جامعة الجزيرة الخاصة
ALJAZEERA PRIVATE UNIVERSITY

2.Fluid and electrolyte balance

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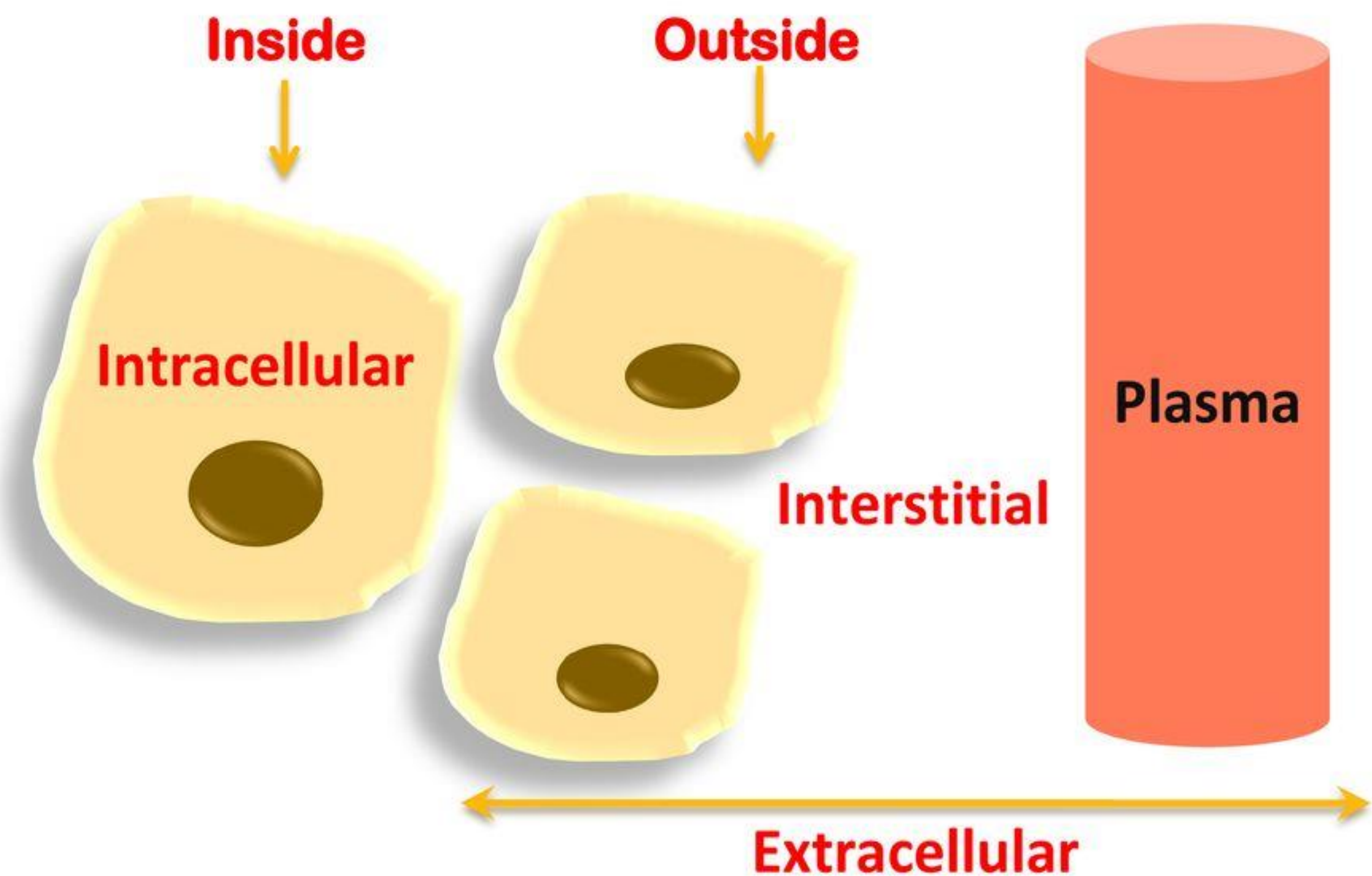
Distribution of Body Fluids

