Homeostasis & Fluid Compartments

9.1.2024

Learning outcomes

- Understand the principle of homeostasis and its role in regulating body's static states

- Recognize and describe examples of homeostasis in different organ systems
    - ✓ Fluid homeostasis: regulation of fluid movement between intra- and extracellular fluid compartments
    - ✓ Regulation of blood glucose level

Homeostasis

- ’homois’ = same, ’stasis’ = standing still
- Maintenance of equilibrium state within on organ or organism

- Example: Control of body temperature

Body temperature decreases

↓

Blood vessels constrict→
Less heat loss

Muscles contract →
Shivering generates heat

Metabolism within tissues increases

↓

Heat loss decreases

Body temperature increases

↓

Blood vessels dilate→
More heat loss from the skin surface

Sweat glands activate

Exhaling increases

Metabolism within tissues decreases

↓

Heat loss increases

Homeostasis

HYPOTALAMUS
"thermostat"

RECEPTORS
skin, blood vessels,
inner organs

AUTONOMIC
NERVOUS SYSTEM,
HORMONES

Body temperature decreases

↓

Blood vessels constrict→
Less heat loss

Muscles contract →
Shivering generates heat

Metabolism within tissues
Increases

↓

Heat loss decreases

Body temperature increases

↓

Blood vessels dilate→
More heat loss from the
skin surface

Sweat glands activate

Exhaling increases

Metabolism within tissues
decreases

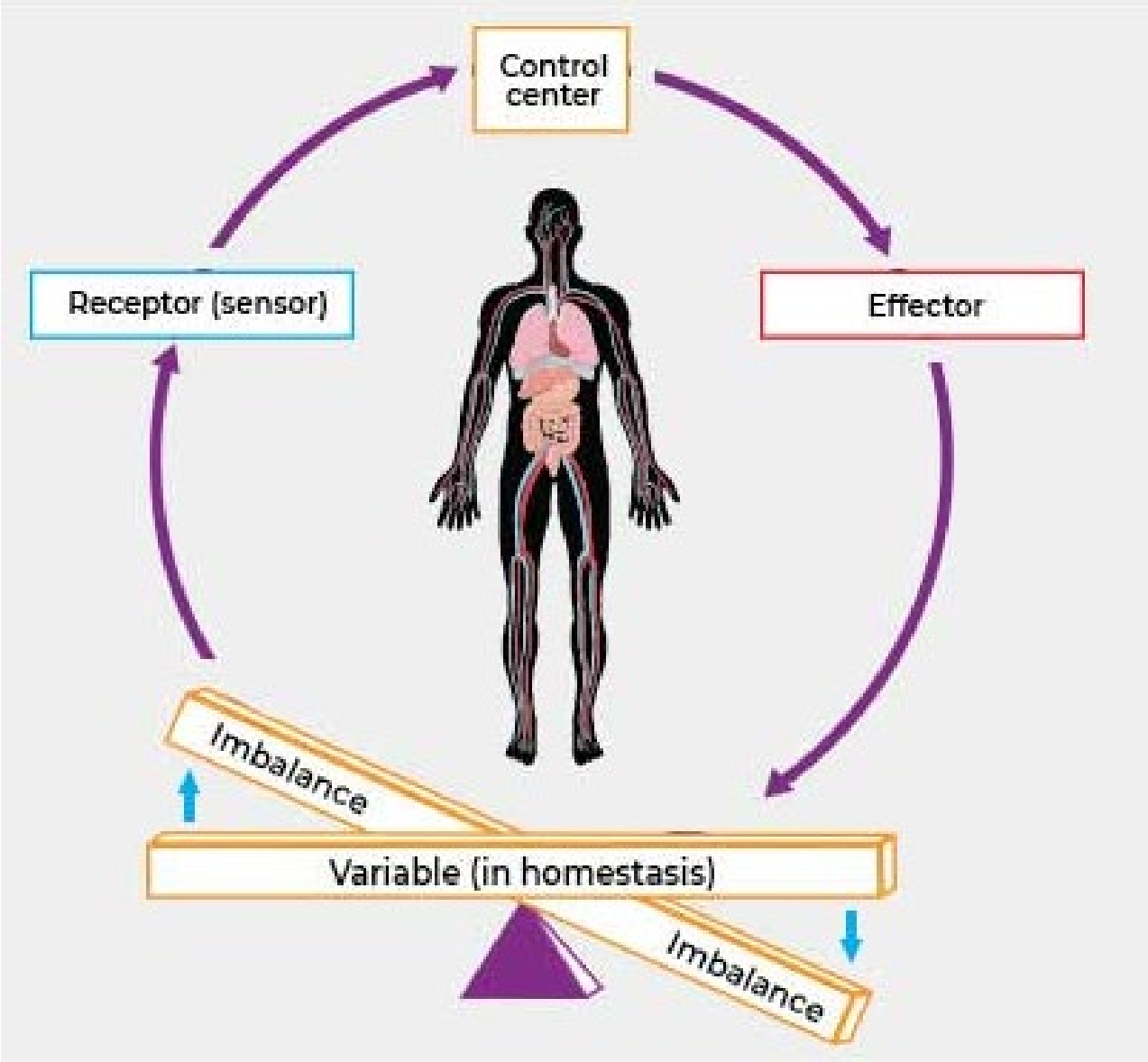
↓

Heat loss increases

Core concepts and examples of homeostasis

- Dependence on regulatory systems (nervous system, hormones)
- Receptors (nervous system) – Control center (brain) – Effectors (muscles, hormones, organs)
- E.g., blood pressure, fluid balance between intra- and extracellular compartments, blood glucose level, acidity

