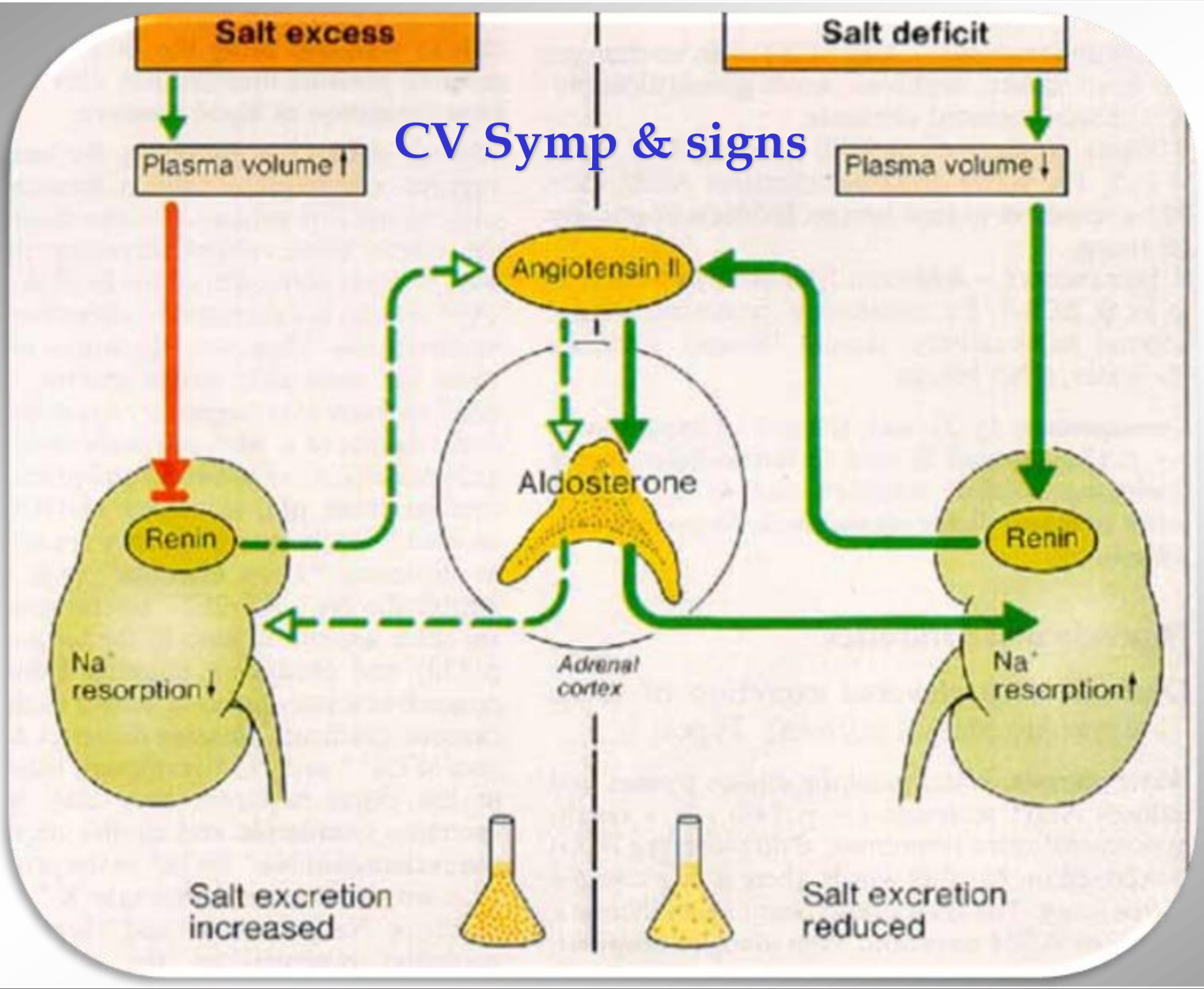
- **Tonicity disorders (water):**
  - **Sensors: Osmoreceptors**
  - **Effectors: ADH and thirst**
- **Volume disorders (sodium):**
  - **Sensors: Low- and high-pressure baroreceptors**
  - **Effectors: RAAS**

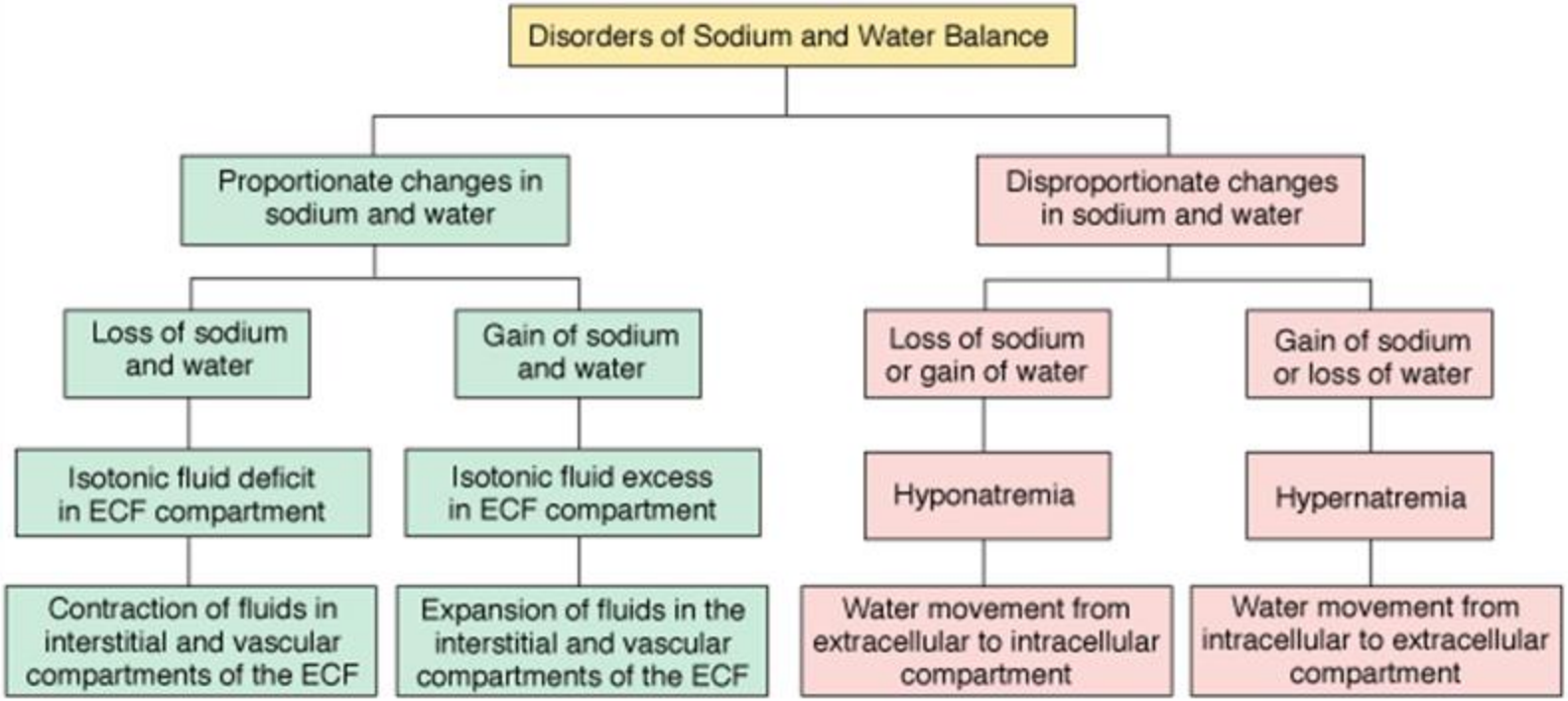

Water deficit
Water excess
↑Serum Sodium↓
Plasma osmolality↑
Atrial pressure↓
Atrial pressure↑
Plasma osmolality↓
Thirst
ADH
Water resorption↑
Water resorption↓
CNS Symptoms
Urine volume reduced
(Antidiuresis)
Urine volume increased
(Diuresis)

AVP-Receptor Subtypes

Receptor Subtype	Site of Action	Pharmacologic Effects
V_{1A}	Vascular smooth muscle Platelets Lymphocytes and monocytes Hepatocytes	Vasoconstriction Platelet aggregation Coagulation factor release Glycogenolysis
V_{1B}	Anterior pituitary	ACTH and β-endorphin release
V_2	Renal collecting duct cells	Free water absorption

CV Symp & signs



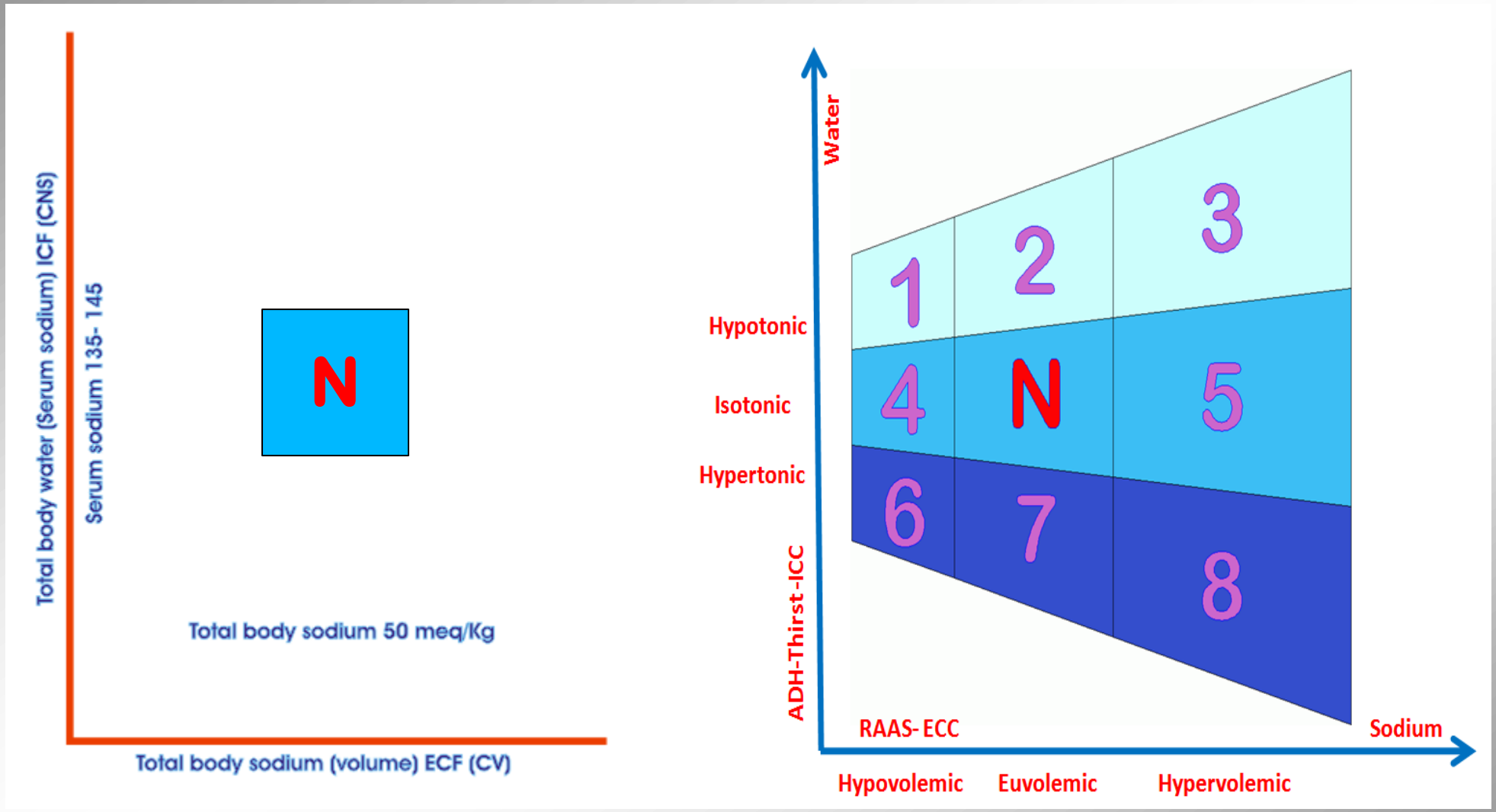


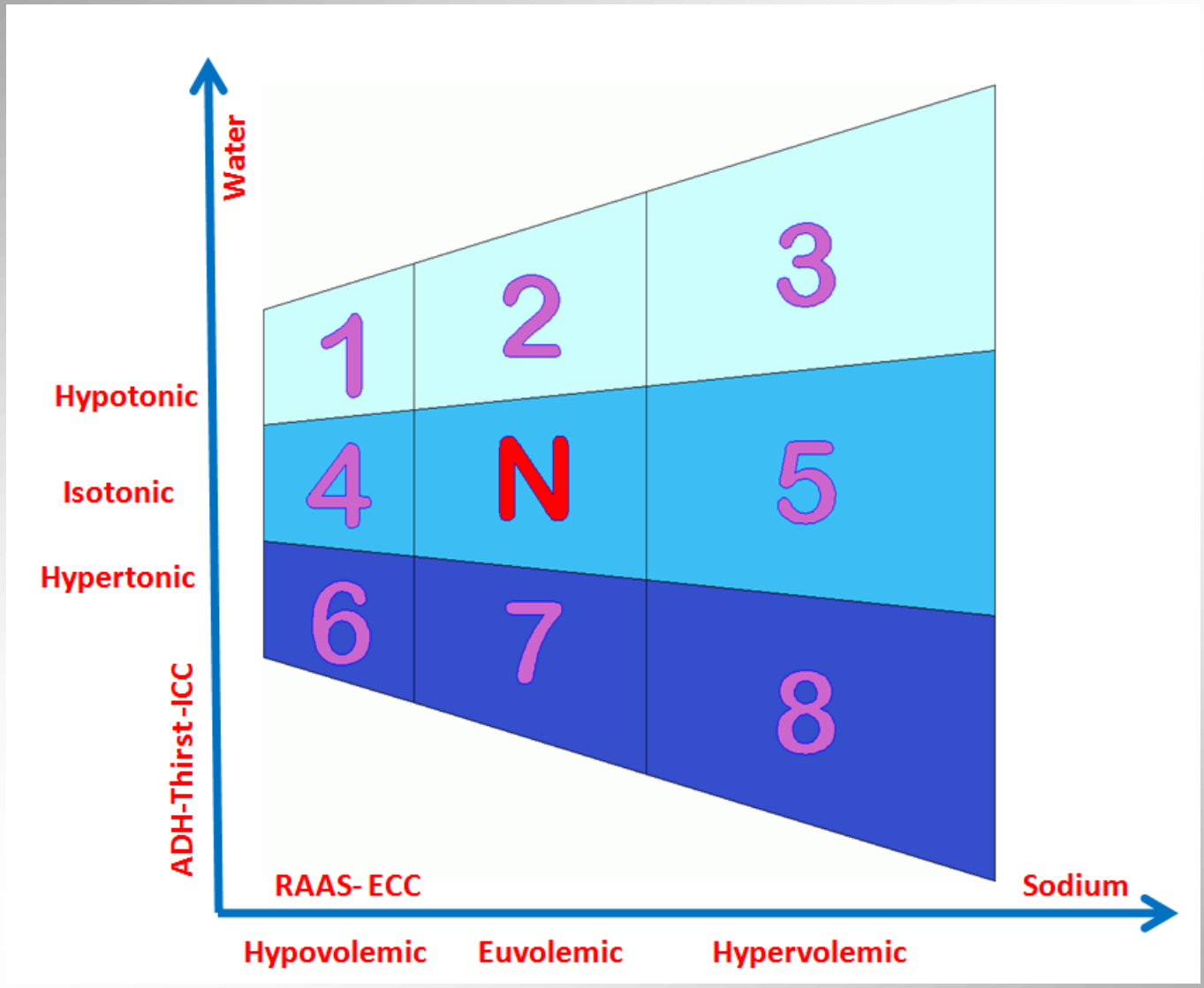
Volume disorders

Water disorders

Figure 33-7 The effect of proportionate and disproportionate changes in sodium and water balance on extracellular sodium concentration.