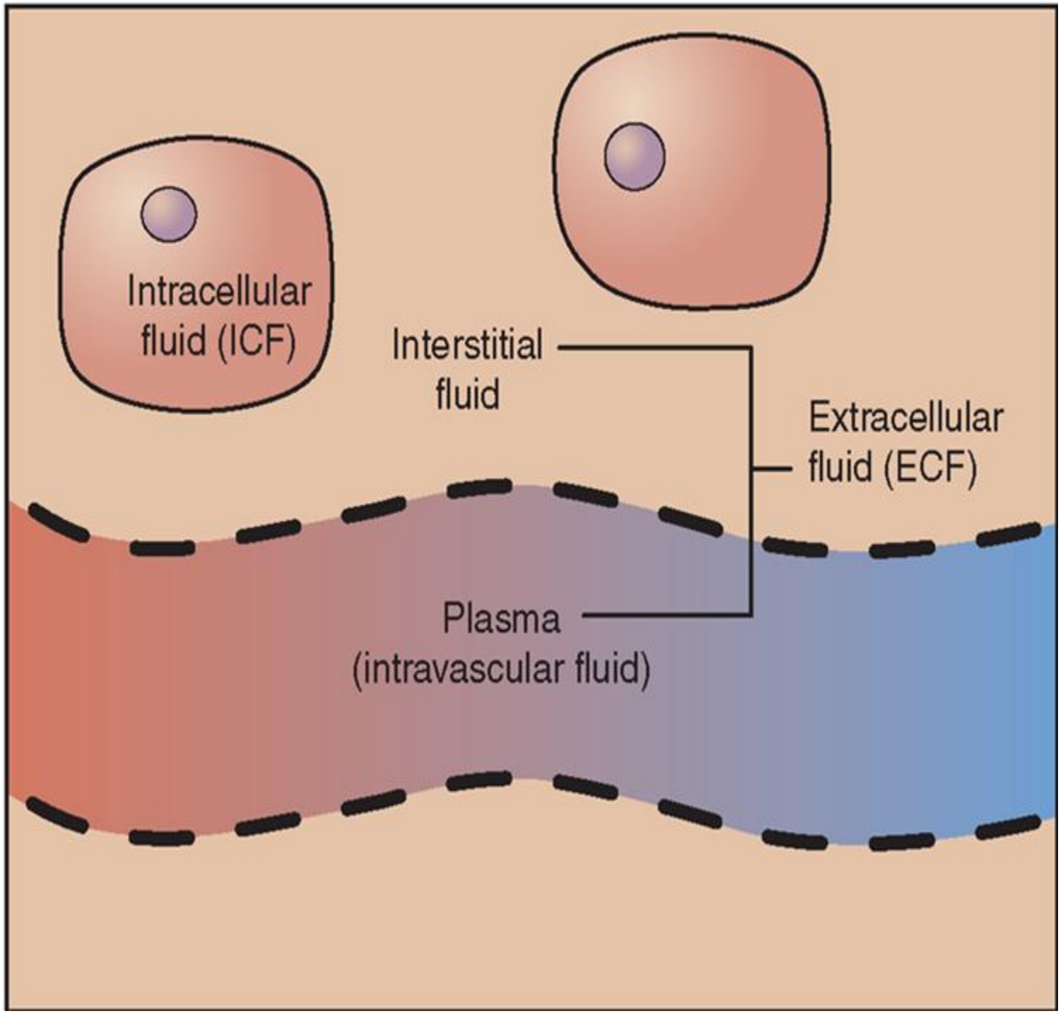


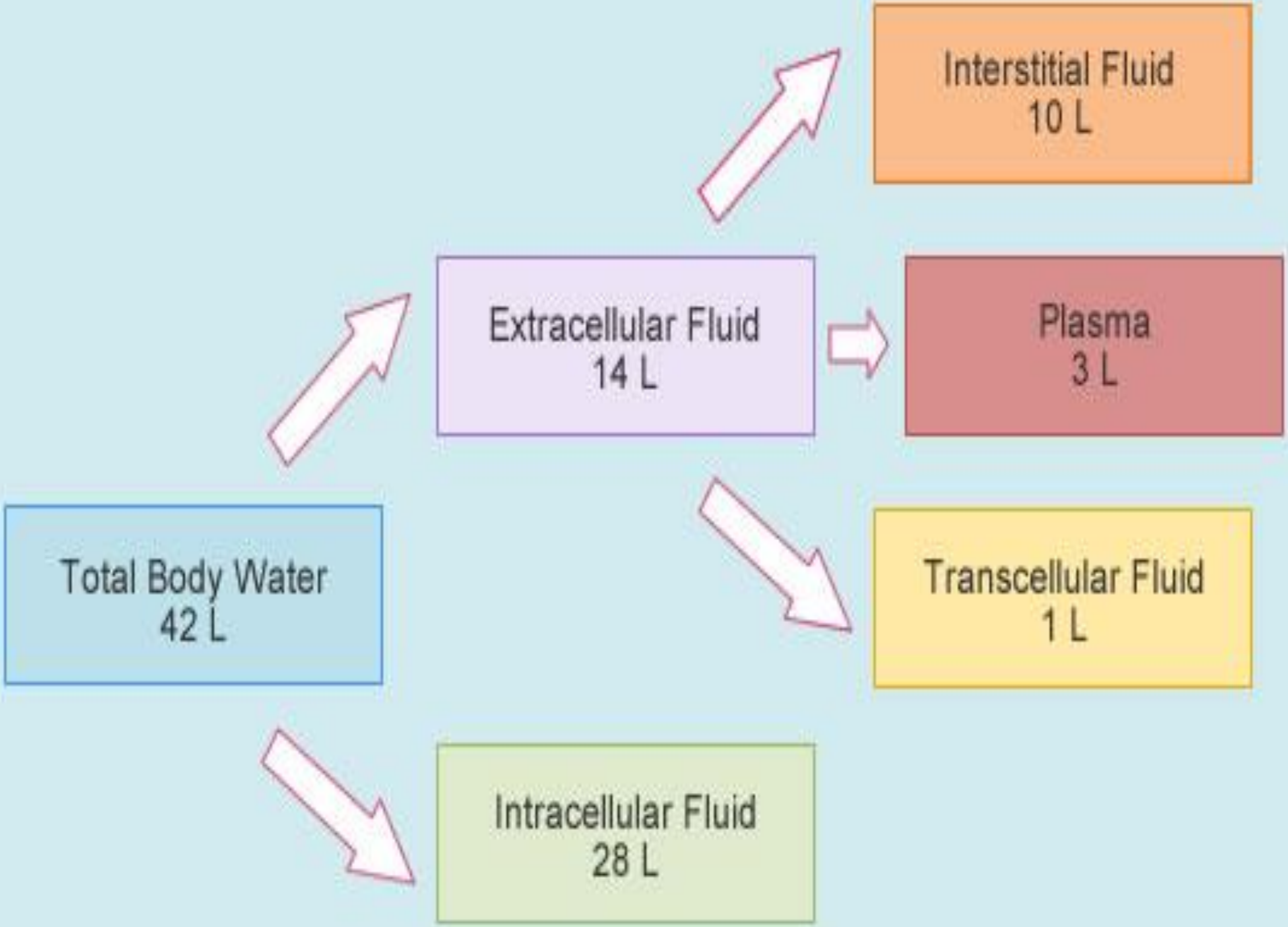
Body fluid compartments

The major body constituent is water. An 'average' person, weighing 70 kg, contains about **42 litres** of water in total.