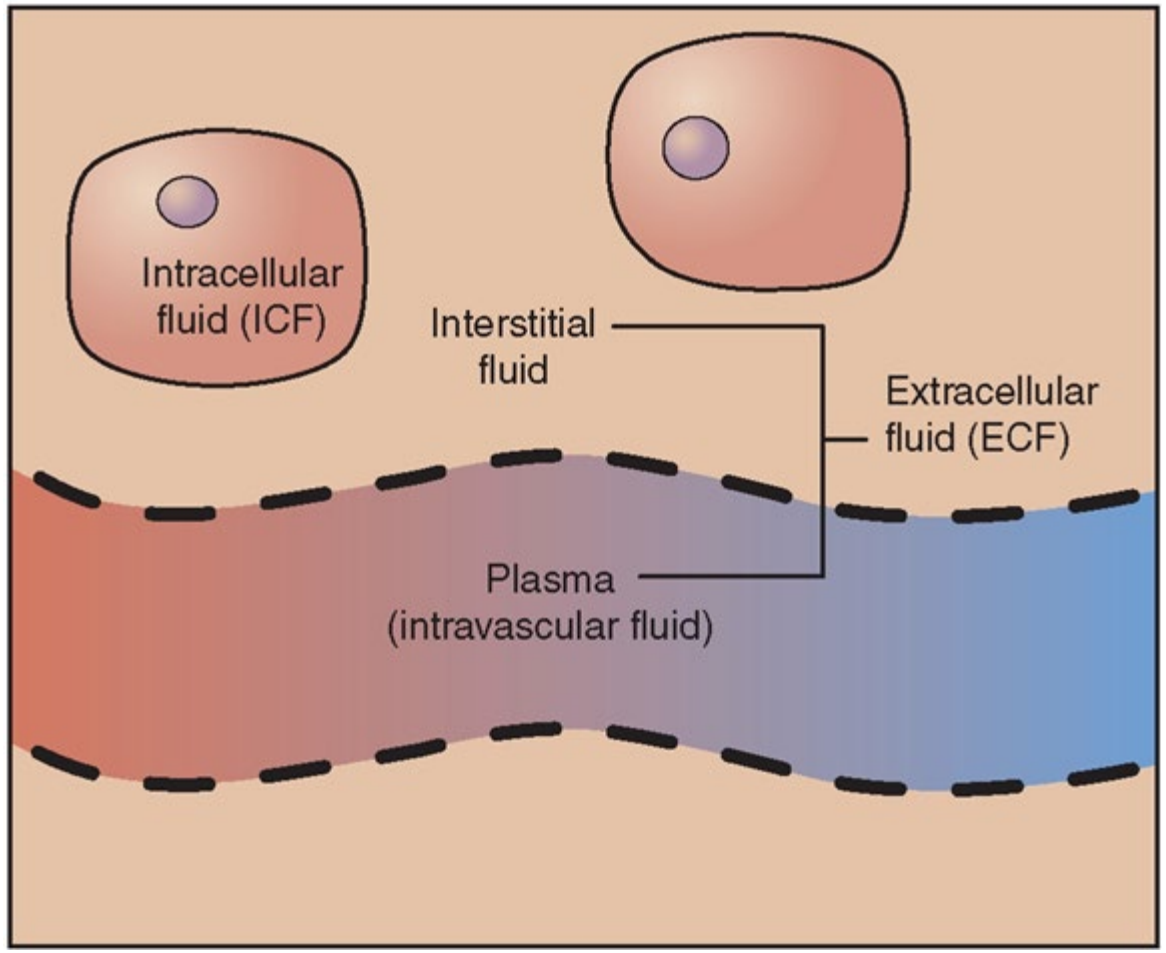
https://www.youtube.com/watch?v=kAy-03hIfck