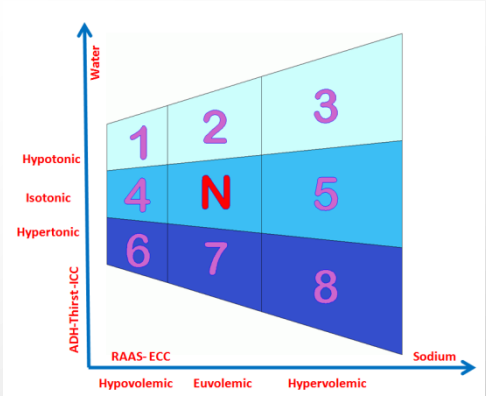

LYNN FELLMAN


Total body water (Serum sodium) ICF (CNS)
Serum sodium 135- 145
N
Total body sodium 50 meq/Kg
Total body sodium (volume) ECF (CV)
Water
Hypotonic
Isotonic
Hypertonic
ADH-Thirst-ICC
1
2
3
4
N
5
6
7
8
RAAS- ECC
Sodium
Hypovolemic
Euvolemic
Hypervolemic


Water
Hypotonic
Isotonic
Hypertonic
ADH-Thirst-ICC
1
2
3
4
N
5
6
7
8
RAAS- ECC
Sodium
Hypovolemic
Euvolemic
Hypervolemic

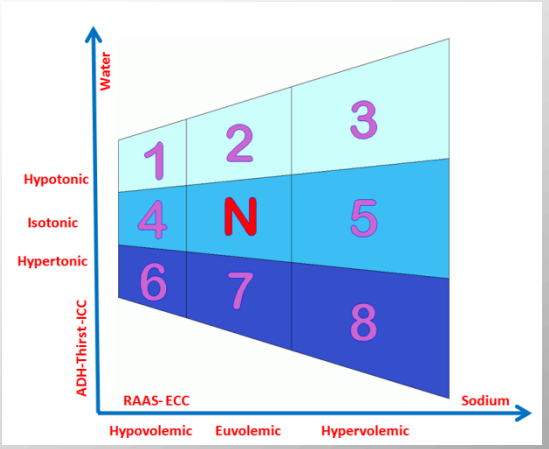
Water and Volume Disorders

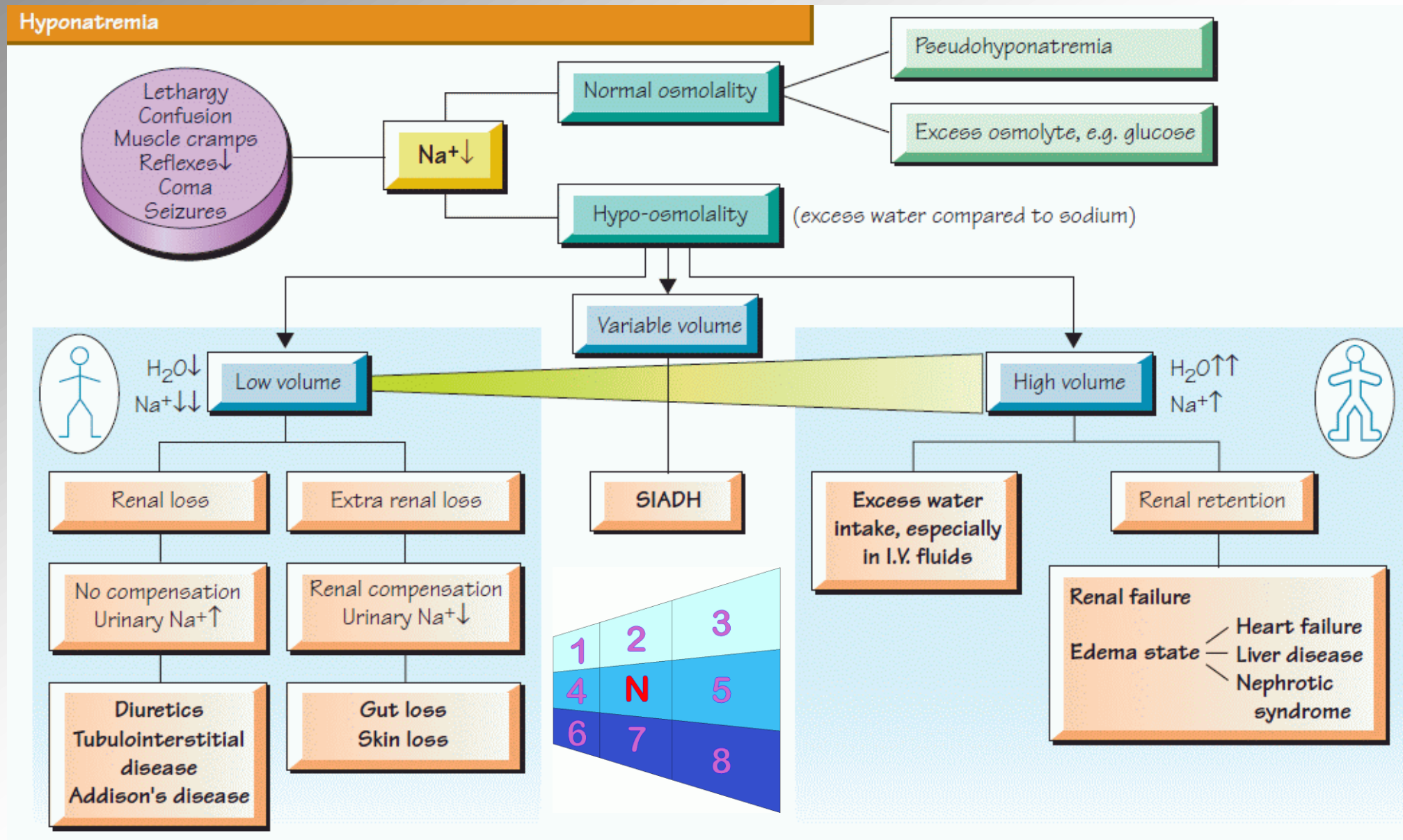
- **Pure**
  - **Volume**
    - **Hypervolemia (isotonic)**
    - **Hypovolemia (isotonic)**
  - **Water**
    - **SIADH (euvolemic)**
    - **Diabetes Insipidus (euvolemic)**



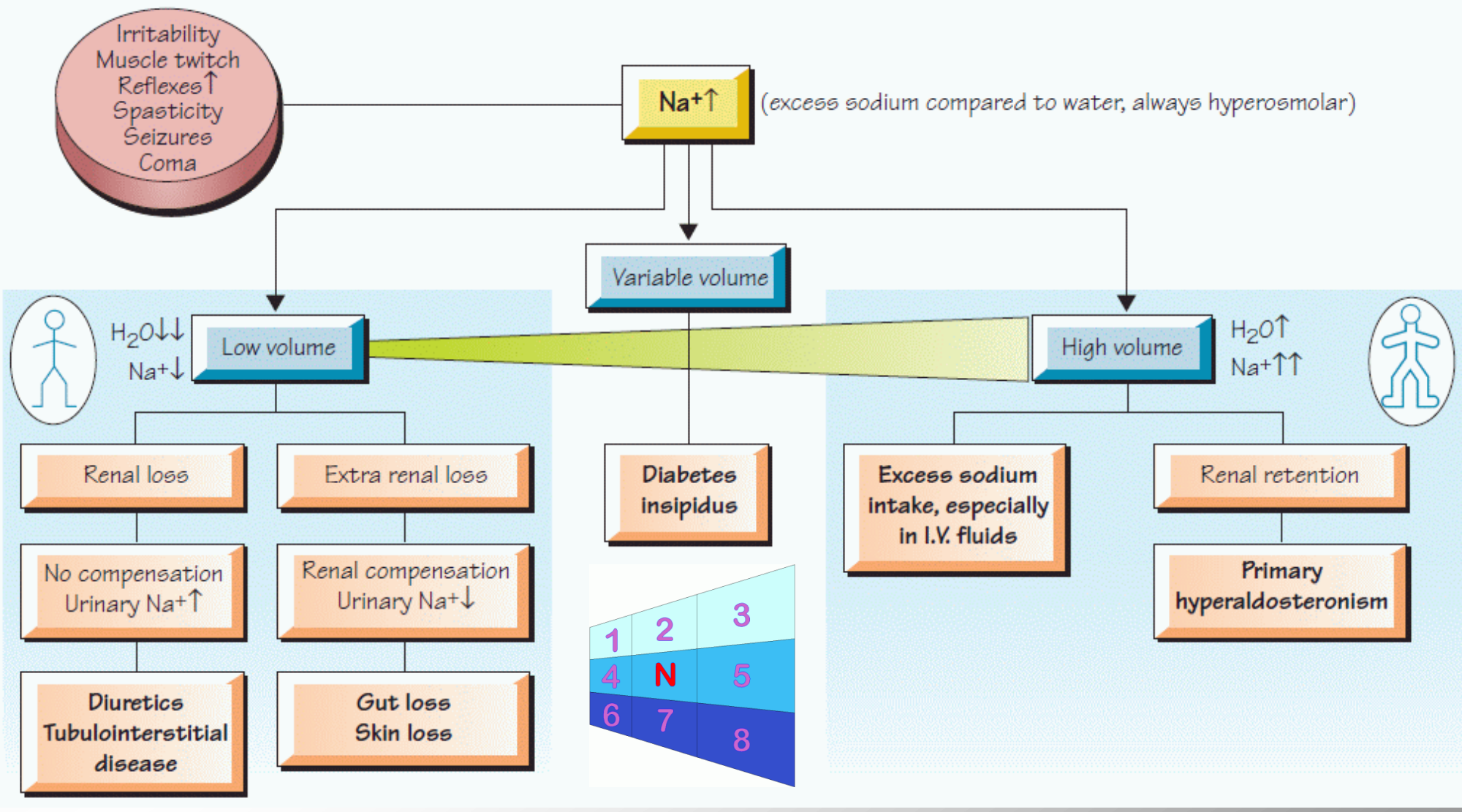
Water and Volume Disorders

- **Mixed (water and volume disorders)**
  - **Hypervolemic hyponatremia**
  - **Hypovolemic hyponatremia**
  - **Hypervolemic hypernatremia**
  - **Hypovolemic hypernatremia**




Hyponatremia
Lethargy
Confusion
Muscle cramps
Reflexes↓
Coma
Seizures
Na+↓
Normal osmolality
Pseudohyponatremia
Excess osmolyte, e.g. glucose
Hypo-osmolality
(excess water compared to sodium)
Variable volume
H2O↓
Na+↓↓
Low volume
H2O↑↑
Na+↑
High volume
Renal loss
Extra renal loss
SIADH
Excess water intake, especially in I.V. fluids
Renal retention
No compensation
Urinary Na+↑
Renal compensation
Urinary Na+↓
Diuretics
Tubulointerstitial disease
Addison's disease
Gut loss
Skin loss
1
2
3
4
N
5
6
7
8
Renal failure
Edema state
Heart failure
Liver disease
Nephrotic syndrome

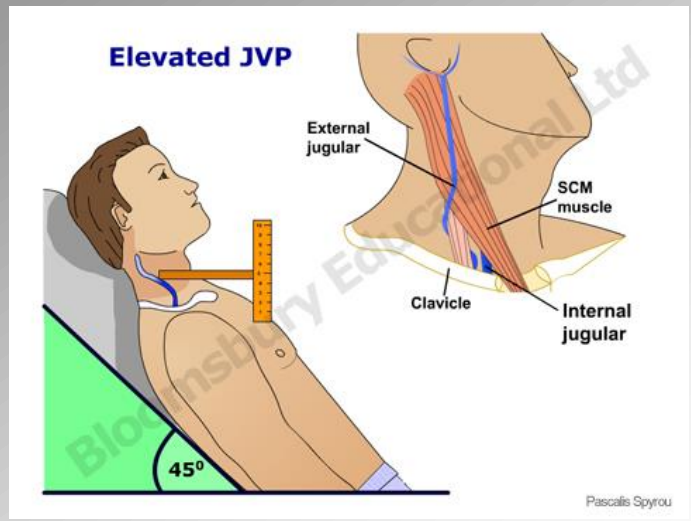
Hypernatremia



Assessment of volume status

Best achieved by simple clinical observations which you should do yourself. Check:

- Jugular venous pressure
- Central venous pressure both basal and after intravenous fluid challenge
- Serial weights of the patient
- Postural changes in blood pressure
- A chest X-ray.