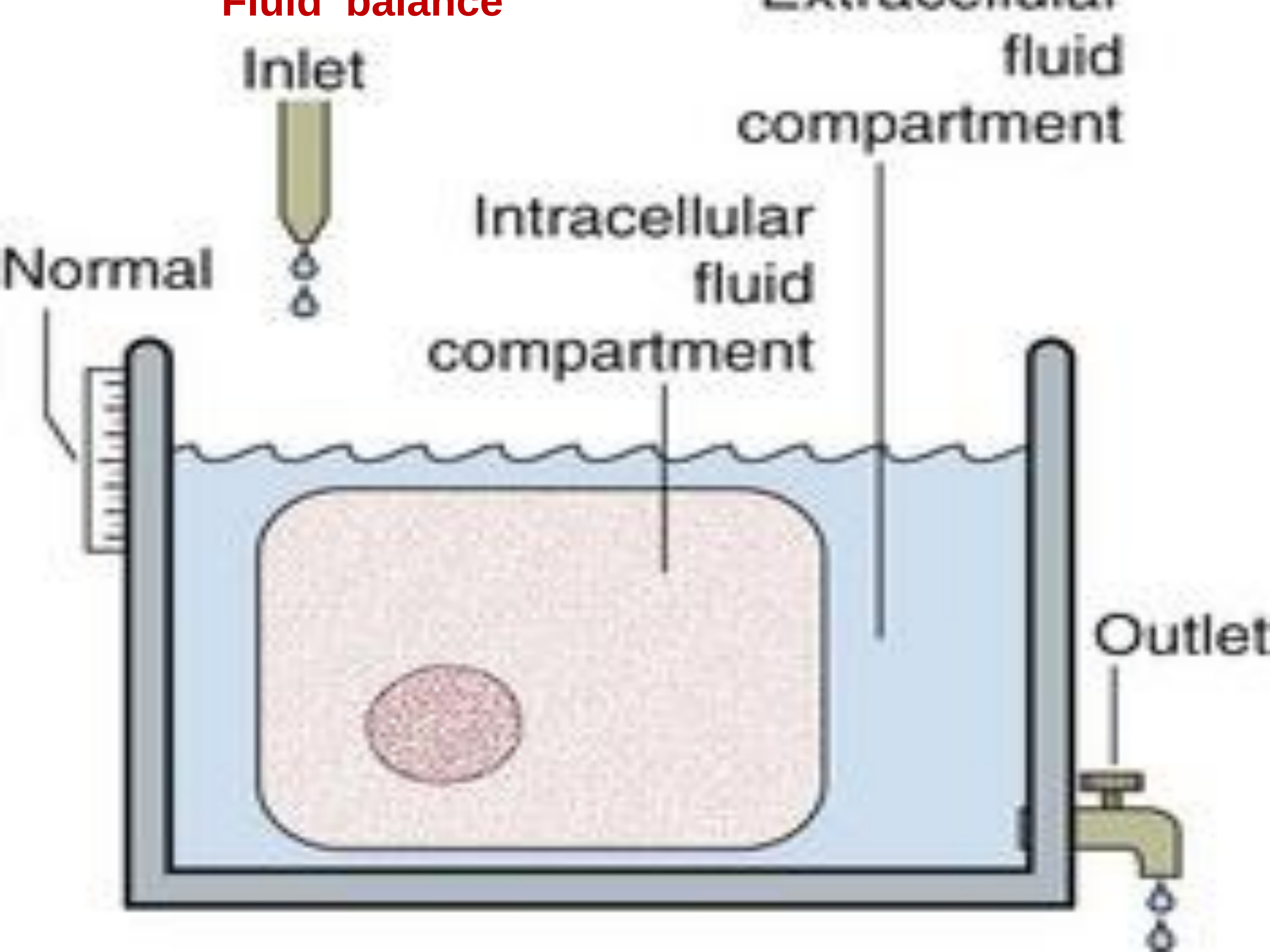
❖Two-thirds (**28 L**) of this is intracellular fluid (ICF)

❖and one-third (**14 L**) is extracellular fluid (ECF).




Total Body Water
42 L
Extracellular Fluid
14 L
Intracellular Fluid
28 L
Interstitial Fluid
10 L
Plasma
3 L
Transcellular Fluid
1 L

Fluid balance



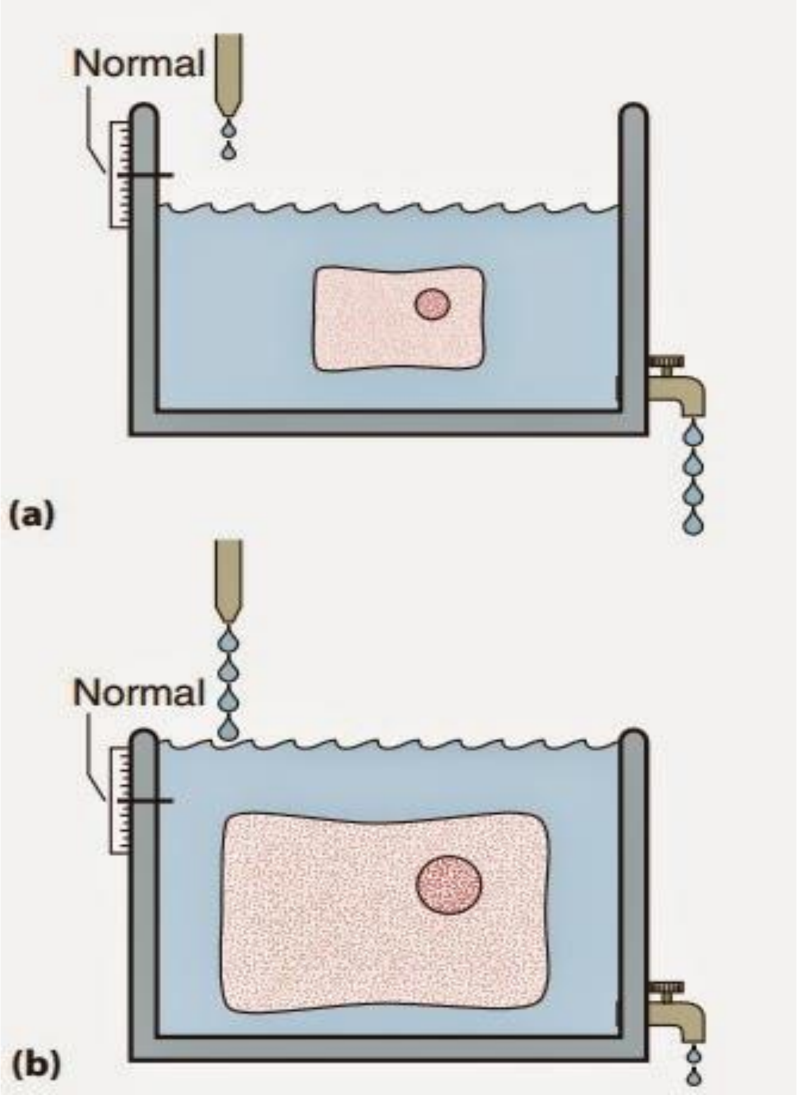
Fluid balance

State of Hydration

Dehydration and Overhydration

- Water retention will cause an **increase (Overhydration)**in the volume of both ECF and ICF.
- Water loss (**Dehydration**) will result in a **decreased** volume of both ECF and ICF.

Fluid balance



The effect of volume depletion and volume expansion on the water tank model of body compartments.

(a)Dehydration: loss of fluid in ICF and ECF due to increased urinary losses.

(b)Overhydration: increased fluid in ICF and ECF due to increased intake.