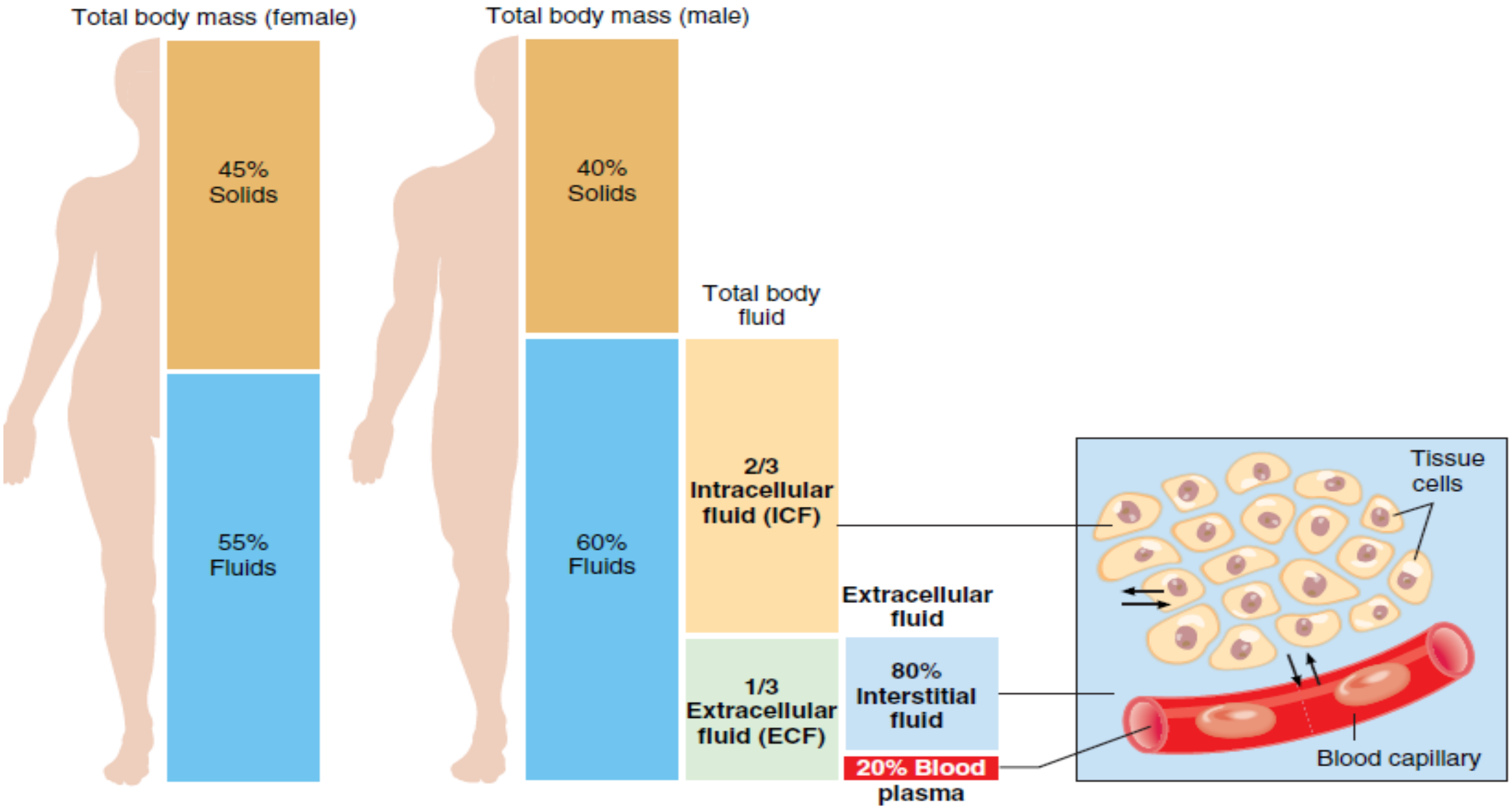
https://www.instantassignmenthelp.com/

Fluid compartments and fluid homeostasis

- Body fluids constitute 50-70% of body mass
- Intracellular (ICF, ~2/3) and extracellular fluid (ECF, ~1/3)
- ECF includes interstitial fluid (4/5), blood plasma (1/5) and so-called transcellular fluids (*e.g.*, cerebrospinal fluid, synovial fluid in joints)
- Fluids move constantly within the body and between the fluid spaces
- Cells are highly independent in maintaining their fluid balance