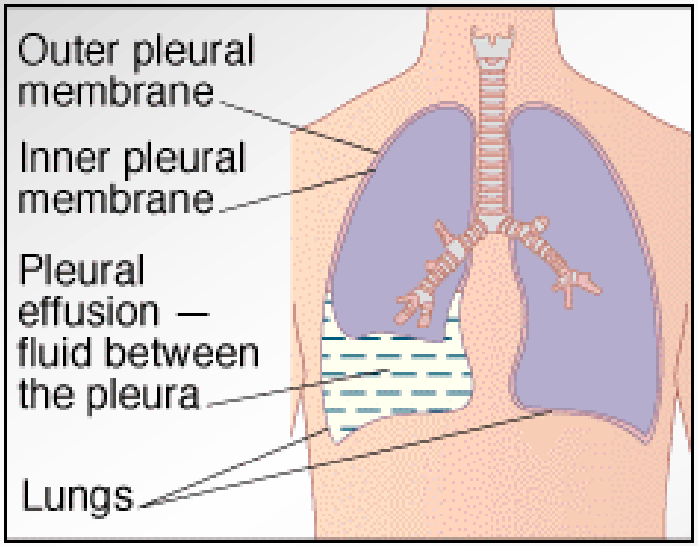
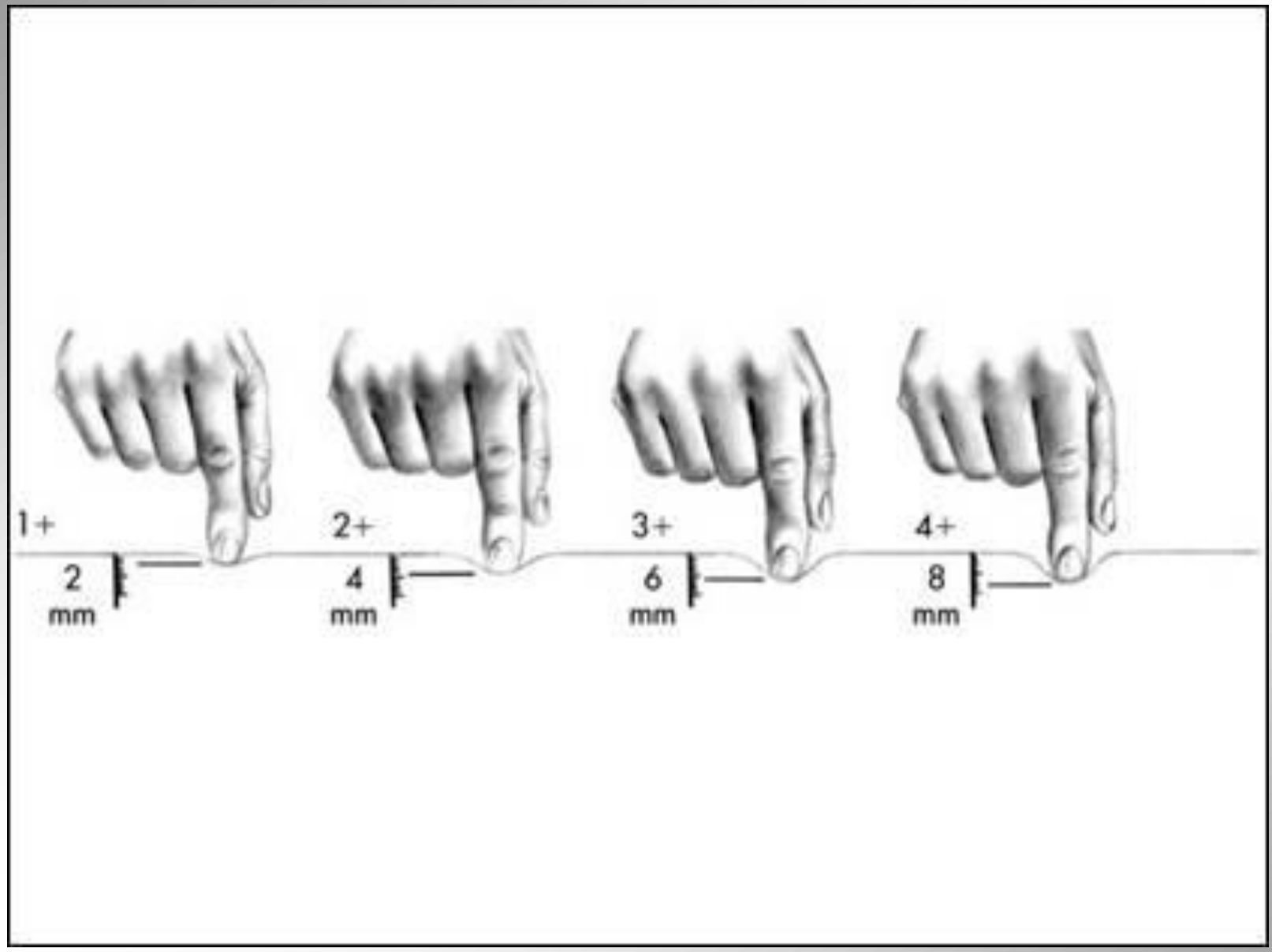
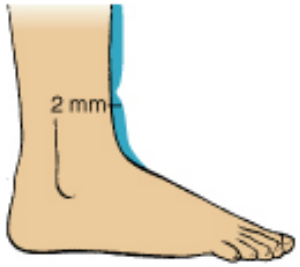


Figure 33-6 3 + pitting edema of the left foot. (Used with permission from Bates B. [1995]. *Bates' guide to physical examination and history taking* [6th ed., p. 438]. Philadelphia: Lippincott Williams & Wilkins)


1+
2
mm
2+
4
mm
3+
6
mm
4+
8
mm

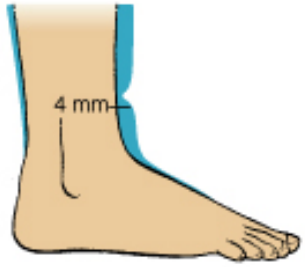
1+ Pitting Edema

- Slight indentation (2 mm)
- Normal contours
- Associated with interstitial fluid volume 30% above normal



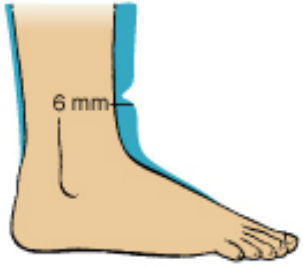
2+ Pitting Edema

- Deeper pit after pressing (4 mm)
- Lasts longer than 1+
- Fairly normal contour



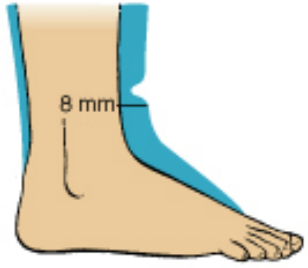
3+ Pitting Edema

- Deep pit (6 mm)
- Remains several seconds after pressing
- Skin swelling obvious by general inspection



4+ Pitting Edema

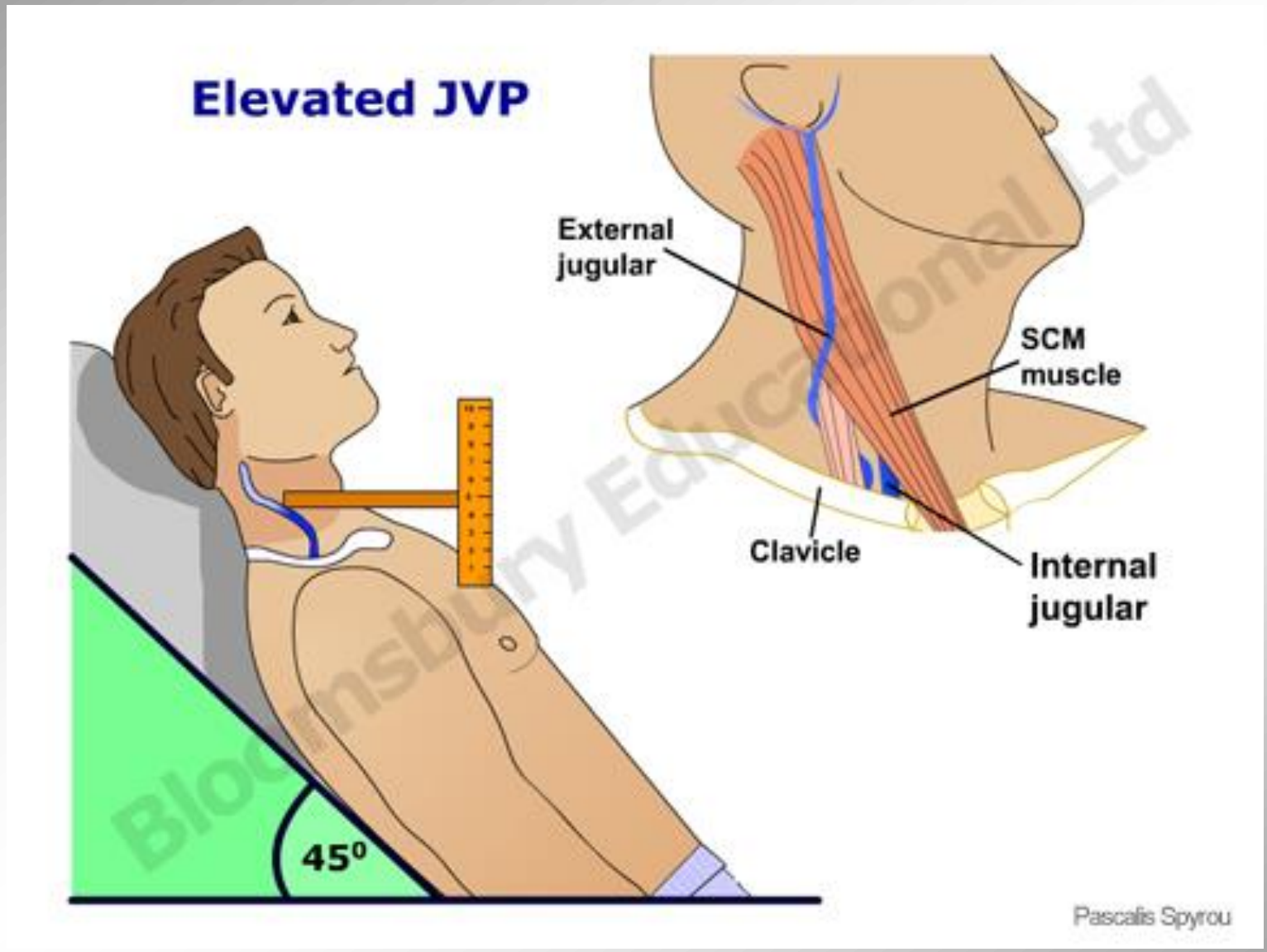
- Deep pit (8 mm)
- Remains for a prolonged time after pressing, possibly minutes
- Frank swelling

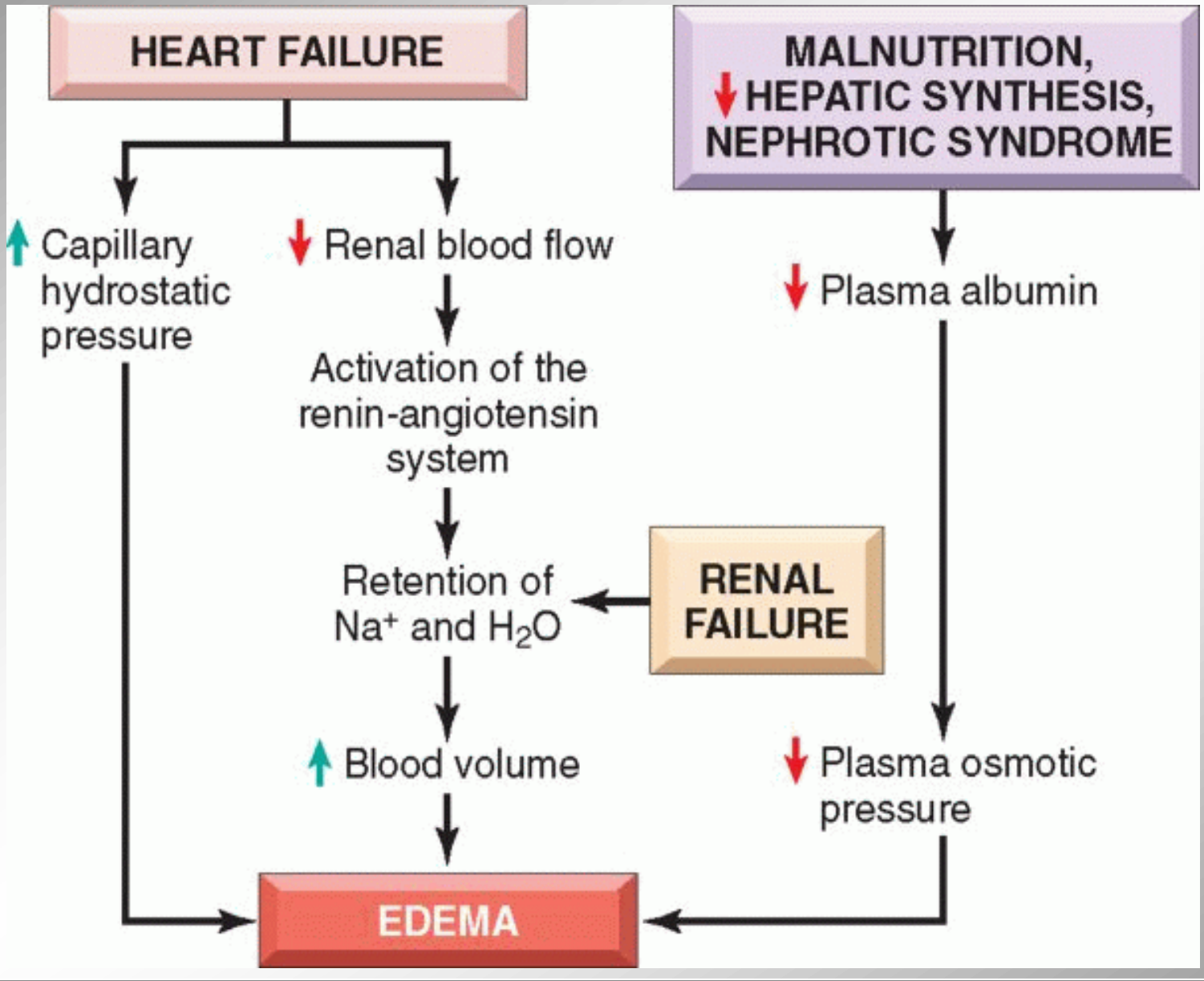


Brawny Edema

- Fluid can no longer be displaced secondary to excessive interstitial fluid accumulation
- No pitting
- Tissue palpates as firm or hard
- Skin surface shiny, warm, moist

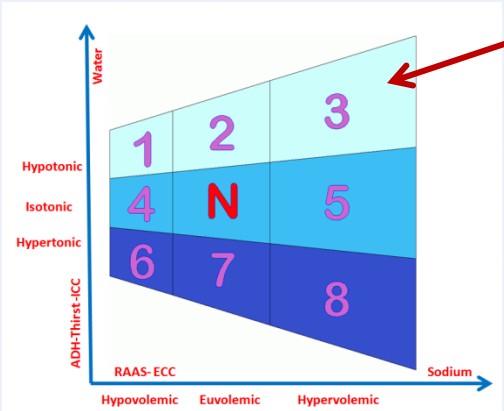
Figure 46-7 System for grading edema.