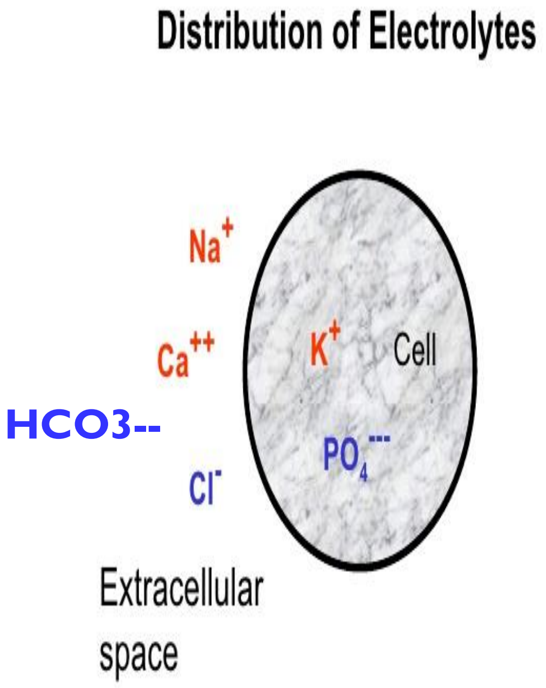
Table 6.1 **The principal clinical features of severe hydration disorders**

Feature	Dehydration	Overhydration
Pulse	Increased	Normal
Blood pressure	Decreased	Normal or increased
Skin turgor	Decreased	Increased
Eyeballs	Soft/sunken	Normal
Mucous membranes	Dry	Normal
Urine output	Decreased	May be normal or decreased
Consciousness	Decreased	Decreased

Electrolytes…

Sodium (Na+) is the principal extracellular cation, and potassium (K+), the principal intracellular cation.

Inside cells the main anions are protein and phosphate, whereas in the ECF: chloride (Cl−) and bicarbonate (HCO3 −) predominate.



Concentration

- **Concentration:** is a ratio of two variables: the amount of solute (e.g. sodium), and the amount of water.
- A concentration can change because either or both variables have changed. For example, a sodium concentration of 140 mmol/L may become 130 mmol/L because the amount of sodium in the solution has fallen or because the amount of water has increased

Osmolality

Osmolality is defined as the concentration of all solutes in a given weight of water and is expressed as units of either osmolality (milliosmoles of solute per kilogram of water, mOsm/kg H_2O) or **osmolarity** (milliosmoles of solute per liter of water, mOsm/L H_2O).

Osmolality

❖In man, the **Osmolality of serum** (and all other body fluids except urine) is around :285 - 295 mOsm/kg

❖**Urine Osmolality (24 -hour): 300-900 mmol/kg**

Calculated osmolality

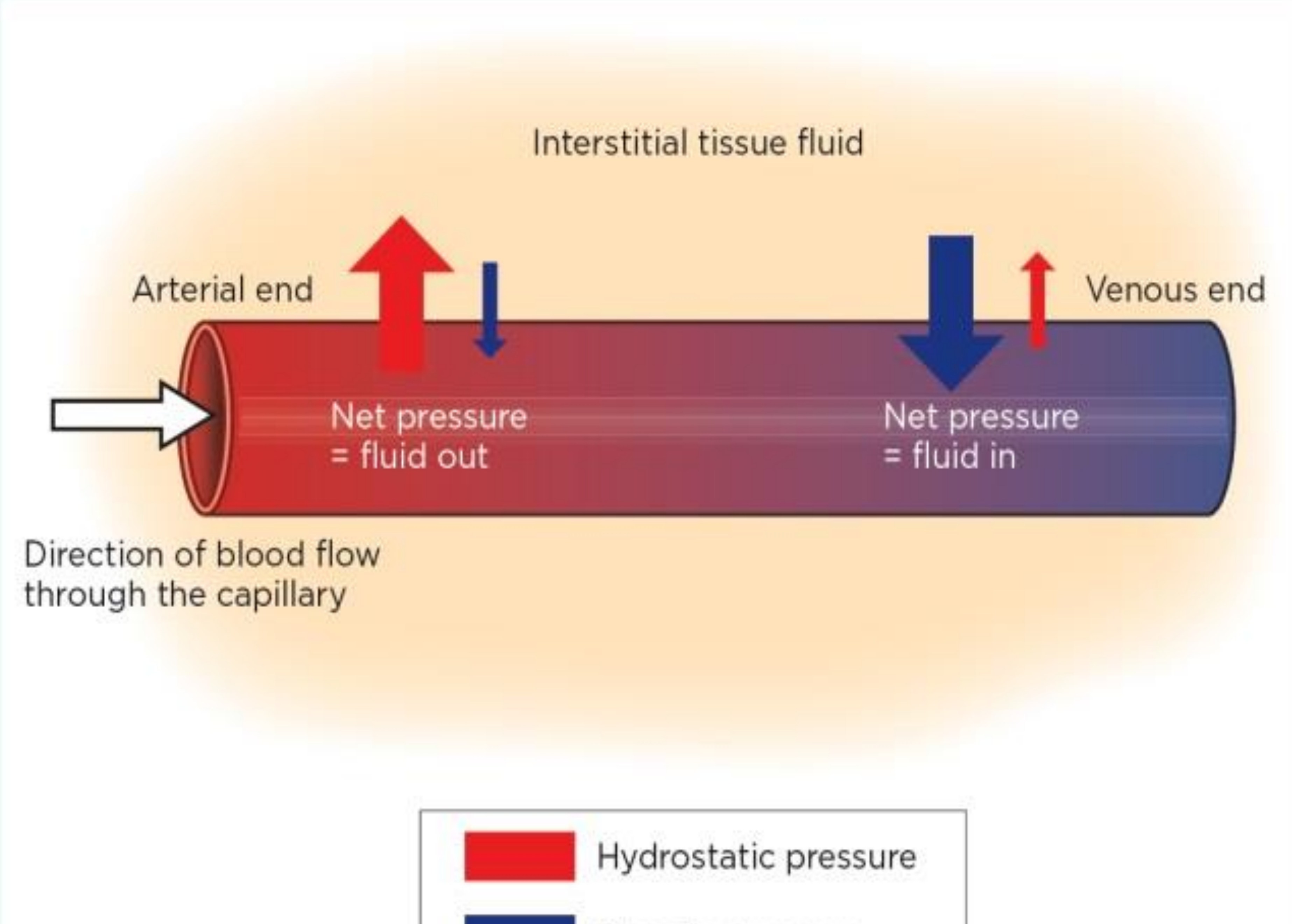
Osmolality = 2[Na^+] + [glucose]/18 + [BUN]/2.8

Calculated osmolarity = 2 Na

Oncotic pressure

Oncotic pressure, or **colloid** osmotic pressure, is a form of osmotic pressure induced by proteins, notably albumin, in a blood vessel's plasma (blood/liquid) that displaces water molecules, thus creating a relative water molecule deficit with water molecules moving back into the circulatory system within the lower pressure venous end of capillaries.