http://what-when-how.com/

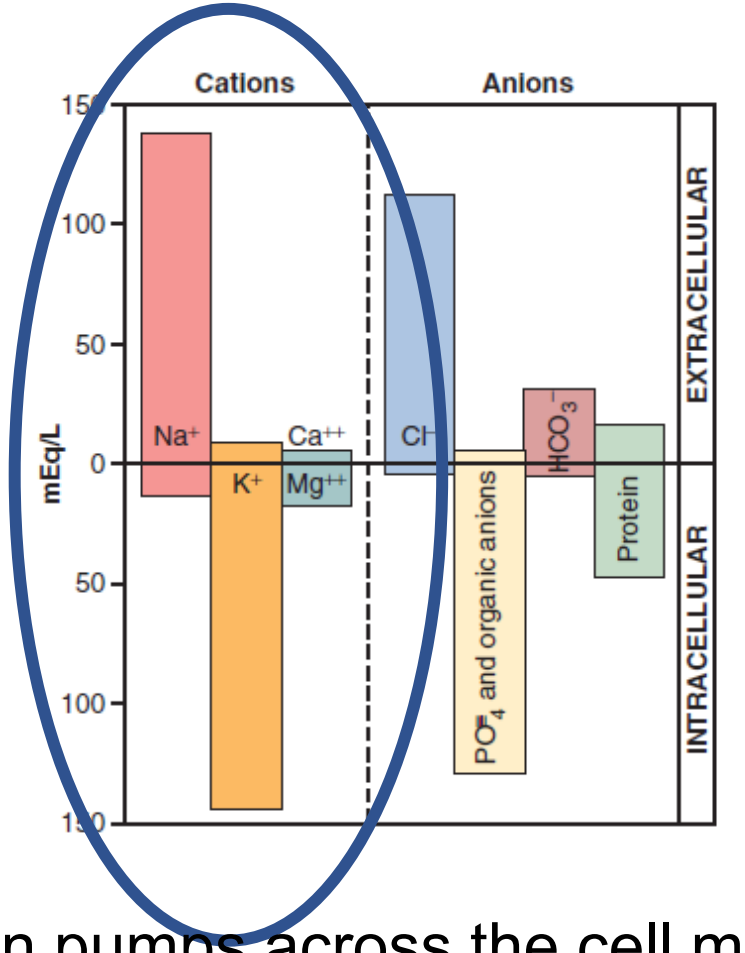


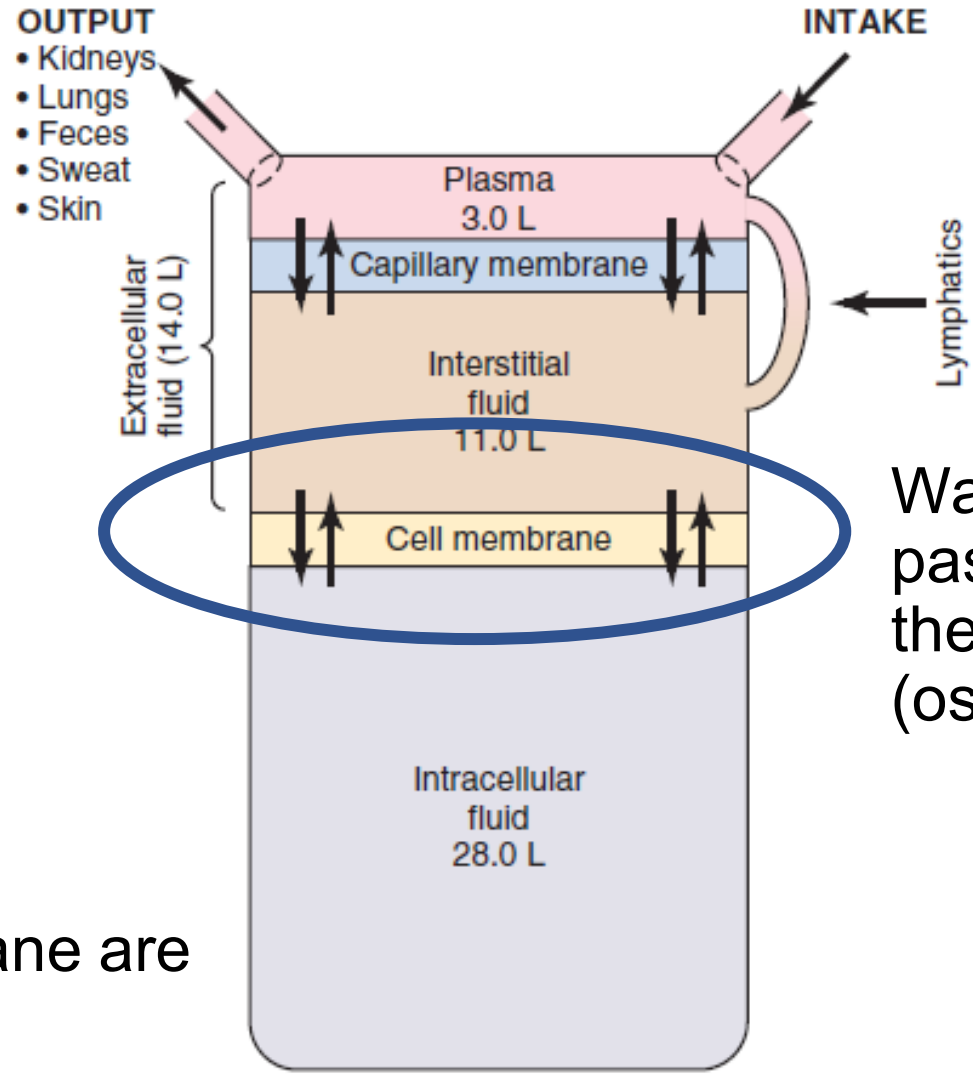
(a) Distribution of body solids and fluids in average lean adult female and male