Elevated JVP
External jugular
SCM muscle
Clavicle
Internal jugular
45⁰
Pascalis Spyrou


HEART FAILURE
MALNUTRITION,
↓HEPATIC SYNTHESIS,
NEPHROTIC SYNDROME
↑ Capillary hydrostatic pressure
↓ Renal blood flow
↓ Plasma albumin
Activation of the renin-angiotensin system
Retention of Na+ and H2O
RENAL FAILURE
↑ Blood volume
↓ Plasma osmotic pressure
EDEMA

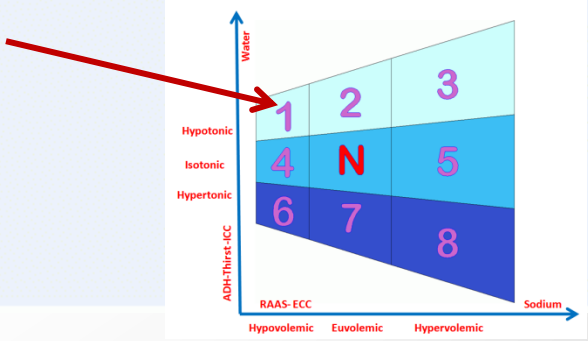
Causes of hyponatraemia with increased extracellular volume (hypervolaemia)

Heart failure
Liver failure
Oliguric renal failure
Hypoalbuminaemia



Causes of hyponatraemia with decreased extracellular volume (hypovolaemia)

Extra-renal (urinary sodium < 20 mmol/L)	Kidney (urinary sodium > 20 mmol/L)
Vomiting	Osmotic diuresis (e.g. hyperglycaemia, severe uraemia)
Diarrhoea	Diuretics
Haemorrhage	Adrenocortical insufficiency
Burns	Tubulo-interstitial renal disease
Pancreatitis	Unilateral renal artery stenosis
	Recovery phase of acute tubular necrosis



Causes of hyponatraemia with normal extracellular volume (euvolaemia)

Abnormal ADH release
Vagal neuropathy (failure of inhibition of ADH release)
Deficiency of adrenocorticotrophic hormone (ACTH) or glucocorticoids (Addison's disease)
Hypothyroidism
Severe potassium depletion

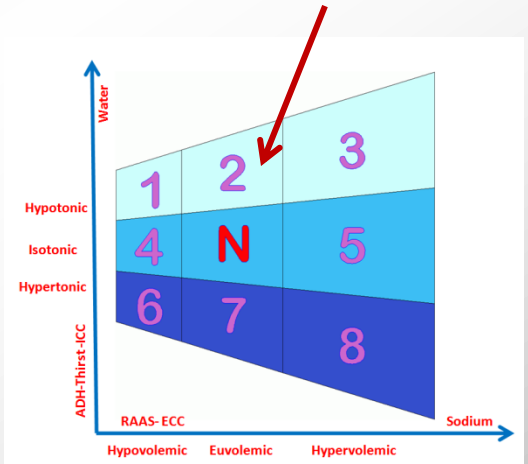
Syndrome of inappropriate antidiuretic hormone (see Table 18.33)

Major psychiatric illness
'Psychogenic polydipsia'
Non-osmotic ADH release?
Anti-depressant therapy

Increased sensitivity to ADH
Chlorpropamide
Tolbutamide

ADH-like substances
Oxytocin
Desmopressin

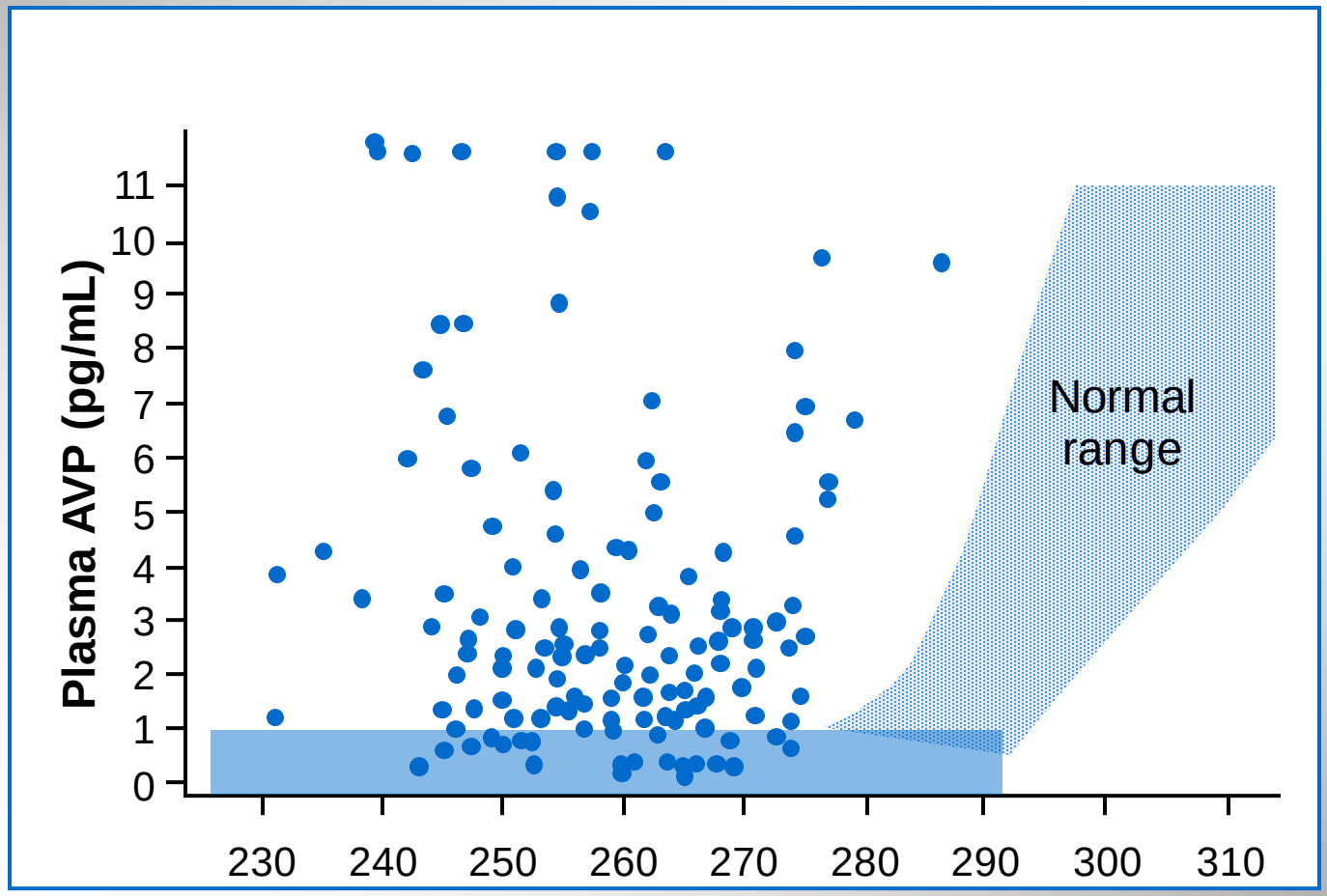
Unmeasured osmotically active substances stimulating osmotic ADH release
Glucose
Chronic alcohol abuse
Mannitol
Sick-cell syndrome (leakage of intracellular ions)



CRITERIA FOR DIAGNOSIS OF SIADH
(Syndrome of Inappropriate ADH secretion)

- Hyposmolar hyponatremia
- Euvolemia
- Urine osmolality >100 (urine not maximally diluted)
- Normal renal, cardiac, hepatic, and endocrine function (EXCLUSION)
- Absence of diuretics & stress
- Urine sodium > 20 mEq/l, low serum UA

Plasma AVP Is Elevated in Patients With SIADH



COMMON DISORDERS ASSOCIATED WITH SIADH

- Malignancy
  - Lung, duodenum, pancreas, lymphoma
- Pulmonary disorders
  - Infection, respiratory failure, IPPB
- CNS disorders
  - Infection, trauma, sol, CVA, psychosis

DRUGS ASSOCIATED WITH HYPONATREMIA

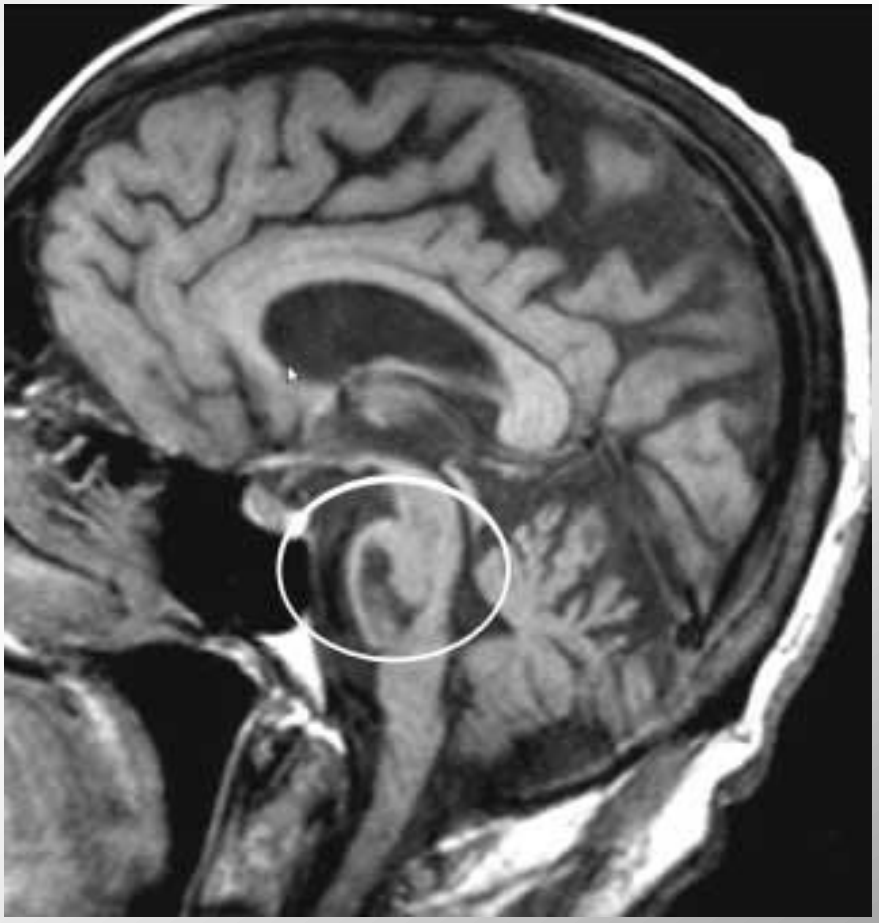
- ADH analogs
- enhance ADH release
  - Chlorpropamide, nicotine, tegretol, narcotics, clofibrate, antipsychotic
- Potentiate ADH renal action
  - NSAID, chlorpropamide, cytoxan
- Unknown mechanisms
  - Haloperidol, amitriptyline

TREATMENT OF HYPONATREMIA

Depends on the following conditions

- Patient volume status
- The degree of hyponatremia
- The severity of symptoms
- The duration of hyposmolality

Osmotic Demyelination Syndrome Can Be a Consequence of Inappropriate Management of Hyponatremia



ELSEVIER

Hyponatremia in patients with central nervous system disease: SIADH versus CSW

Biff F. Palmer

Table 1. Clinical features of CSW and SIADH[a]

	CSW	SIADH
Extracellular fluid volume[b]	Decreased	Increased
Hematocrit	Increased	Normal
Plasma albumin concentration	Increased	Normal
Plasma BUN/creatinine	Increased	Decreased
Plasma K^+	Normal or increased	Normal
Plasma uric acid	Normal or decreased	Decreased
Treatment	Normal saline	Fluid restriction

[a]Abbreviations: BUN, blood urea nitrogen; CSW, cerebral salt wasting; SIADH, syndrome of inappropriate antidiuretic hormone secretion.

[b]Determination of extracellular fluid volume is the primary way to differentiate CSW from SIADH.

Causes of hypernatraemia

ADH deficiency
Diabetes insipidus

Iatrogenic
Administration of hypertonic sodium solutions

Insensitivity to ADH (nephrogenic diabetes insipidus)
Lithium
Tetracyclines
Amphotericin B
Acute tubular necrosis

Osmotic diuresis
Total parenteral nutrition
Hyperosmolar hyperglycaemic state

PLUS
Deficient water intake

CAUSES OF DIABETES INSIPIDUS

- **Central DI**
  - **Idiopathic, posttraumatic, tumors, infection, granuloma, histocytosis**
- **Nephrogenic DI**
  - **Congenital**
  - **Acquired**
    - **Hypercalcemia, hypokalemia, drugs, renal cystic and interstitial diseases**

WATER-DEPRIVATION TEST

	Urine Osm. & deprivation	Plasma AVP & deprivation	Urine Osm. After AVP
Normal	> 800	> 2 pg/ml	little or no Δ
Complete central DI	<300	undetectable	great increase
Partial central DI	300-800	<1.5 pg/ml	>10% increase
Nephrogenic DI	<300-800	>5 pg/ml	little or no Δ
Primary polydipsia	>500	<5 pg/ml	little or no Δ

TREATMENT OF HYPERNATREMIA

- Goal is to restore normal volume & osmolality
- Slow correction over 48 hours
- H_2O deficit = 0.6 * Wt * (P Na/140 -1)
- Replace concomitant continuous losses
- Treat the cause of hypernatremia

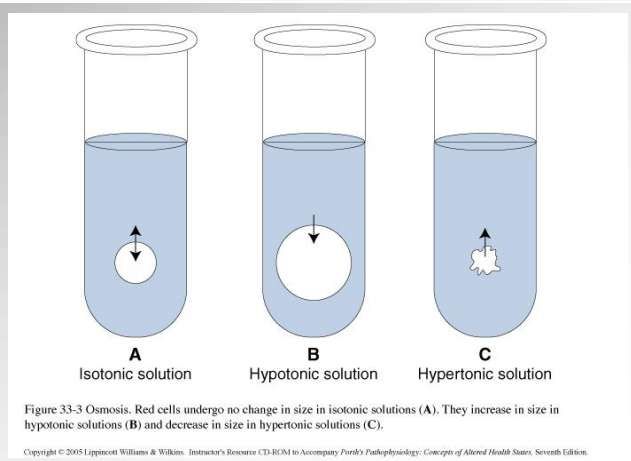
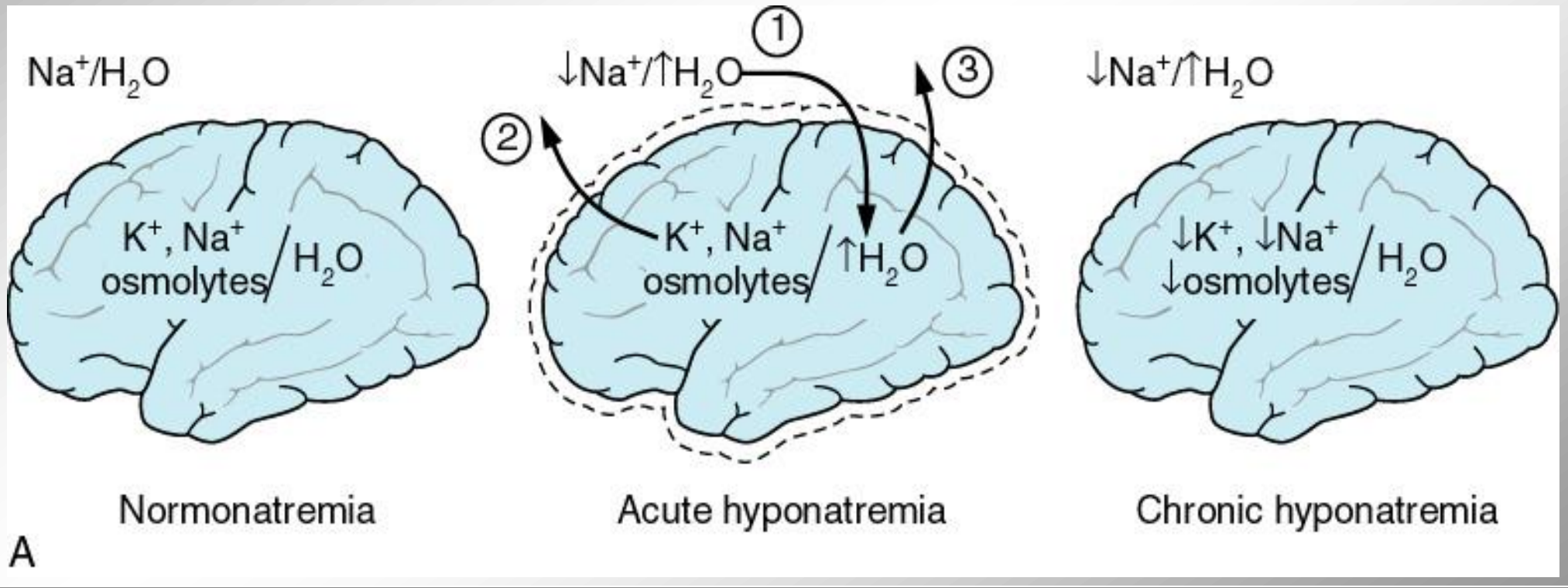


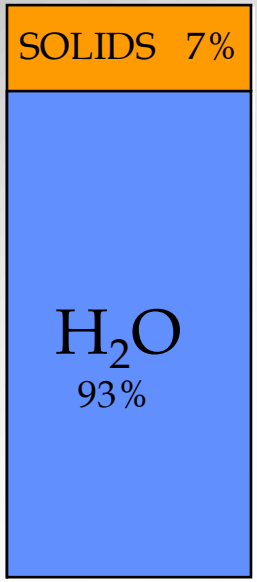
Figure 33-3 Osmosis. Red cells undergo no change in size in isotonic solutions (**A**). They increase in size in hypotonic solutions (**B**) and decrease in size in hypertonic solutions (**C**).