Fig 2. **Fluid movement between capillary and tissue**



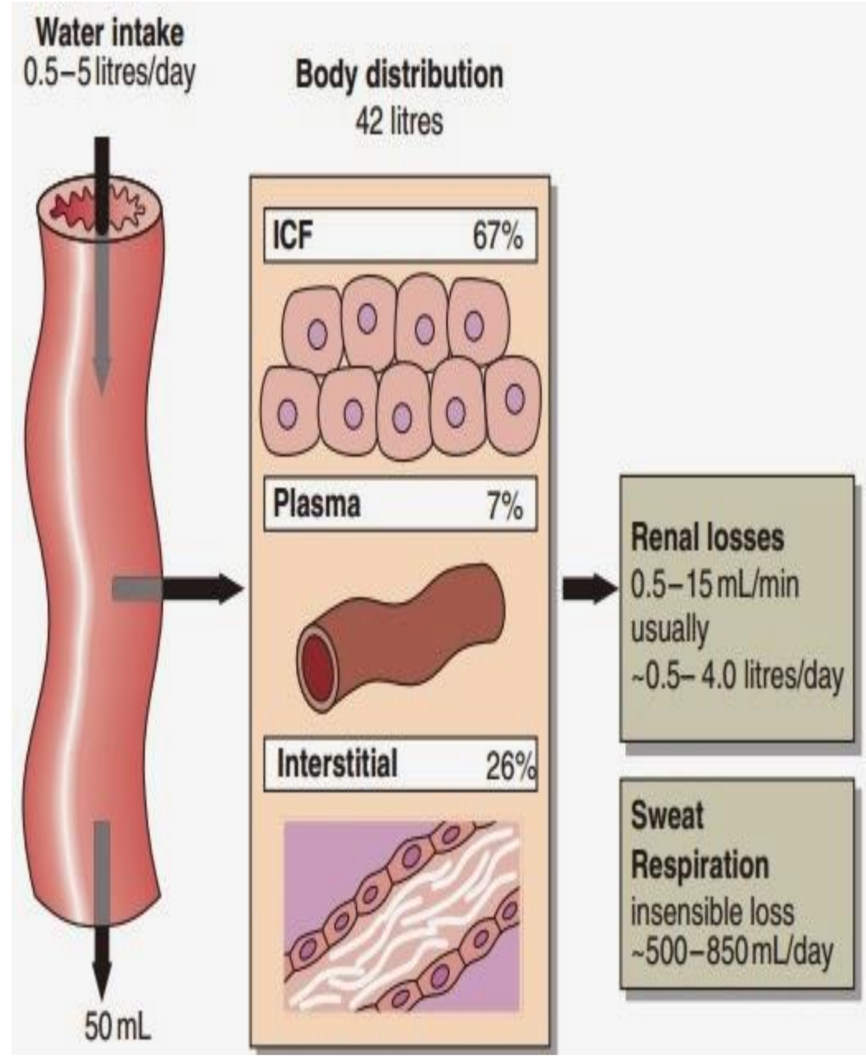
Water and sodium balance

Water balance

- Water intake largely depends on social habits and is very variable.

- Water losses are equally variable and are normally seen as changes in the volume of urine produced.

- **Water excretion** by the **kidney** is very tightly controlled by:
 arginine vasopressin (**AVP**; also called antidiuretic hormone, **ADH**).



AVP and the regulation of osmolality

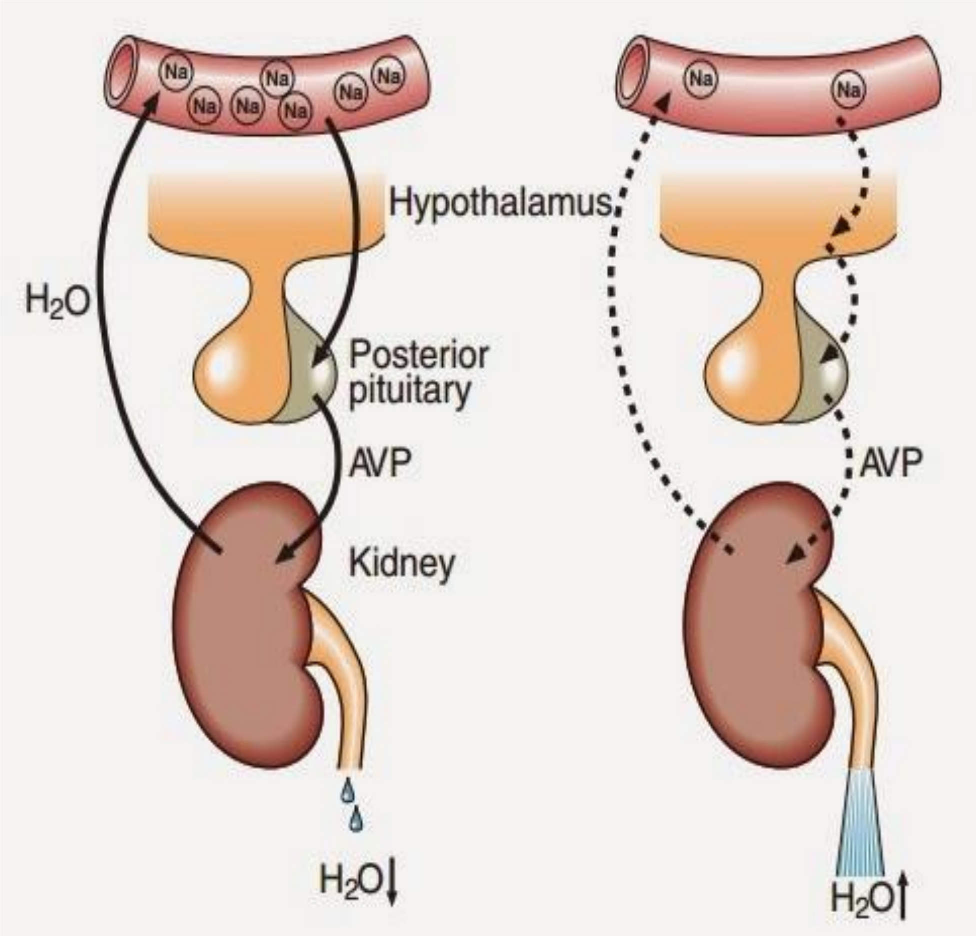
•Specialized cells in the hypothalamus sense differences between their intracellular osmolality and that of the extracellular fluid, and adjust the

• secretion of **AVP** from the posterior pituitary gland.