(b) Exchange of water among body fluid compartments

Tortora, Derrickson: Principle's of Anatomy and Physiology

Composition of intracellular fluid remains stable





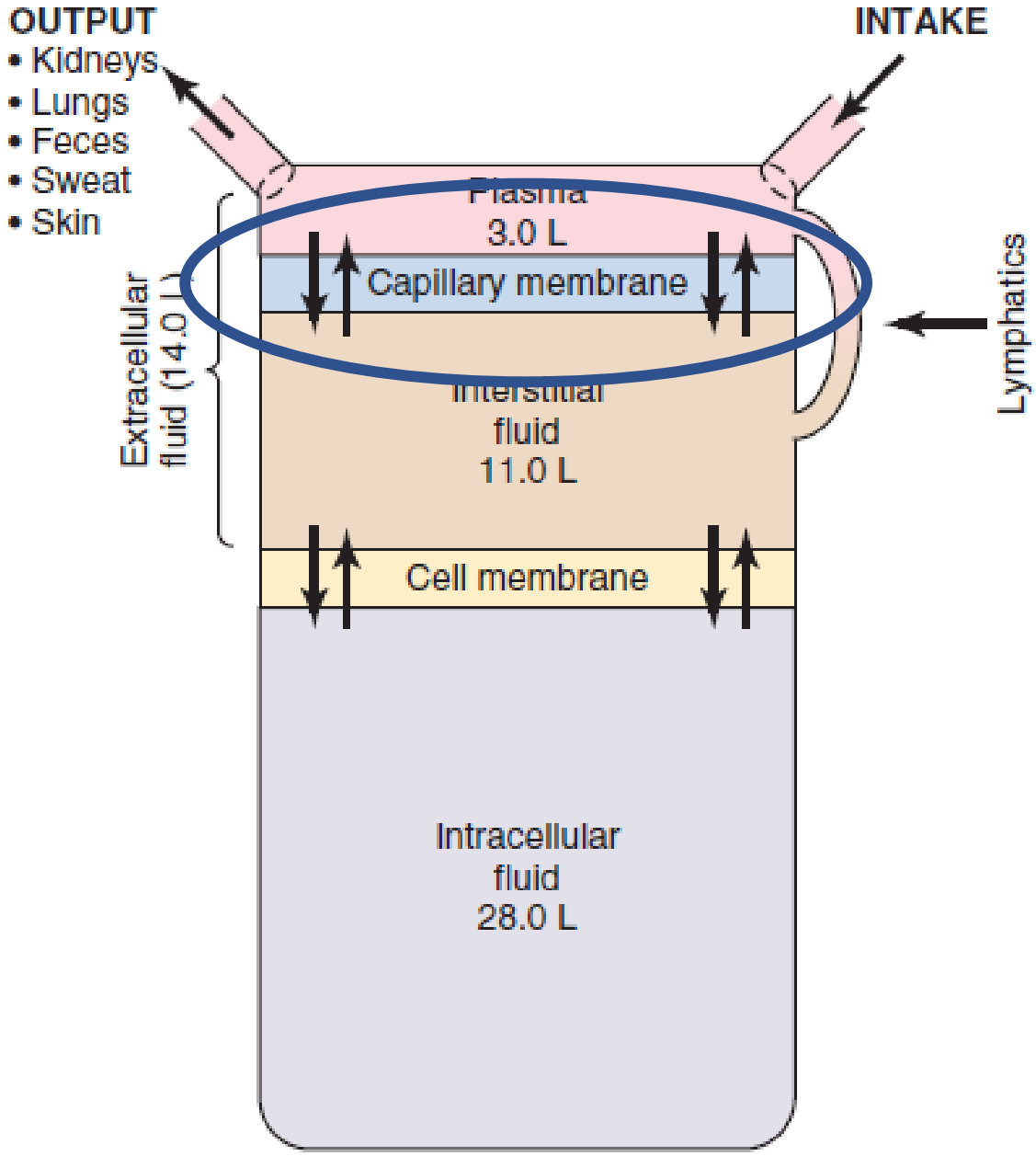
Water follows ions passively through the cell membrane (osmosis)

Ion pumps across the cell membrane are crucial: ~1/3 of the body's energy consumption goes to Na^+ – K^+ pumps

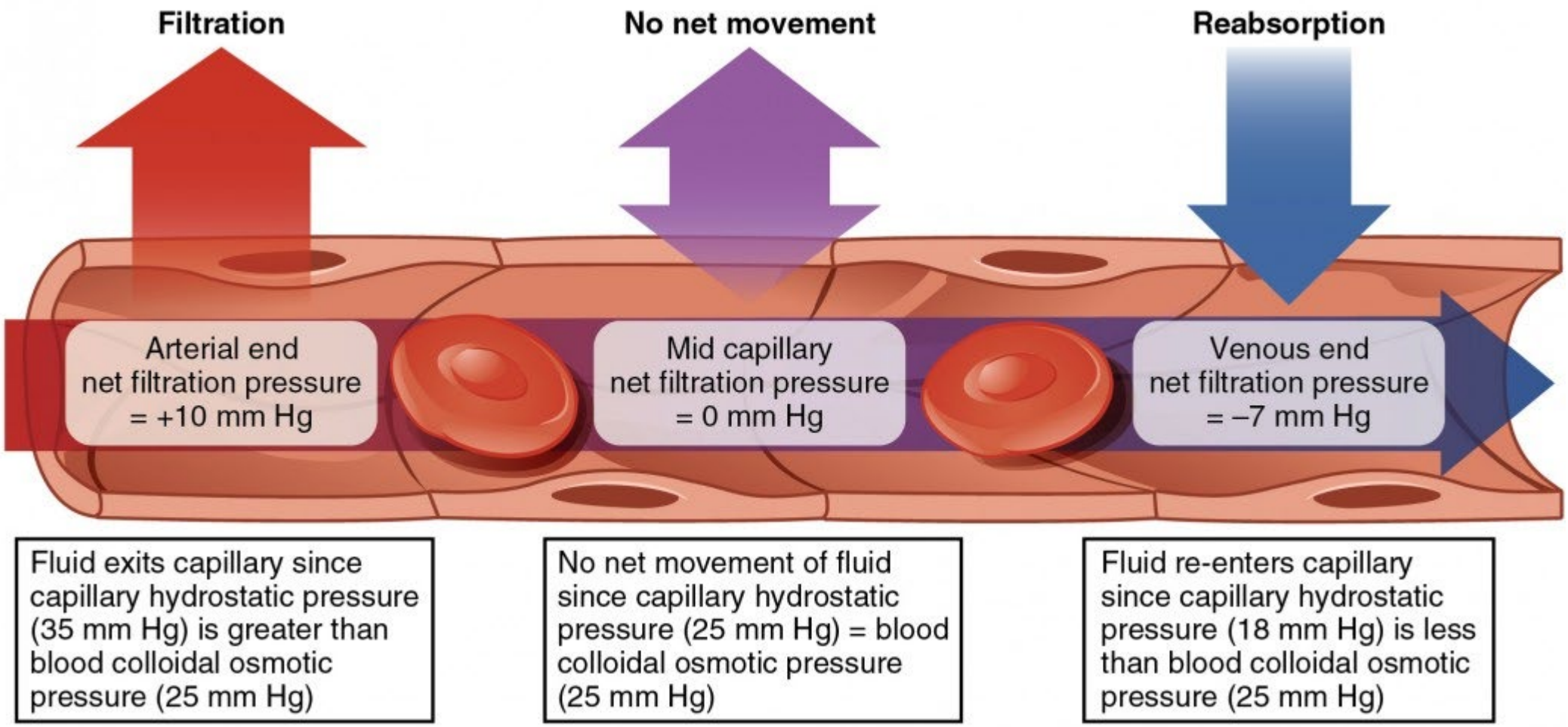
Guyton & Hall, Medical Physiology

Water and electrolyte composition of the interstitial fluid and blood plasma are similar