PSEUDOHYPONATREMIA

ISOTONIC HYPONATREMIA

SERUM Na^+ = 140 meq/L



140/930

Serum Osmolality= 2Na+urea+glucose

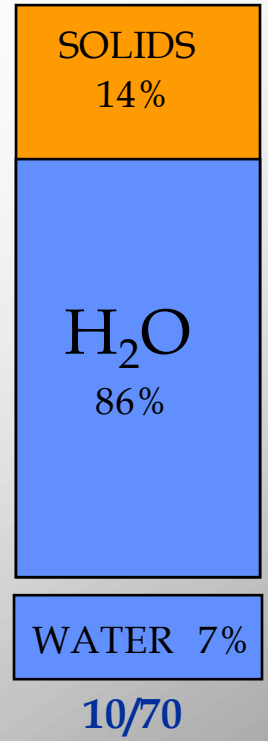
HYPERLIPIDEMIA

HYPERPROTEINEMIA

Measured>Calculated

140/930 = 151/1000 = 130/860

SERUM Na^+ = 130 meq/L



130/860

10/70

OSMOLALITY: MEASURES SOLUTE PER UNIT PLASMA WATER

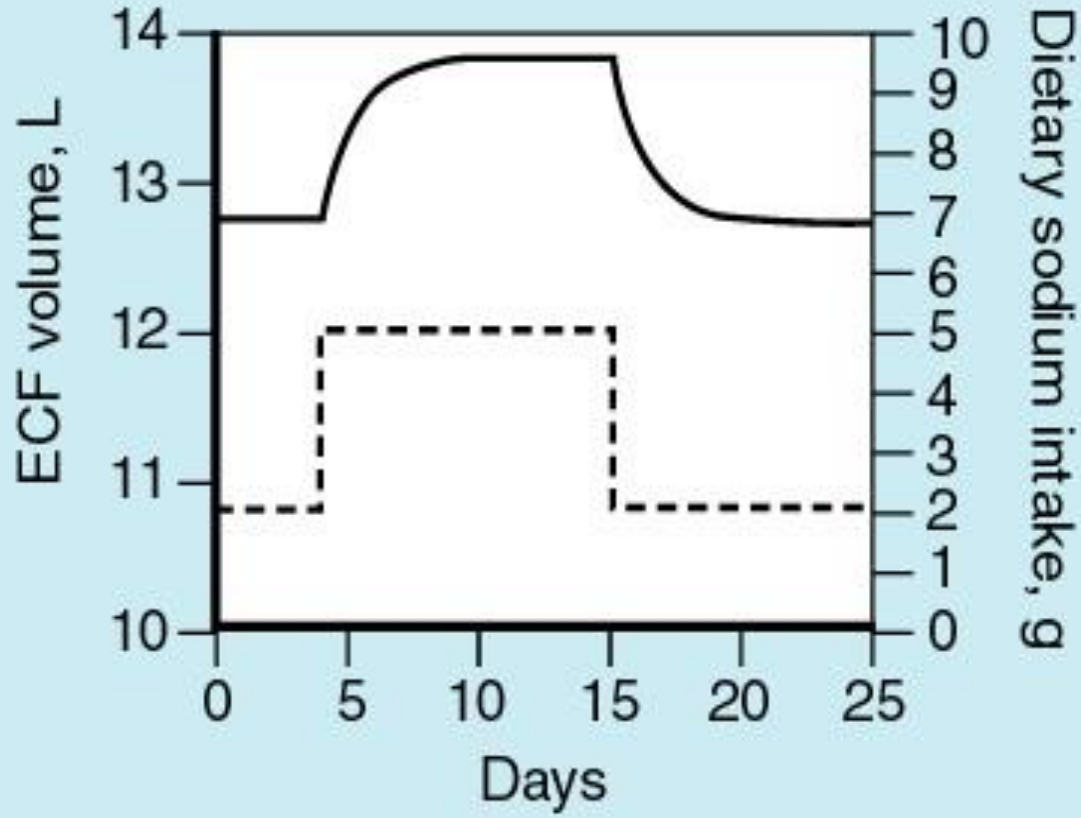
Salt and Water Rules (I)

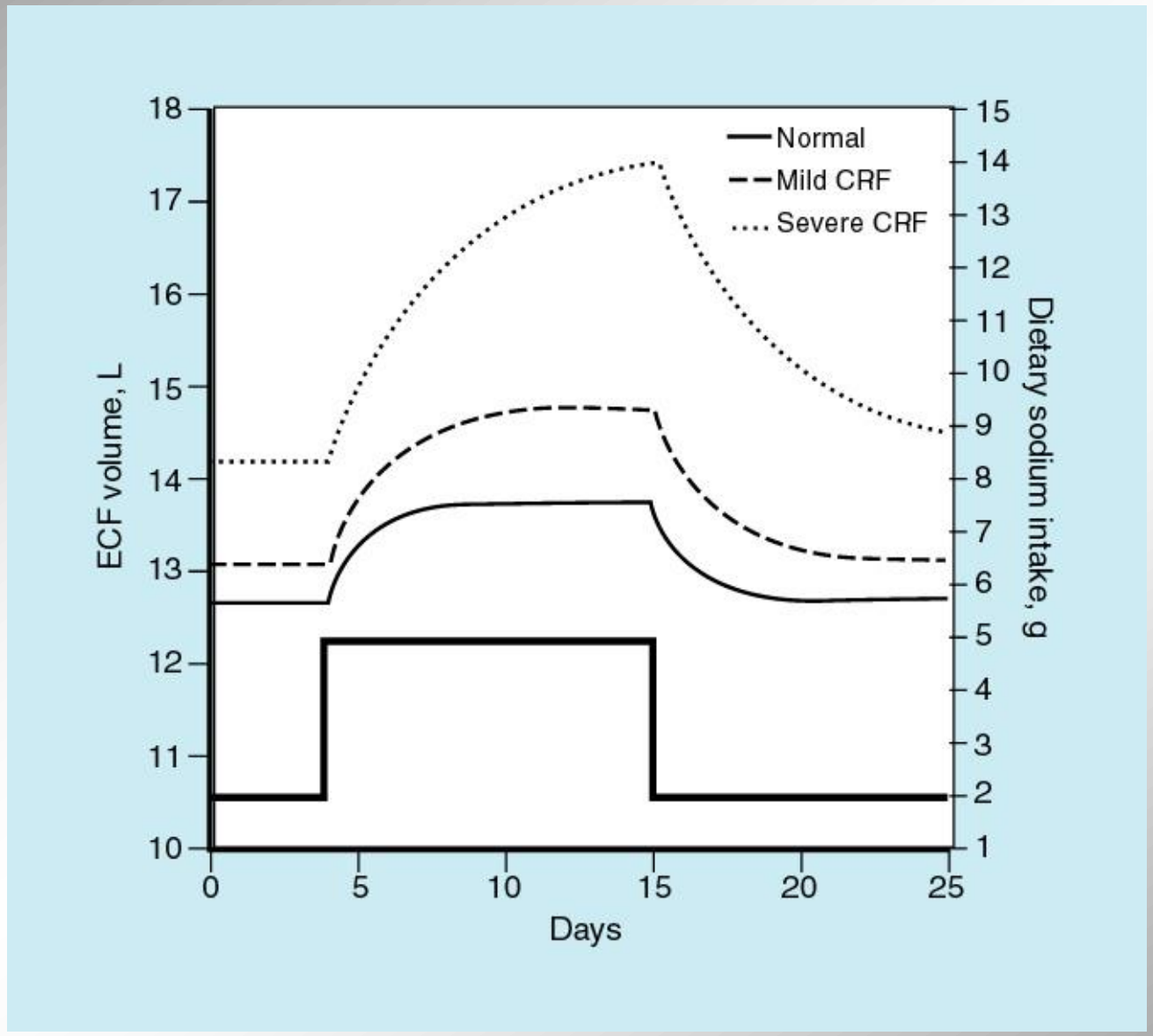
- Regulation of the plasma sodium and of extracellular volume involve separate pathways
- The plasma sodium is regulated by changes in water excretion (ADH) and water intake (thirst)
- Hyponatremia is usually due to inability to excrete water, mostly due to persistent ADH
- Symptoms of hyponatremia (acute) are due to cerebral edema (decreased plasma osmolality)
- Chronic hyponatremia is usually asymptomatic, (loss of CNS osmolytes). Avoid rapid correction

Salt and Water Rules (II)

- All patients will tend to return to a steady state in which intake equals excretion
- The maximal diuretic effect is seen with the first dose, counterregulatory factors then stimulated
- Chronic diuretic use is associated with a steady state at lower volume and potassium levels
- The ability to markedly increase water, sodium, potassium, and bicarbonate excretion means that chronic accumulation of these substances requires an impairment in urinary excretion

The Concept of Normal Steady State




Normal
Mild CRF
Severe CRF
ECF volume, L
Dietary sodium intake, g
Days
18
17
16
15
14
13
12
11
10
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
5
10
15
20
25

Isotonic (pure) Hypovolemia

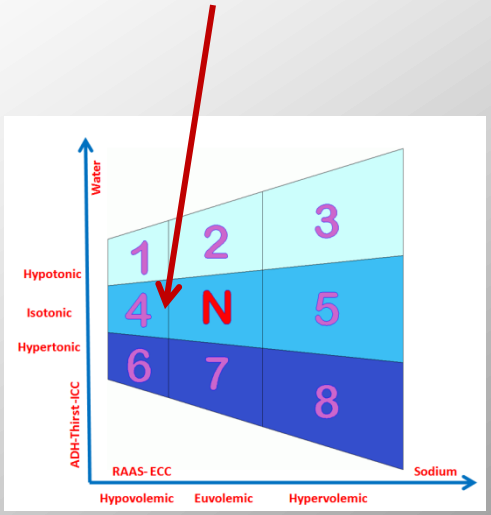
Most Common form of hypovolemia

Occurs when fluids and electrolytes are lost in even (proportionate) amounts

There are **no intercellular fluid shifts** in isotonic dehydration (EC fluid disorder)

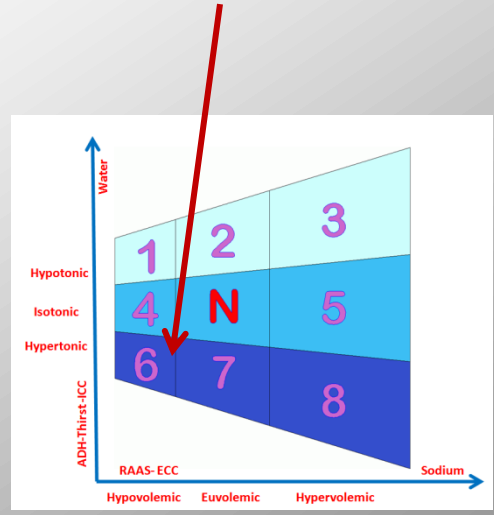
Common Causes

- diuretic therapy
- excessive vomiting
- excessive urine loss
- hemorrhage
- decreased fluid intake



Hypertonic Dehydration

Second most common type of hypovolemia
Occurs when water loss from ECF is greater than solute loss (disproportionate disorder) (EC and IC disorder):
Causes:
hyperventilation, pure water loss with high fevers, and watery diarrhea
Diabetic Ketoacidosis and Diabetes Insipidus
Iatrogenic Causes
prolonged NPO



Hypotonic Hypovolemia

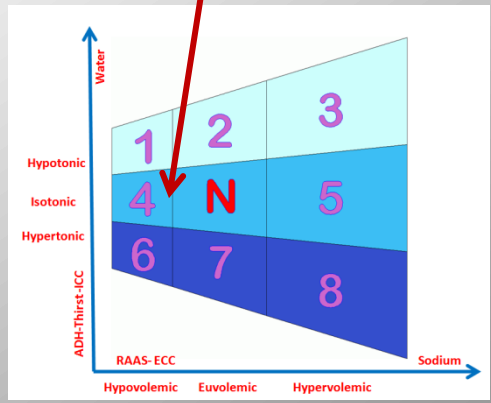
Relatively Uncommon - Loss of more solute (usually sodium) than water.

Hypotonic hypovolemia causes fluid to shift from the blood stream into the cells, leading to decreased vascular volume and eventual shock

Seen in Heat Exhaustion

Increased cellular swelling -causes increased intracranial pressure - Headache and Confusion.

Seen in Heat Stroke

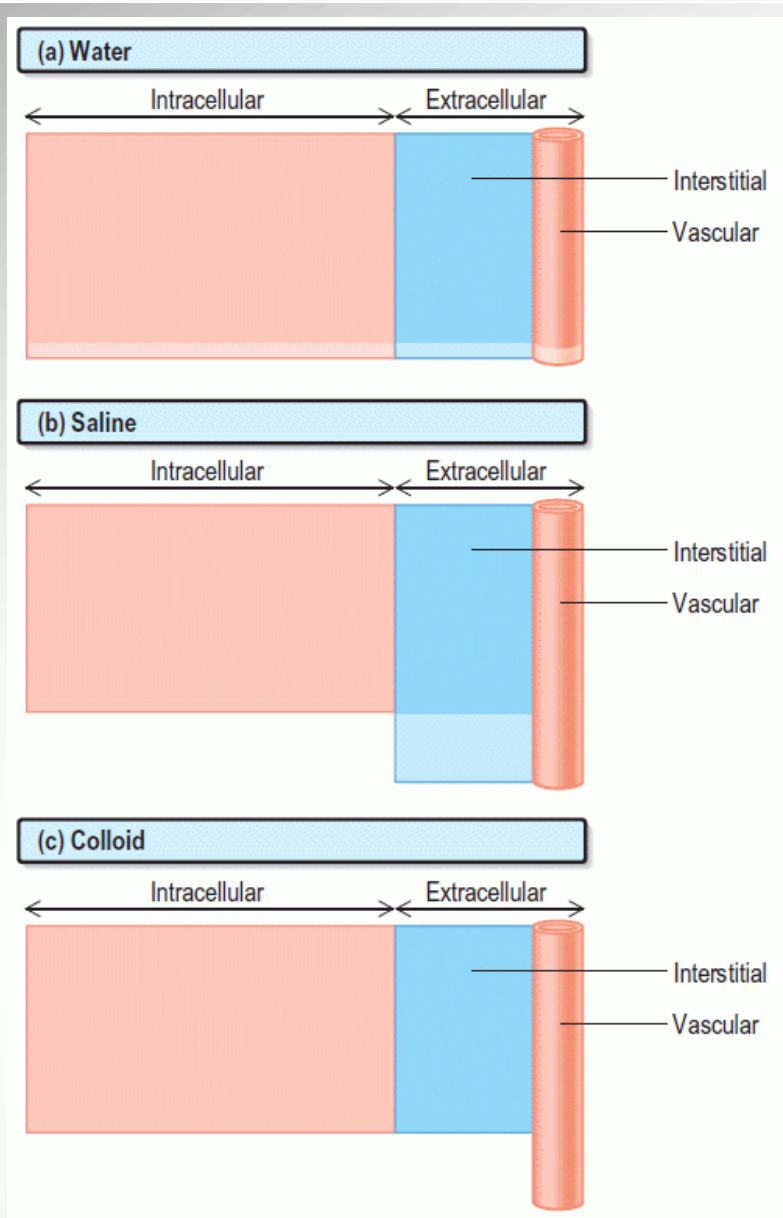


Fluids can be described as being from three categories

-**Isotonic:** Fluid has the same osmolarity as plasma
Normal Saline (N/S or 0.9% NaCl),
Ringers Acetate(RA), Ringer's lactate (RL)