• **AVP** causes water to be retained by the kidneys.

•The main function of **ADH** is **osmoregulation**

Arising osmolality | declining osmolality



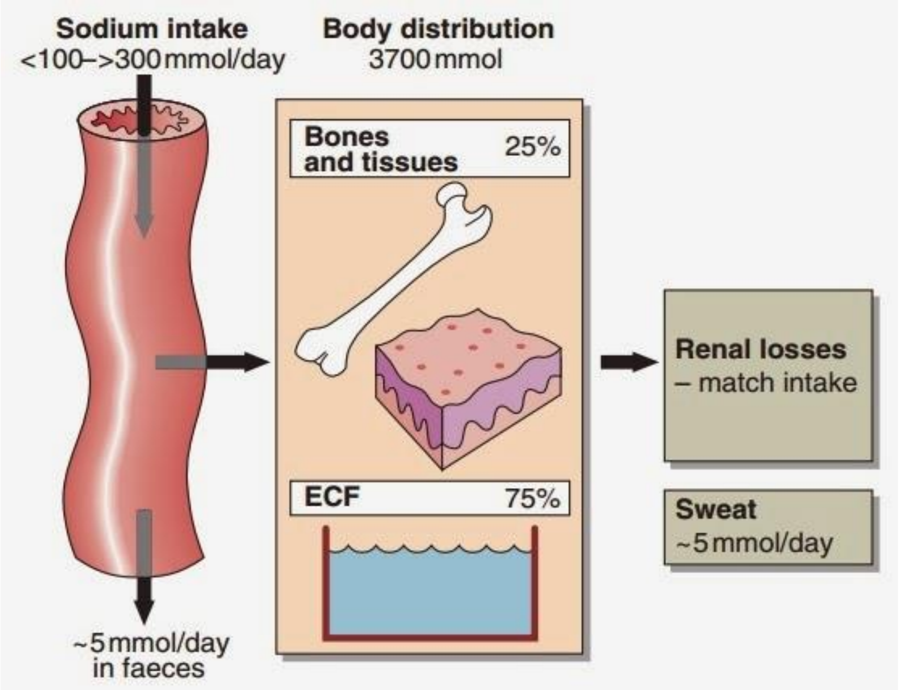
the secretion of AVP | AVP secretion is shut down

▪The total body sodium of the average 70 kg man is approximately 3700 mmol, of which approximately 75% is exchangeable.

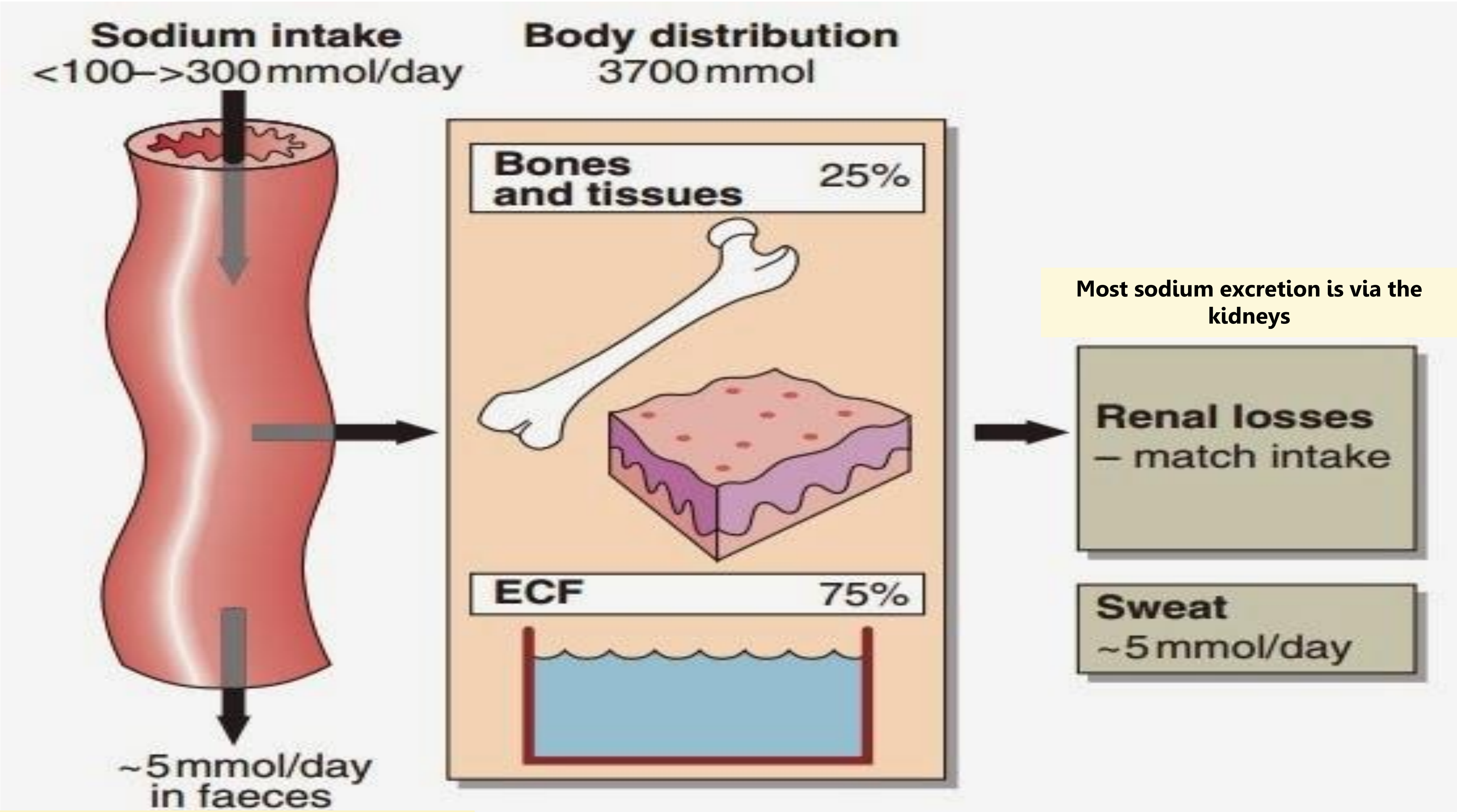
▪quarter of the body sodium is termed non-exchangeable,which means it is incoporated into tissues such as bone and has a slow turnover rate.