- Capillary membranes are highly permeable for water, oxygen, cell metabolic waste
- Protein level 7% in plasma, but only 1-2% in the interstitial fluid
- Blood pressure *vs.* blood colloid osmotic pressure



Capillaries



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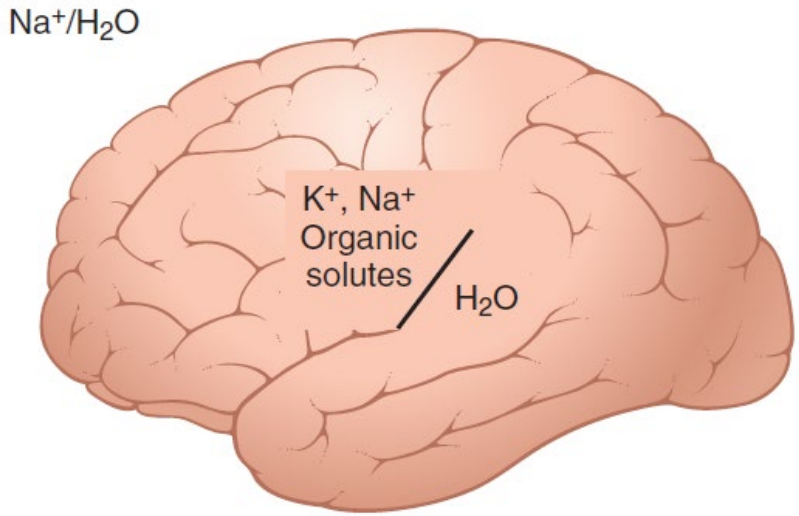
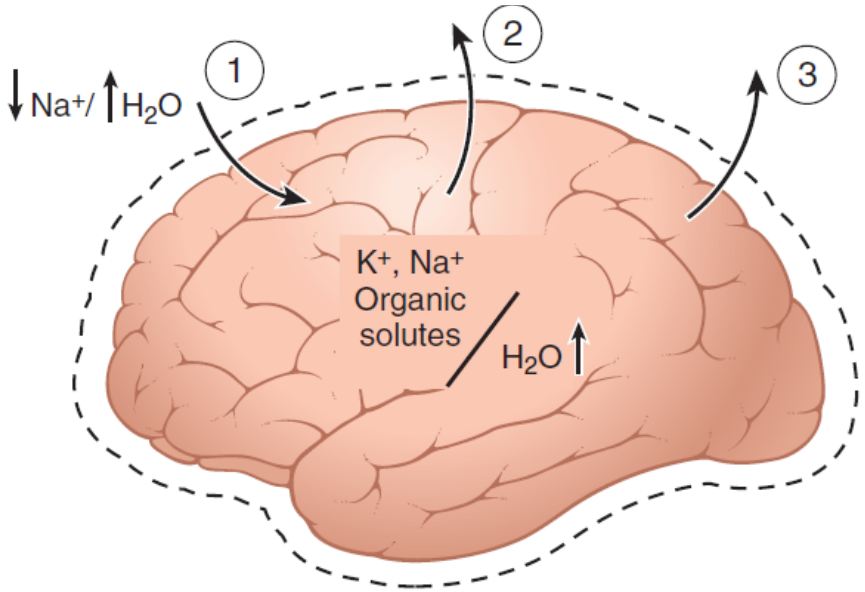
Abnormalities in fluid volume regulation are common

- Dehydration, excess drinking, fluid loss (intestines, major bleeding)
- Hypernatremia & hyponatremia are easily measured from plasma
- Rapid changes in Na^+ are dangerous to brain cells