-**Hypotonic:** Fluid has fewer solutes than plasma
Water, 1/2 N/S (0.45% NaCl), and D5W
(5% dextrose in water) after the sugar is
used up

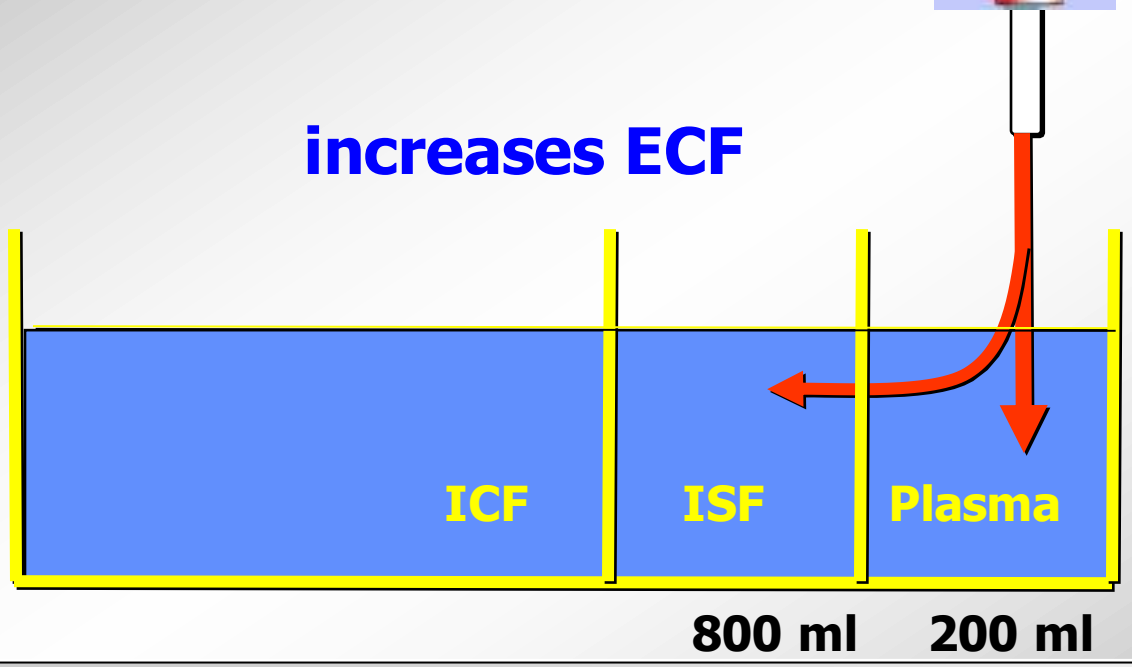
-**Hypertonic**: Fluid has more solutes than plasma
5 % Dextrose in Normal Saline (D5 N/S),
3% saline solution, D5 in RL.


(a) Water
Intracellular
Extracellular
Interstitial
Vascular
(b) Saline
Intracellular
Extracellular
Interstitial
Vascular
(c) Colloid
Intracellular
Extracellular
Interstitial
Vascular

Isotonic infusion

- Ringer's acetate
- Ringer's lactate
- Normal saline

increases ECF

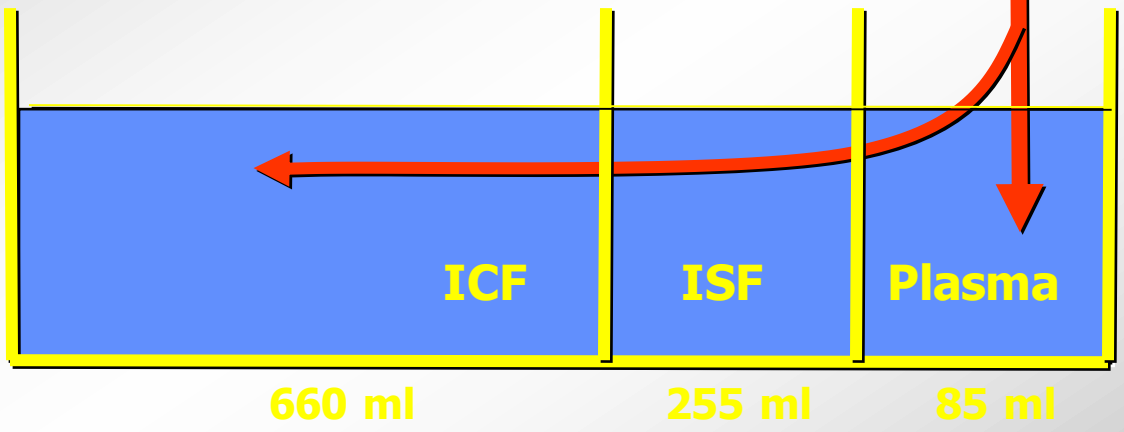


Replace acute/ abnormal loss

Hypotonic infusion

- 5% dextrose

increases ICF > ECF



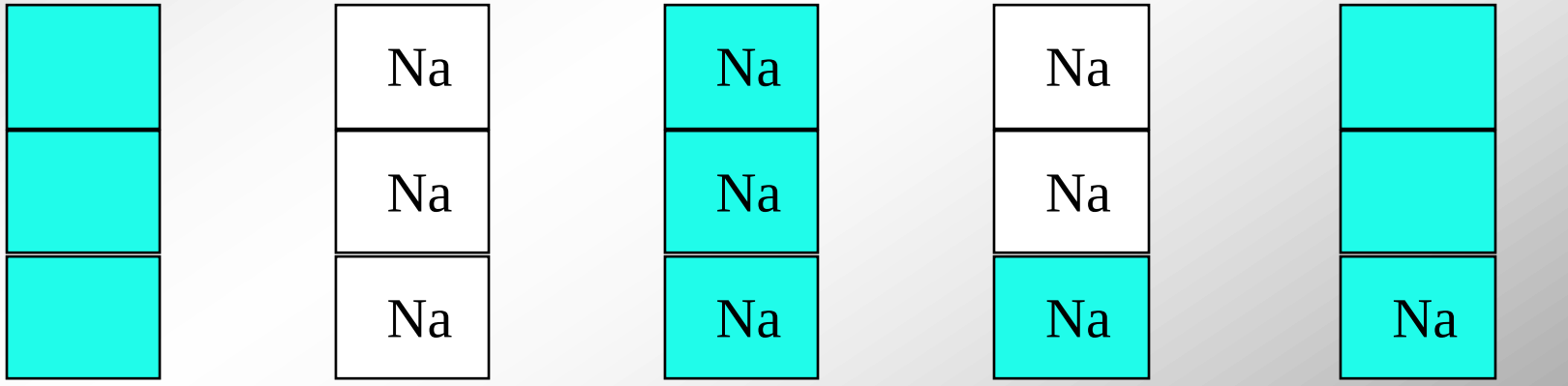
Replace Normal loss (IWL + urine)

Volume
CV

Water
CNS

ECF=1/3 **ICF=2/3**

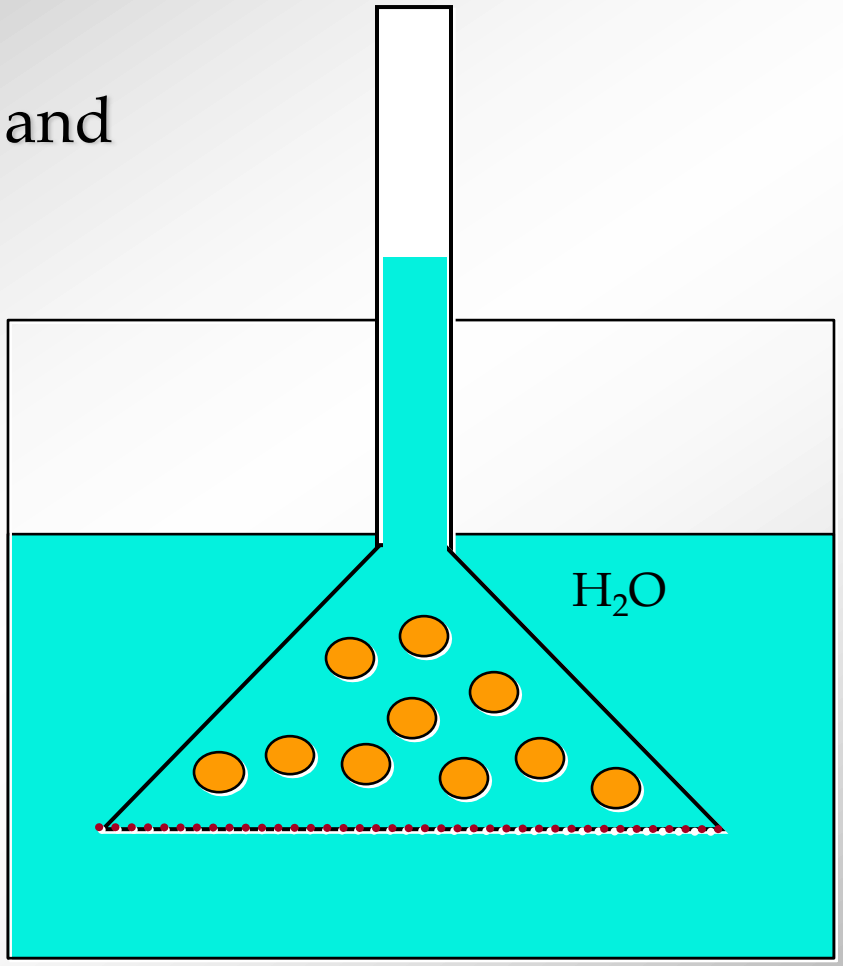
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	O	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

