Department of biology

Biochemistry

Second Stage – Second Course

Lecture 1

Water, Electrolyte and PH Balance

By

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Introduction of Biochemistry

➢**Biochemistry:** can be defined as the science concerned with the chemical basis of life.

➢**The Aim** of biochemistry is to describe & explain, in molecular terms, all chemical processes of living cells.

➢**Water**: is the predominant chemical component of living organisms. Its unique physical properties, which include the ability to solvate a wide range of organic and inorganic molecules, derive from water's dipolar structure and exceptional capacity for forming hydrogen bonds.

PH AND BUFFER

Acid Base Balance

Prakash Pokhrel

Acid base balance

PH

It is the negative log of the hydrogen ion concentration.

$pH = -\log [H^+]$

- pH is a unit of measure which describes the degree of acidity or alkalinity (basic) of a solution.
- **It is measured on a scale of 0 to 14.**
- Low pH values correspond to high concentrations of H+ and high pH values correspond to low concentrations of H+.

PH VALUE

- The pH value of a substance is directly related to the ratio of the hydrogen ion and hydroxyl ion concentrations.
- If the H+ concentration is higher than OH- the material is acidic.
- If the OH- concentration is higher than H+ the material is basic.
- 7 is neutral, < is acidic, >7 is basic

THE PH SCALE

- The pH scale corresponds to the concentration of hydrogen ions.
- For example pure water H+ ion concentration is 1 x 10^-7 M, therefore the pH would then be 7.

pH value as shown by different colour in universal indicator

Acid

Any compound which forms H^+ ions in solution (proton donors)

eg: Carbonic acid releases H^+ ions

Base

Any compound which combines with H^+ ions in solution (proton acceptors)

eg:Bicarbonate($HCO3^-$) accepts H+ ions

Acid–Base Balance

- **Normal pH : 7.35-7.45**
- **Acidosis**

  Physiological state resulting from abnormally low plasma
- **Alkalosis**

  Physiological state resulting from abnormally high plasma
- **Acidemia:** plasma pH < 7.35
- **Alkalemia:** plasma pH > 7.45

Measurement of pH

The pH can be measured by:

- ph strips
- Ph indicators
- Ph meter

Some important indicators used in a Clinical Biochemistry Laboratory are listed below:

sr,. No.	INDICATOR	Ph range	Colour in acidic ph	Colour in basic ph
1	Phenophthalein	9.3-10.5	colourless	pink
2	Methyl orange	3.1-4.6	red	yellow
3	Bromophenol blue	3.0-4.6	yellow	blue
4	Methyl red	4.4-6.2	Red	yellow
5	Phenol red	6.8 – 8.4	yellow	red
6	Litmus	4.5-8.3	red	Blue

PH METER

- The pH **meter** is a laboratory equipment which used to measure acidity or alkalinity of a solution
- The pH meter measures the concentration of hydrogen ions [H^+] using an ion-sensitive electrode.
- It is the most reliable and convenient method for measuring ph.

BUFFERS

BUFFER

- A **buffer solution** is a solution which resists changes in pH when a small amount of **acid** or **base** is added.

- Typically a mixture of a weak acid and a salt of its conjugate base or weak base and a salt of its conjugate acid.

TYPES OF BUFFERS

Two types :

❑ ACIDIC BUFFERS –

Solution of a mixture of a weak acid and a salt of this weak acid with a strong base.

E.g. CH_3COOH + CH_3COONa

(weak acid) (Salt)

❑ BASIC BUFFERS –

Solution of a mixture of a weak base and a salt of this weak base with a strong acid.

e.g. NH_4OH + NH_4Cl

(Weak base) (Salt)

HOW BUFFERS WORK

- Equilibrium between acid and base.
- Example: ACETATE BUFFER
  - $CH_3COOH \leftrightarrow CH_3COO^- + H^+$
- If more H^+ is added to this solution, it simply shifts the equilibrium to the left, absorbing H^+, so the $[H^+]$ remains unchanged.
- If H^+ is removed (e.g. by adding OH-) then the equilibrium shifts to the right, releasing H^+ to keep the pH constant

•HANDERSON HASSELBALCH EQUATION

- Lawrence Joseph **Henderson** wrote an equation, in 1908, describing the use of carbonic acid as a buffer solution.