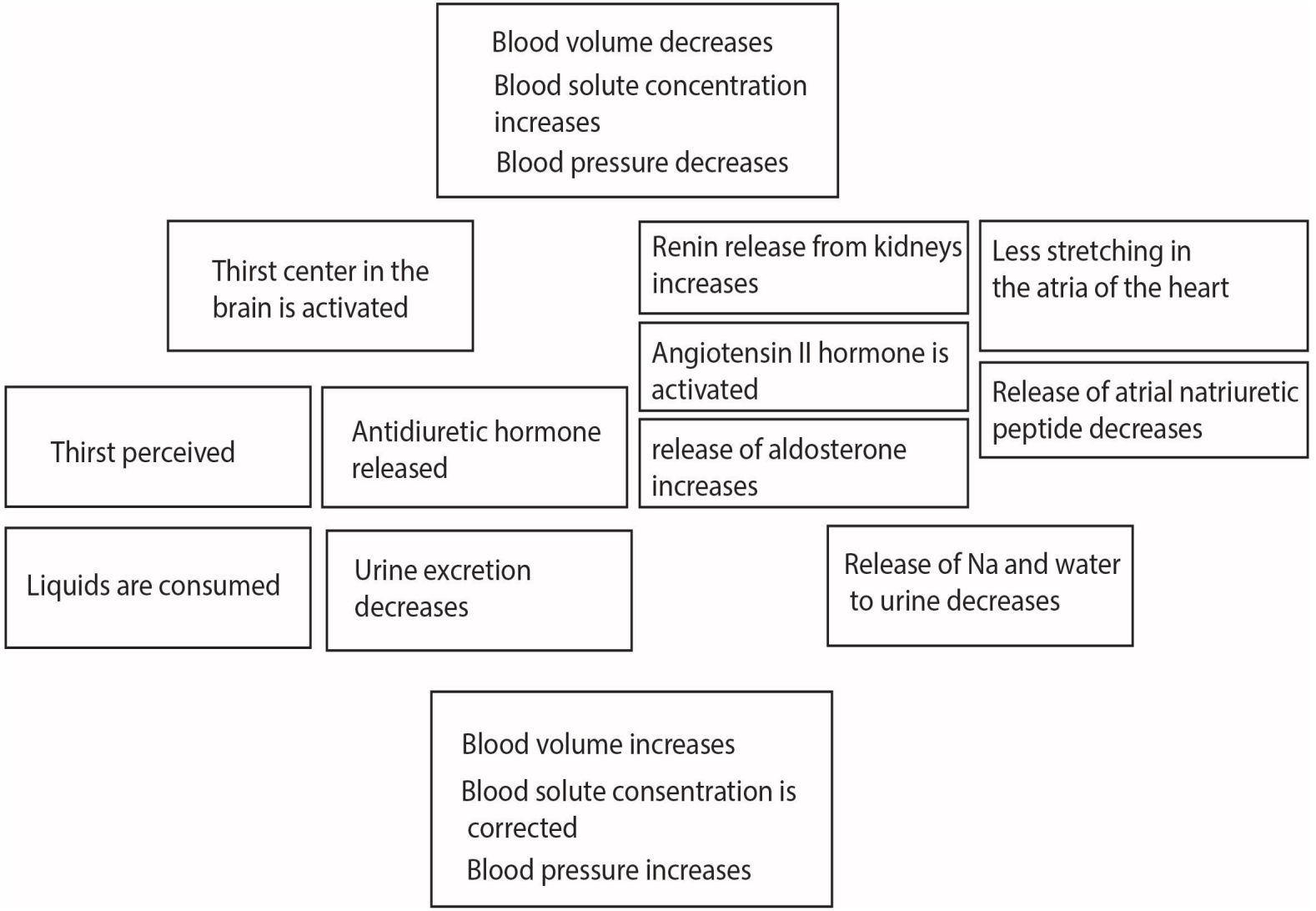


Normonatremia

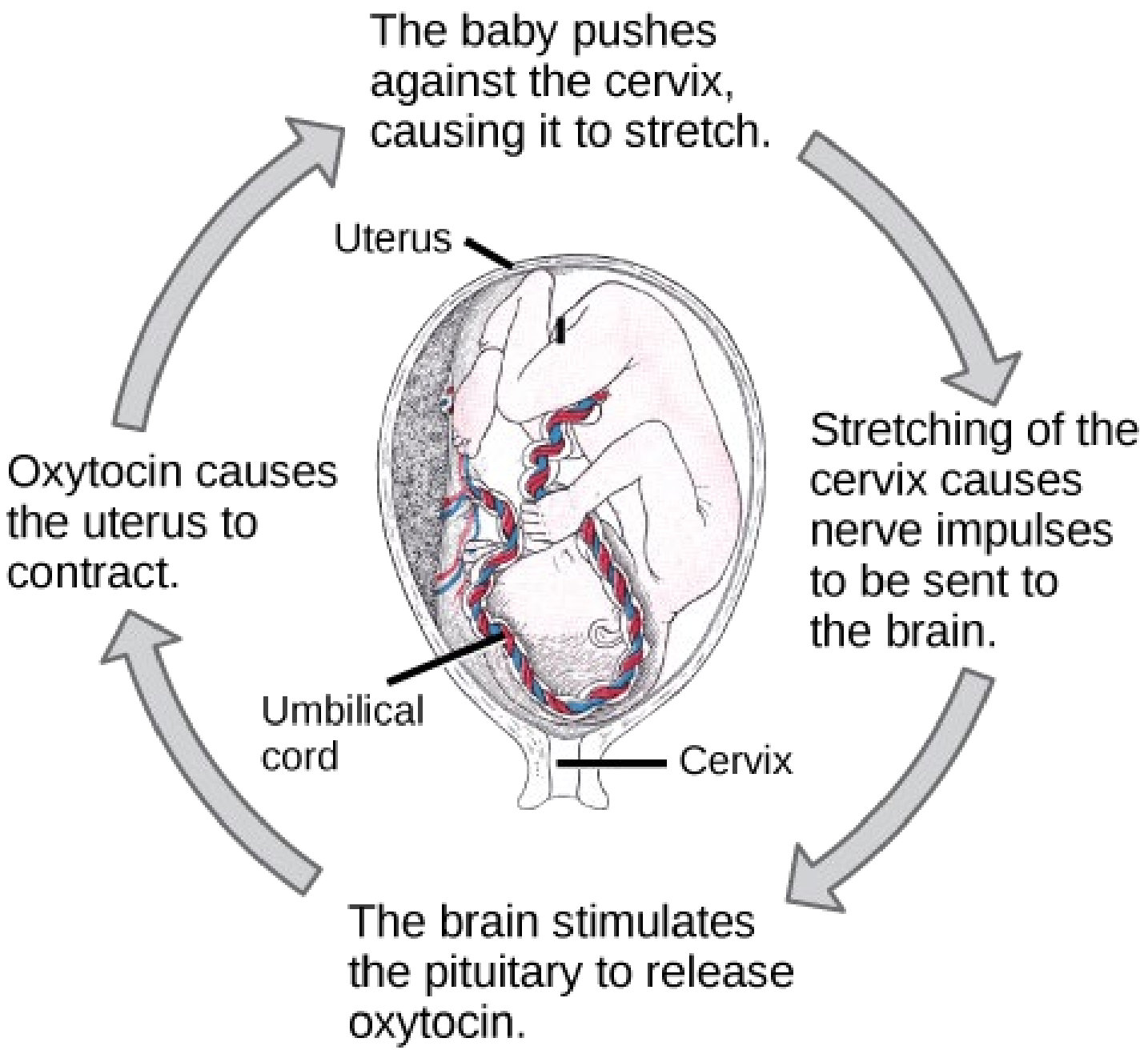


Acute hyponatremia

Regulation of blood pressure



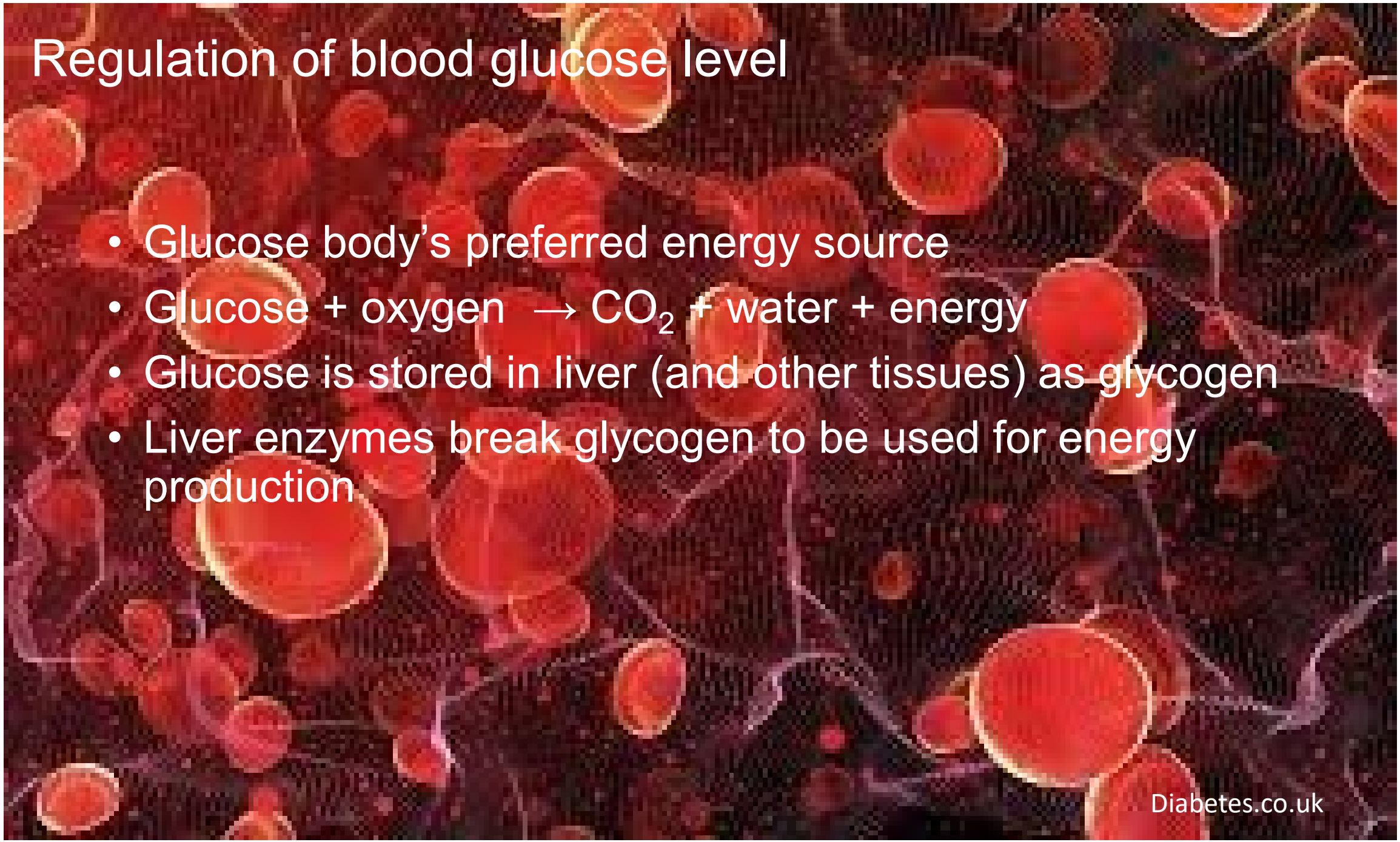
Positive feedback: Control of labor



bio.libretext.org

Regulation of blood glucose level

- Glucose body's preferred energy source
- Glucose + oxygen $\rightarrow CO_2$ + water + energy
- Glucose is stored in liver (and other tissues) as glycogen
- Liver enzymes break glycogen to be used for energy production



Diabetes.co.uk

Regulation of blood glucose level

- Dependent on insulin and glucagon hormones released by pancreas
- Diabetes: Results from lack of insulin production, resistance to insulin action, or both
- Very difficult to mimic with, *e.g.*, glucose sensors or artificial pancreas