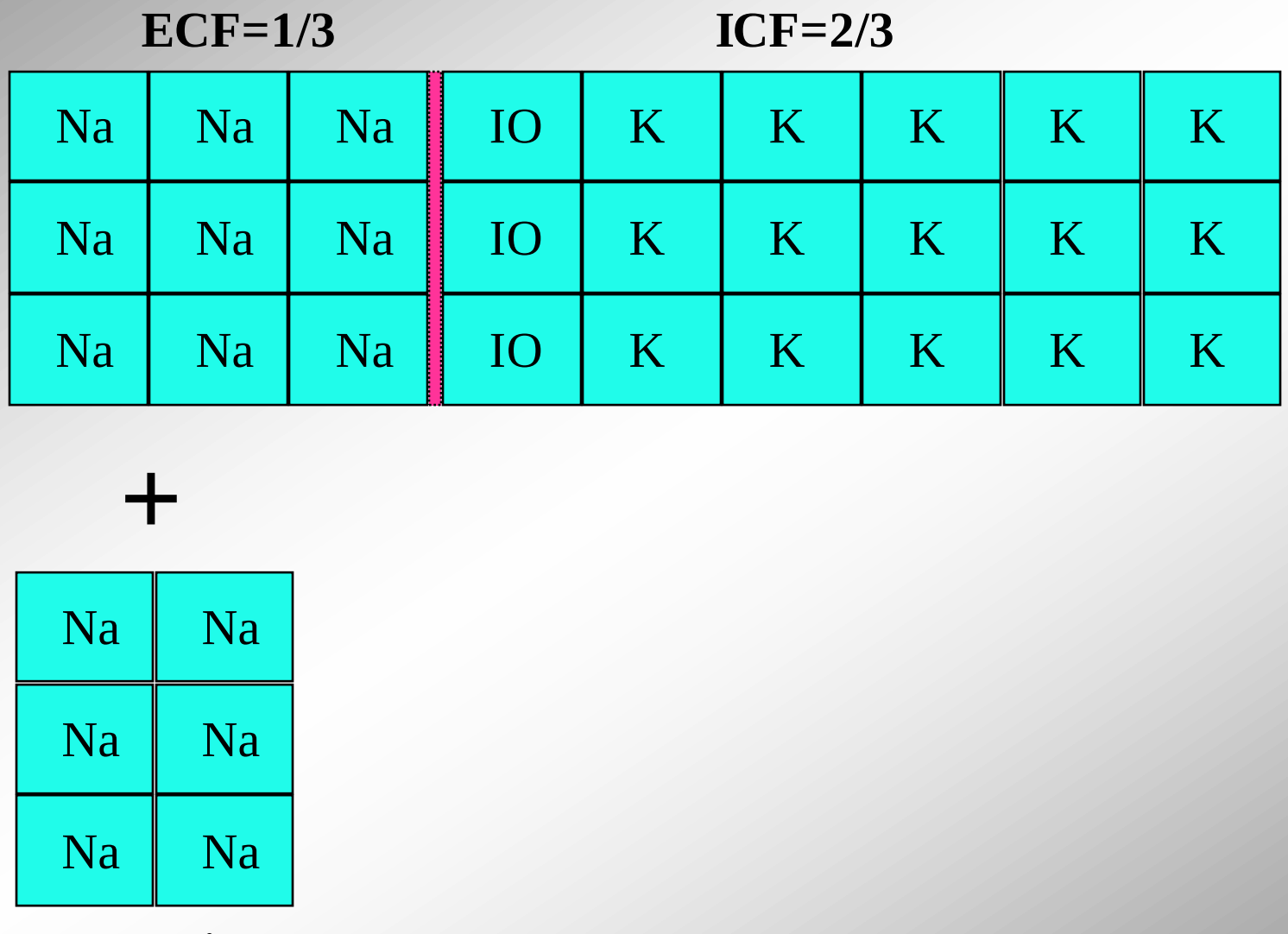


H_2O **Sodium** **Isotonic** **Hypertonic** **Hypotonic**

Osmotic Pressure

Relation of volume and osmotic force



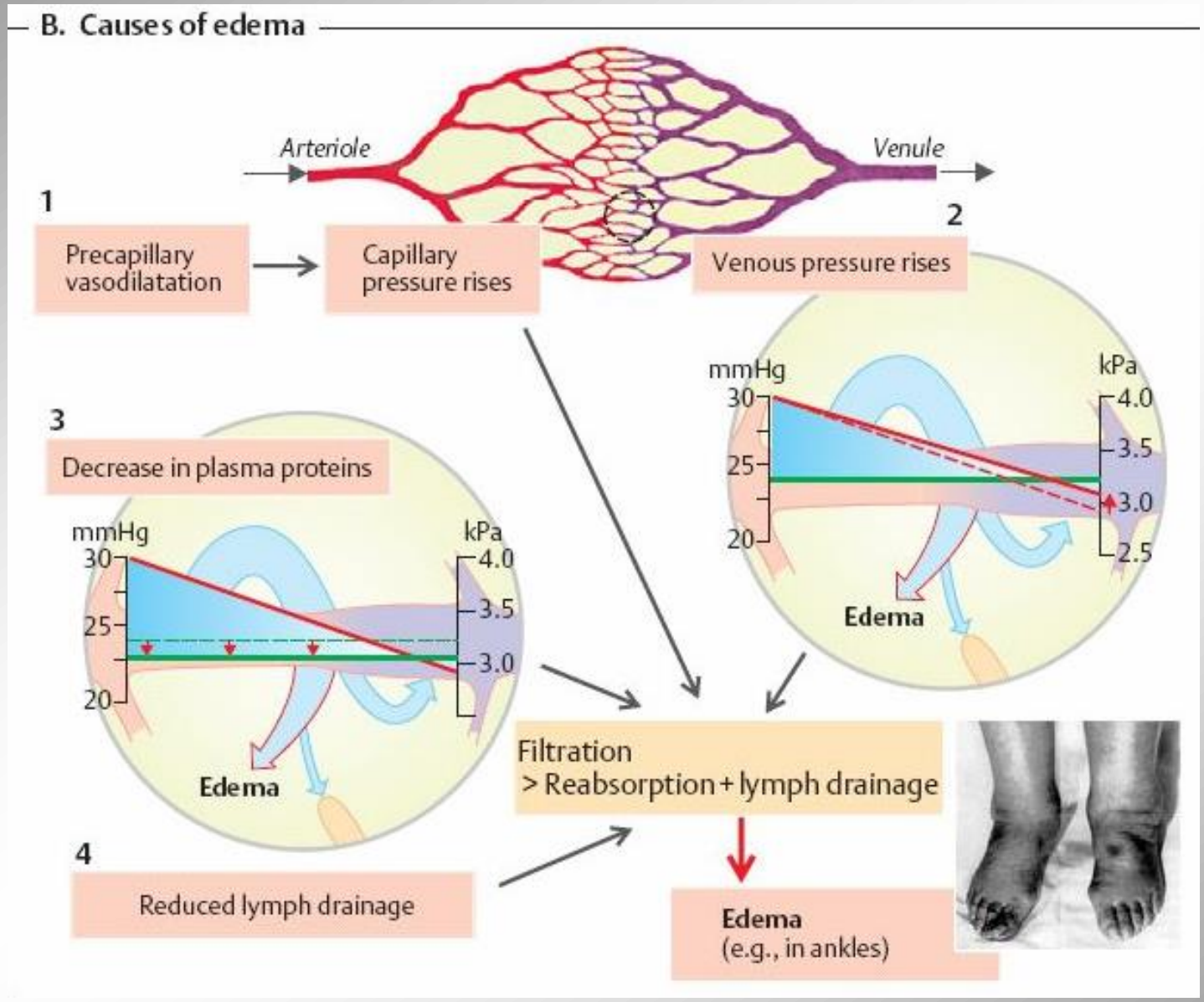

ECF=1/3
ICF=2/3
Na Na Na IO K K K K K
Na Na Na IO K K K K K
Na Na Na IO K K K K K
+
Na Na
Na Na
Na Na
Isotonic

ECF=1/3					ICF=2/3					
Na	Na	Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	Na	Na	IO	K	K	K	K	K

SIGNS:

INTRAVASCULAR: HTN, S3 GALLOP, ELEVATED JVP, HEPATIC CONGESTION
INTERSTITIAL: DEPENDENT PITTING EDEMA, PULMONARY RALES
THIRD SPACE: ASCITIS, PLEURAL EFFUSION

(PURE) HYPERVOLEMIA


B. Causes of edema
Arteriole
Venule
1
Precapillary vasodilatation
Capillary pressure rises
2
Venous pressure rises
mmHg
kPa
30
25
20
4.0
3.5
3.0
2.5
Edema
3
Decrease in plasma proteins
mmHg
kPa
30
25
20
4.0
3.5
3.0
Edema
Filtration > Reabsorption + lymph drainage
4
Reduced lymph drainage
Edema (e.g., in ankles)

ECF=1/3 **ICF=2/3**

Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

–

Na	Na
Na	Na
Na	Na

Isotonic

ECF=1/3 **ICF=2/3**

Na	IO	K	K	K	K	K
Na	IO	K	K	K	K	K
Na	IO	K	K	K	K	K

SIGNS:

INTRAVASCULAR: MILD (ORTHOSTATIC CHANGE IN BP & PULSE, FLAT JVP)
SEVERE (HYPOTENSION, SHOCK)
INTERSTITIAL: DIMINISHED SKIN TURGOR
TRANSCELLULAR: DRY MOUTH AND MM. DIMINISHED OCULAR PRESSURE

(PURE) HYPOVOLEMIA

ECF=1/3			ICF=2/3					
Na	Na	Na	O	K	K	K	K	K
Na	Na	Na	O	K	K	K	K	K
Na	Na	Na	O	K	K	K	K	K

+

Na	Na
Na	Na
Na	Na

Sodium

NewYork nursery catastrophe

ECF=1/3					ICF=2/3					
Na	Na	Na	Na	Na	O	K	K	K	K	K
Na	Na	Na	Na	Na	O	K	K	K	K	K
Na	Na	Na	Na	Na	O	K	K	K	K	K

CNS SYMPTOMS & SIGNS OF HYPERNATREMIA:

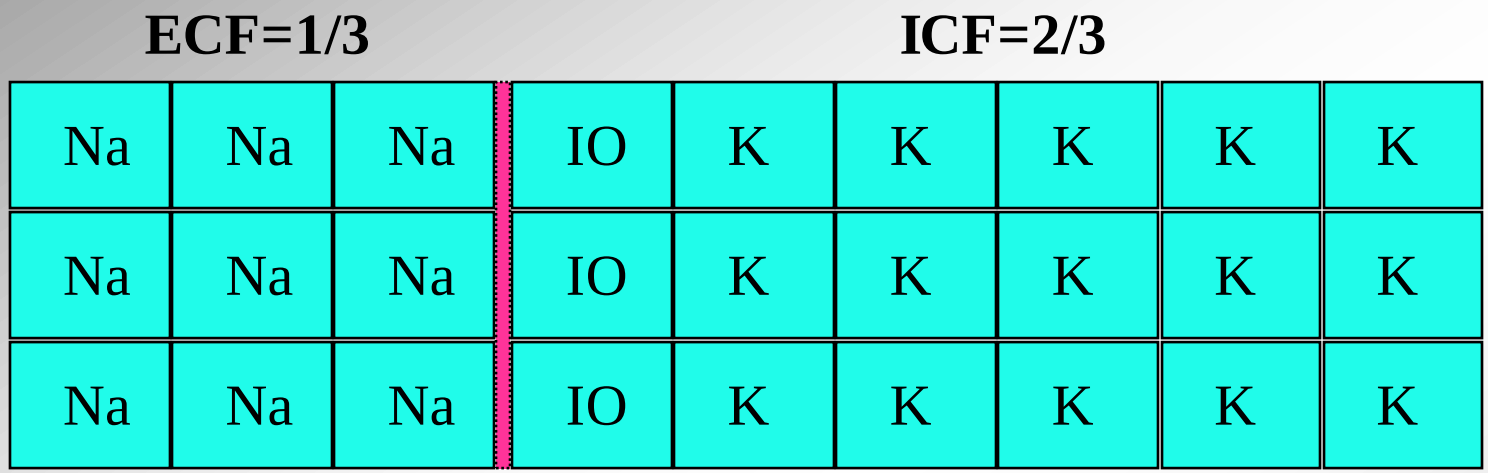
LETHARGY, IRRITABILITY, SPASTICITY, CONFUSION, STUPOR, COMA
FOCAL NEUROLOGIC DEFICITS
INTENSE THIRST, EMESIS, FEVER, LABORED RESPIRATION

Mixed Disorder

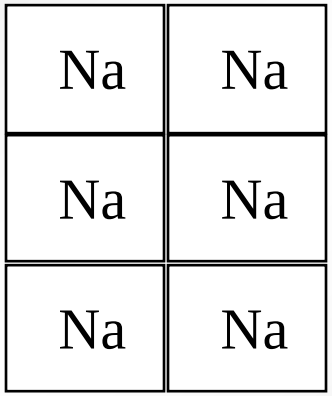
HYPERVOLEMIC HYPERNATREMIA
ACUTE

ECF=1/3					ICF=2/3				
Na	Na	Na	Na	Na	K	K	K	K	K
Na	Na	Na	Na	Na	K	K	K	K	K
Na	Na	Na	Na	Na	K	K	K	K	K

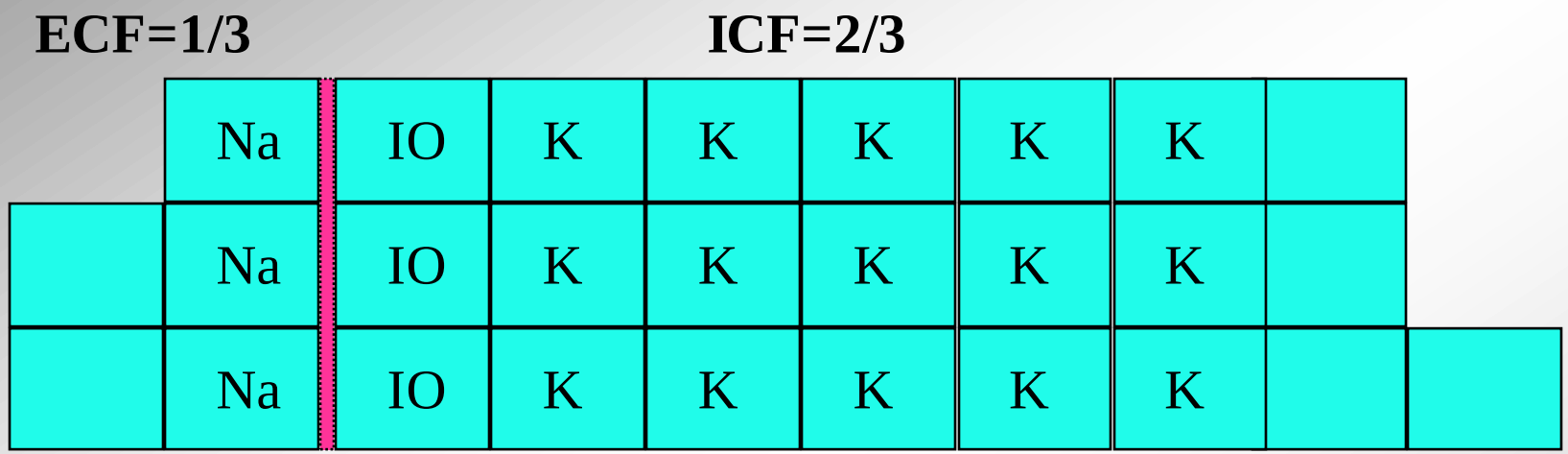
HYPERVOLEMIC HYPERNATREMIA
CHRONIC (48 HOURS)


ECF=1/3
ICF=2/3
Na Na Na IO K K K K K
Na Na Na IO K K K K K
Na Na Na IO K K K K K

–


Na Na
Na Na
Na Na

Sodium



CNS SYMPTOMS & SIGNS OF HYPONATREMIA:

SHOCK

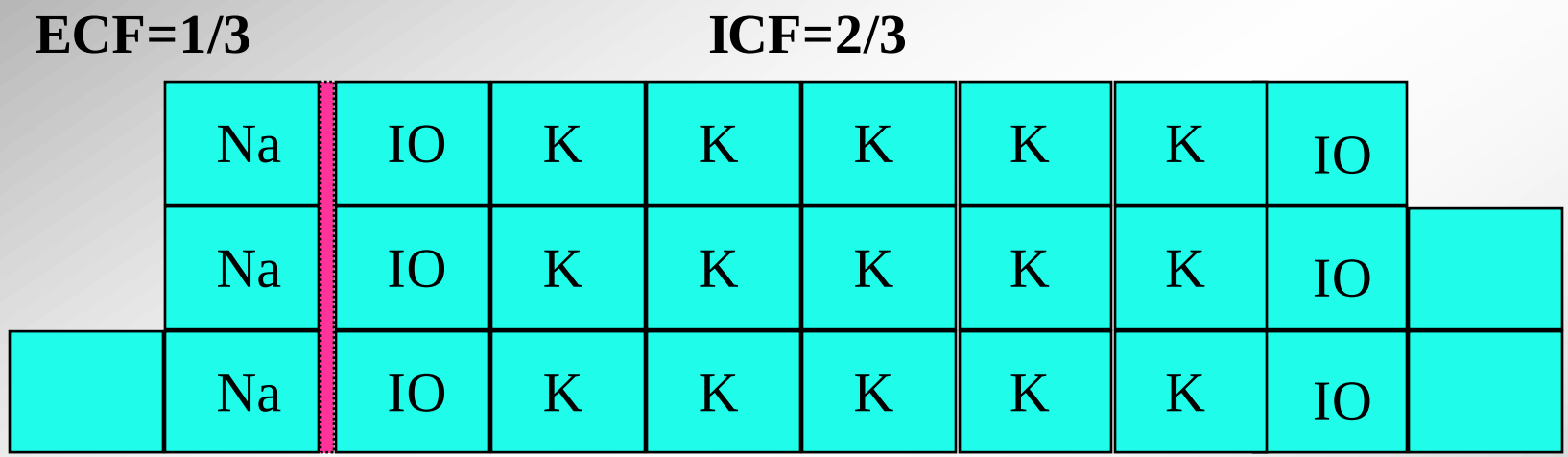
GI: ANOREXIA

CNS: LETHARGY, HEADACHE, CONFUSION, STUPOR, SEIZURES, COMA

Mixed Disorder

HYPOVOLEMIC HYPONATREMIA

ACUTE



HYPOVOLEMIC HYPONATREMIA
CHRONIC (48 HOURS)

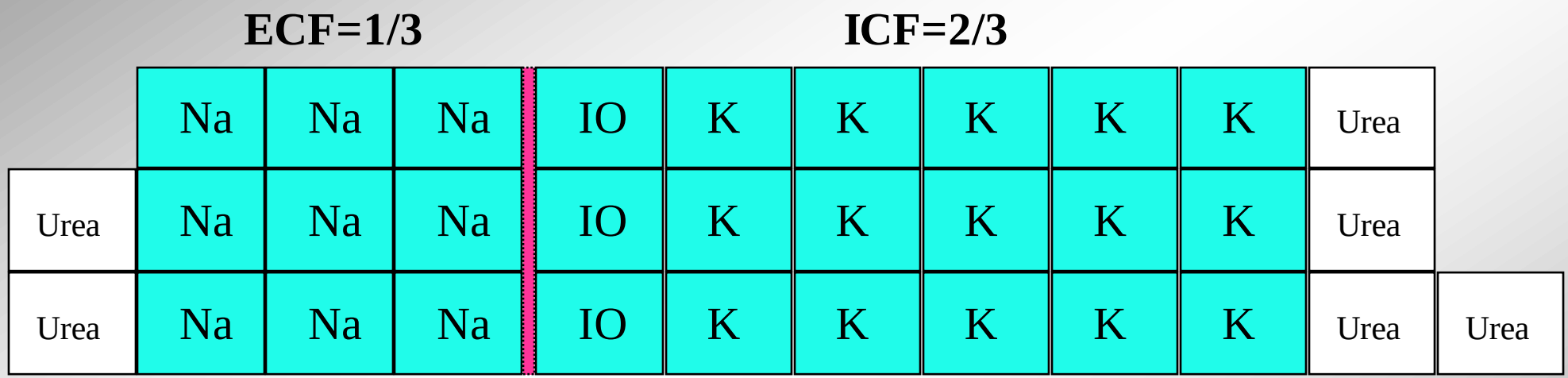
ECF=1/3 **ICF=2/3**

Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

+

Urea	Urea
Urea	Urea
Urea	Urea

UREA



HYPEROSMOLAR ISOTONIC STATE (CRF)