▪Most of the **exchangeable** sodium is in the extracellular fluid. In the ECF, which comprises both the plasma and the interstitial fluid, the sodium concentration is tightly regulated at around 140 mmol/L.

Sodium balance



Normal sodium balance



Most sodium excretion is via the kidneys

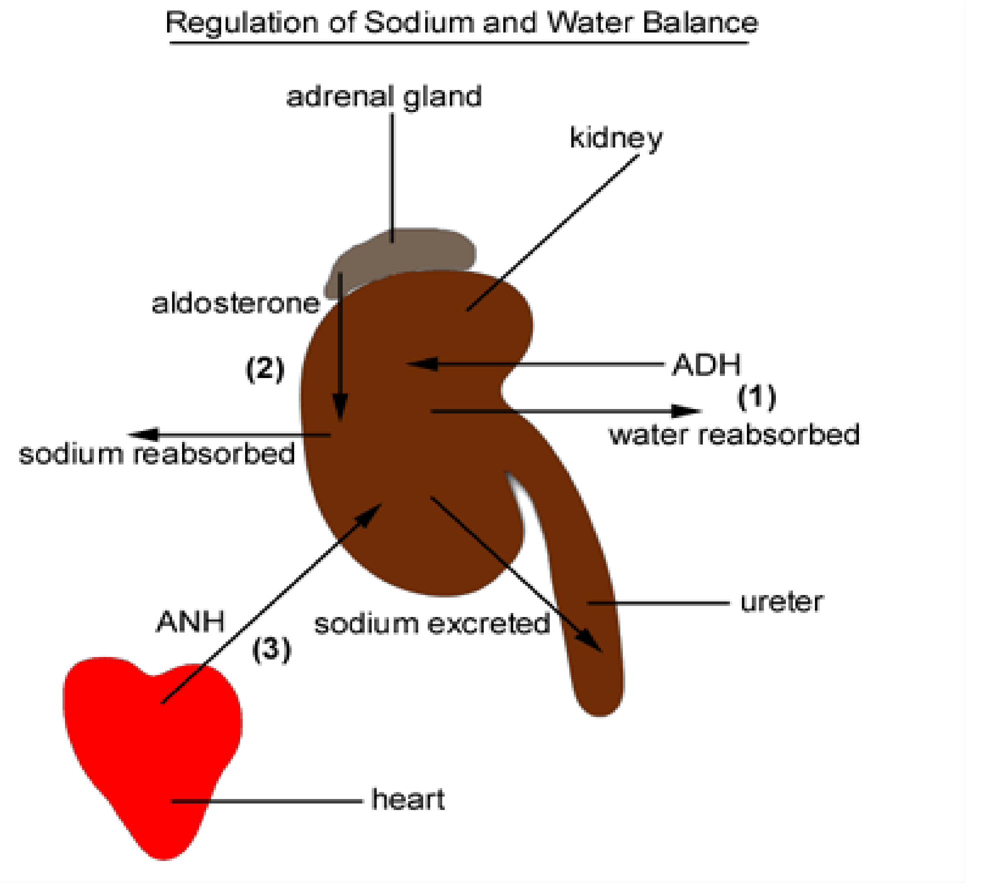
In disease the gastrointestinal tract is often the major route of sodium loss. This is a very important clinical point, especially in paediatric practice, as infantile diarrhoea may result in death from salt and water depletion.

Regulation of sodium balance

Urinary sodium output is regulated

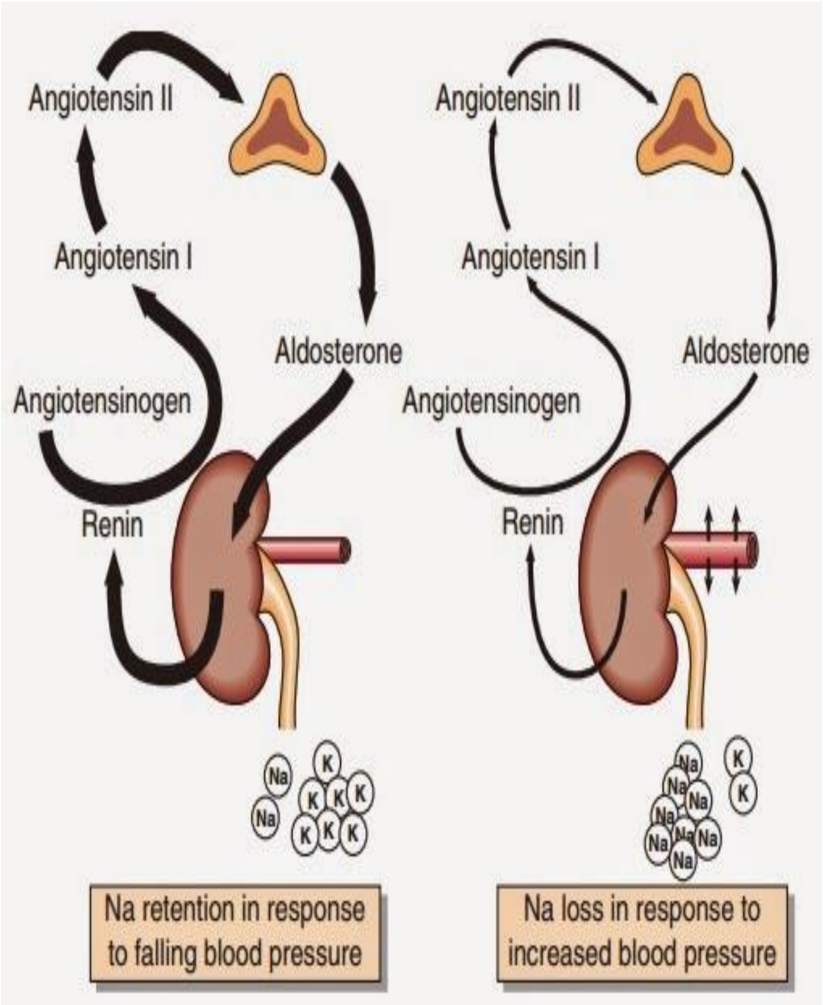
by the followings hormones:

- Aldosterone
- Atrial natriuretic peptide.