ECF=1/3 **ICF=2/3**

Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

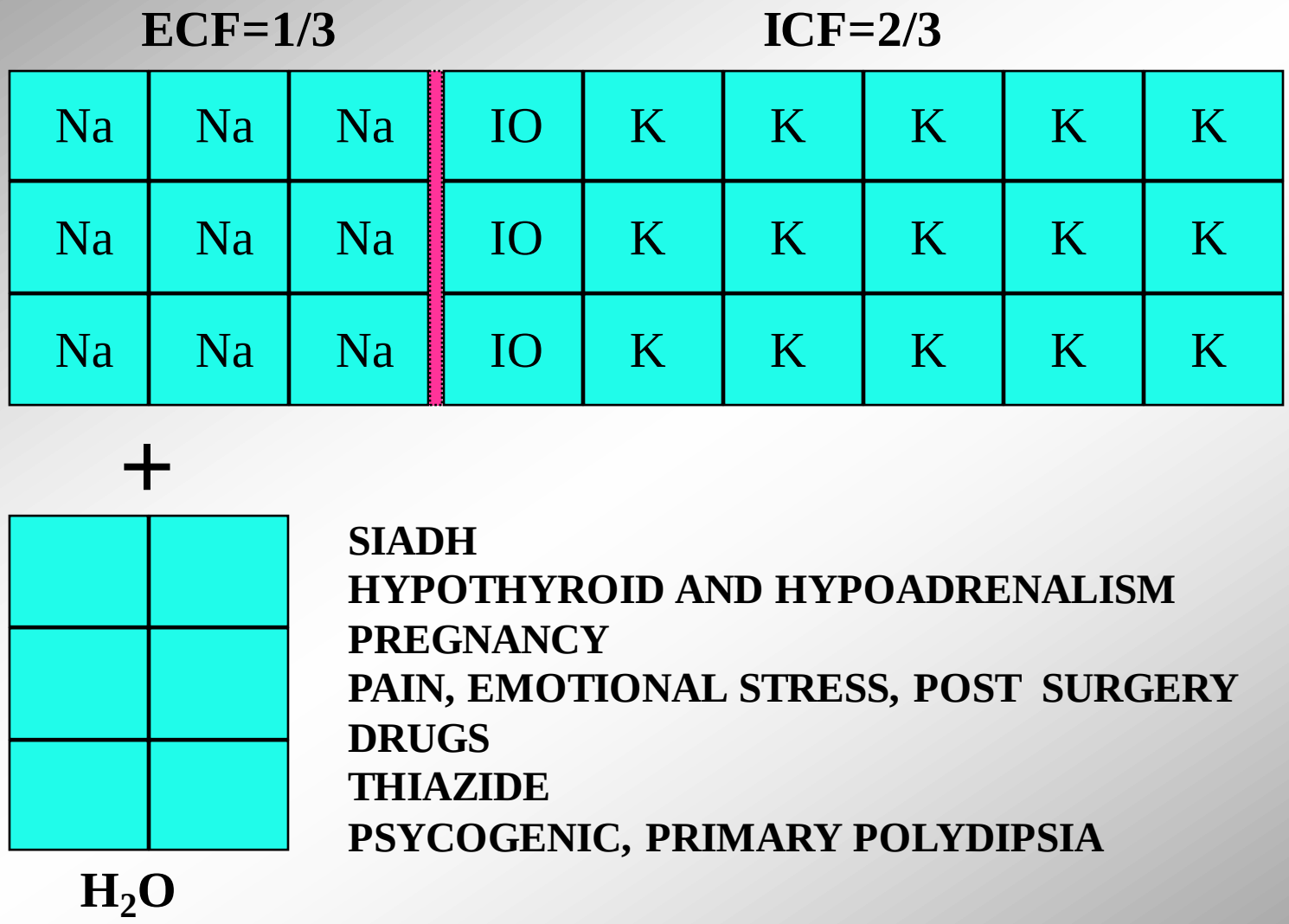
+

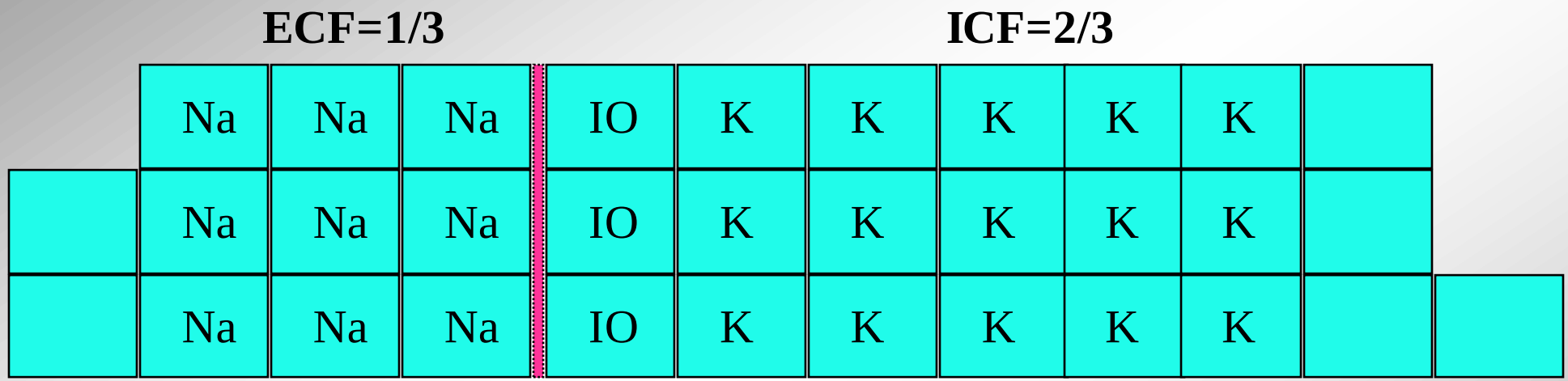
Glu
Glu
Glu

GLUCOSE

ECF=1/3				ICF=2/3					
Glu	Na	Na	Na	IO	K	K	K	K	K
Glu	Na	Na	Na	IO	K	K	K	K	K
Glu	Na	Na	Na	IO	K	K	K	K	K

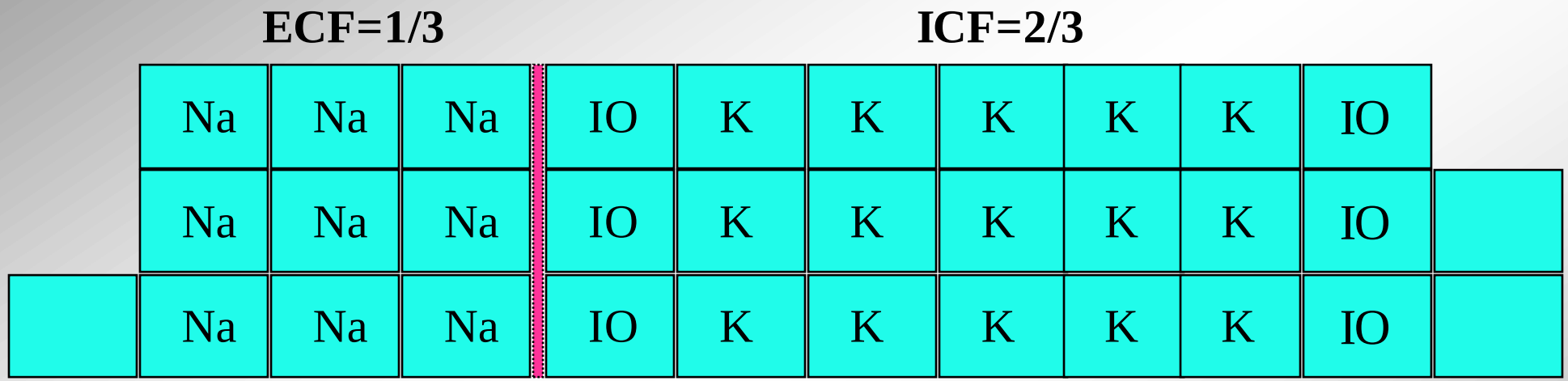
HYPEROSMOLAR HYPERTONIC STATE


ECF=1/3
ICF=2/3
Na Na Na IO K K K K K
Na Na Na IO K K K K K
Na Na Na IO K K K K K
+
H_2O
SIADH
HYPOTHYROID AND HYPOADRENALISM
PREGNANCY
PAIN, EMOTIONAL STRESS, POST SURGERY
DRUGS
THIAZIDE
PSYCOGENIC, PRIMARY POLYDIPSIA



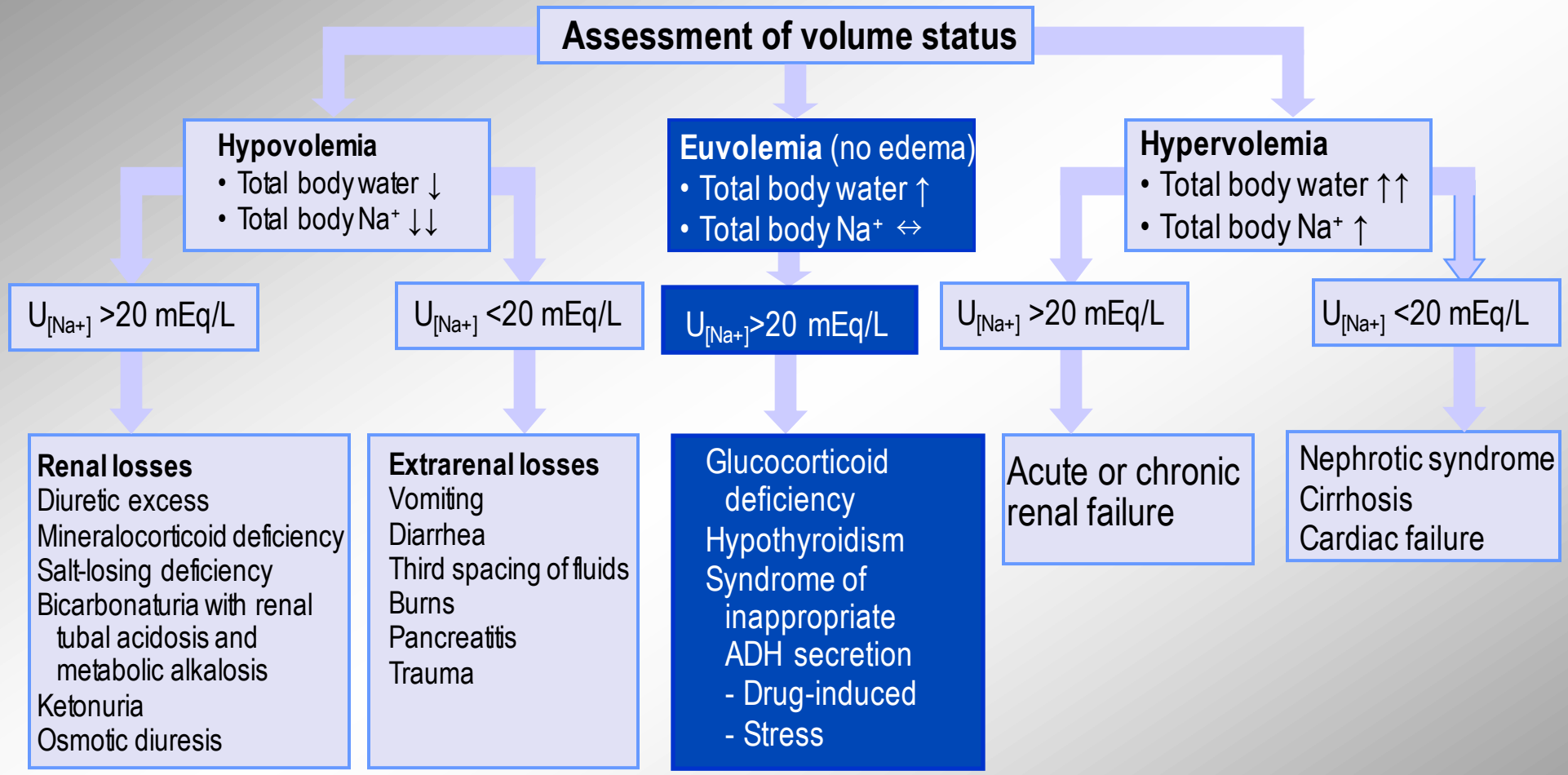
ISOVOLEMIC HYPONATREMIA
ACUTE

Pure Disorder



ISOVOLEMIC HYPONATREMIA
CHRONIC (48 HOURS)

Diagnostic Algorithm for Hyponatremia



Legend: ↑ increase; ↑↑ greater increase; ↓ decrease; ↓↓ greater decrease; ↔ no change.

(Adrogue-Madias) FORMULA

$$\Delta \text{ Na} = \frac{(\text{infusate Na } (+\text{K}) - \text{actual Na})}{\text{TBW}^* + 1}$$

*TBW = 0.5 X body wt (Kg)

TREATMENT OF HYPONATREMIA

70 year old male, serum Na = 110 ?

TBW = 70 * 0.6 = 42 liters

Excess water = 42 - (110/120* 42) = 3.5 L

110 = TBC/TBW TBC = 42 * 110 = 4620

Over 2h he received 200 ml NaCl 3%, and excreted 1000 ml urine (Na+K=70+30)

TBW = 42 - 0.8 = 41.2 , Na=4620/41.2 = 112

Aquaresis

- Aquaresis is defined as the solute-free excretion of water by the kidney
- Because electrolytes represent a major component of urine solutes, aquaresis is also electrolyte-sparing
  - Measured by increases in EWC and is calculated from the urine volume and from the plasma and urine [Na+] and [K+]
  - Typically accompanied by increased urine output and reduced urine osmolality
- Distinguished from diuresis (increased urine output accompanied by electrolyte excretion)

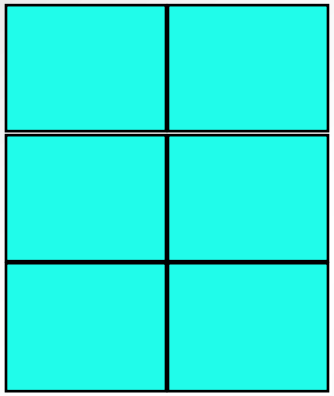
VAPRISOL®
(conivaptan hydrochloride injection)

- **Vaprisol is indicated for the treatment of euvolemic hyponatremia (eg, SIADH, or in the setting of hypothyroidism, adrenal insufficiency, pulmonary disorders, etc) in hospitalized patients**
- **Vaprisol is also indicated for the treatment of hypervolemic hyponatremia in hospitalized patients**
- **Not indicated for the treatment of congestive heart failure (effectiveness and safety have not been established in these patients)**

ECF=1/3 **ICF=2/3**

Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

–



H_2O

RENAL LOSS (DI)
EXTRA RENAL (RESP., DERMAL)
INABILITY TO GAIN ACCESS TO FLUIDS
HYPODIPSIA, ADIPSIA
RESET OSMOSTST (ESSENTIAL HYPERNATREMIA)

ECF=1/3 **ICF=2/3**

Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K
Na	Na	Na	IO	K	K	K	K	K

ISOVOLEMIC HYPERNATREMIA
ACUTE

ECF=1/3			ICF=2/3				
Na	Na	Na	K	K	K	K	K
Na	Na	Na	K	K	K	K	K
Na	Na	Na	K	K	K	K	K

ISOVOLEMIC HYPERNATREMIA
CHRONIC (48 HOURS)


CALCULUS I