The effect of Aldosterone

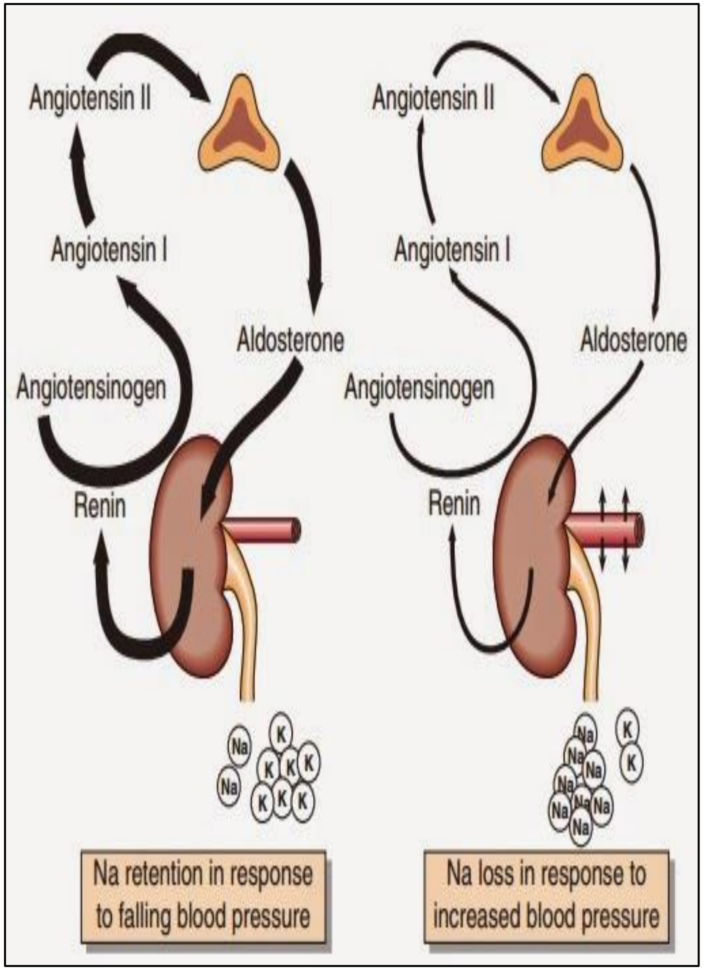
- Specialized cells in the juxtaglomerular apparatus of the nephron sense decreases in **blood pressure** and secrete **Renin**, the first step in a sequence of events that leads to the secretion of aldosterone by the glomerular zone of the adrenal cortex.



A major stimulus to aldosterone secretion is the volume of the ECF.

The effect of Aldosterone

- Aldosterone decreases urinary sodium excretion by **increasing** sodium reabsorption in the renal tubules at the expense of potassium and hydrogen ions.
- Aldosterone also stimulates sodium conservation by the **sweat glands and the mucosal cells** of the colon, but in normal circumstances these effects are trivial.



A major stimulus to aldosterone secretion is the volume of the ECF.

Atrial natriuretic peptide

Atrial natriuretic peptide(ANP):

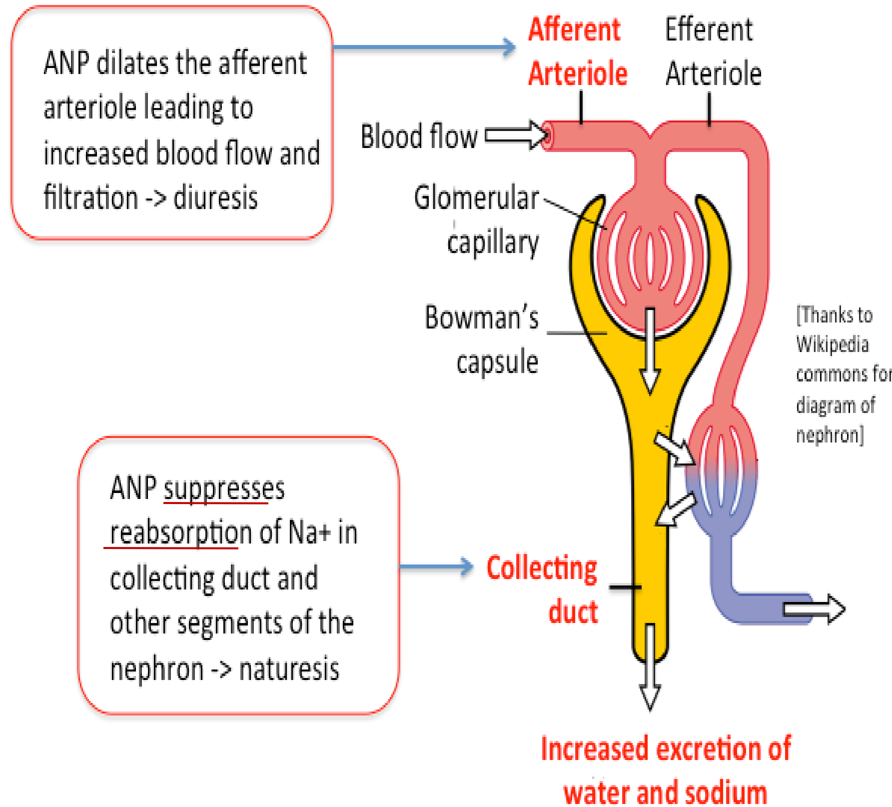
is a polypeptidehormone

predominantly secreted by the

cardiocytes of the right atrium of the

heart. It increases urinary sodium

excretion.



Regulation of volume

- Changes in sodium content (a patient who has been vomiting and has diarrhoea from a gastrointestinal infection)the ECF cause changes in volume of this compartment.
- Aldosterone and AVP interact to maintain normal volume and concentration of the ECF.

Fluid and electrolyte balance: concepts and vocabulary

- The body has two main fluid compartments, the intracellular fluid and the extracellular fluid.
- The ICF is twice as large as the ECF.
- Water retention will cause an increase in the volume of both ECF and ICF.
- Water loss (dehydration) will result in a decreased volume of both ECF and ICF.
- Sodium ions are the main ECF cations.
- Potassium ions are the main ICF cations.
- The volumes of the ECF and ICF are estimated from knowledge of the patient’s history and by clinical examination.
- Serum osmolality can be measured directly or calculated from the serum sodium, urea and glucose concentrations.

Water and sodium balance

- Water is lost from the body as urine and as obligatory ‘insensible’ losses from the skin and lungs.
- Sodium may be lost from the body in urine or from the gut, e.g. prolonged vomiting, diarrhoea and intestinal fistulae.
- Arginine vasopressin (AVP) regulates renal water loss and thus causes changes in the osmolality of body fluid compartments.
- Aldosterone regulates renal sodium loss and controls the sodium content of the ECF.
- Changes in sodium content of the ECF cause changes in volume of this compartment because of the combined actions of AVP and aldosterone.