- Karl Albert **Hasselbalch** later re-expressed that formula in logarithmic terms, resulting in the **Henderson–Hasselbalch equation**.

The Henderson-Hasselbalch Equation derivation

$$HA \rightleftharpoons H^+ + A^-$$

$$K_a = \frac{[H^+]\,[A^-]}{[HA]}$$

take the -log on both sides

$$-\log K_a = -\log [H^+] - \log \frac{[A^-]}{[HA]}$$

apply p(x) = -log(x)

$$pK_a = pH - \log \frac{[A^-]}{[HA]}$$

and finally solve for pH…

$$pH = pK_a + \log \frac{[A^-]}{[HA]} = pK_a + \log \frac{[\text{Proton acceptor}]}{[\text{Proton donor}]}$$

- - The greater the buffer capacity the less the pH changes upon addition of H^+ or OH^-

- Choose a buffer whose pK_a is closest to the desired pH.

  - pH should be within $pK_a \pm 1$

Electrolytes

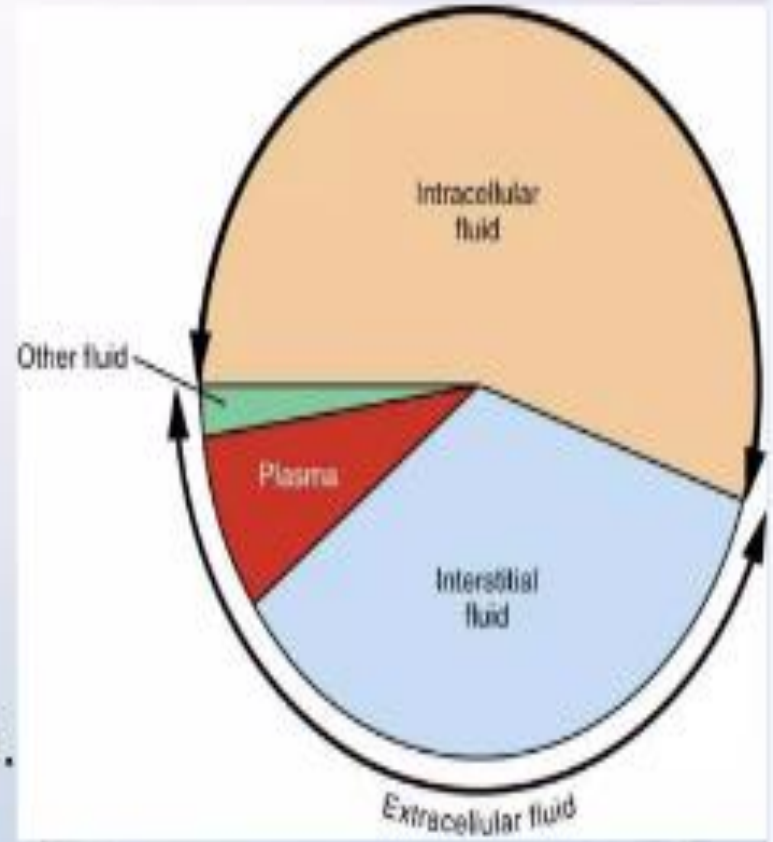
- Electrolytes are minerals found in bodily fluid that carry an electric charge.
- Electrolytes in living system includes Sodium, Potassium, Chloride, Bicarbonate, Calcium, Phosphate, Magnesium, Copper Zinc, Iron, Manganese, Molybdenum And Chromium.
- In terms of body function, six electrolytes are most important: Sodium, Potassium, Chloride, Bicarbonate, Calcium And Phosphate.

Body Fluid:

The total amount of water present in different forms is known as body fluid.

Compartments of body fluid

- Extracellular fluid compartment
- Intracellular fluid compartment



60% of body weight is due to body fluid.

Intracellular Fluid Compartment

- The fluid present inside the cells is called intracellular fluid.
- It includes water and electrolytes within the cell.
- About 40% of total body weight is constitute by intracellular fluid.

Extracellular Fluid Compartment

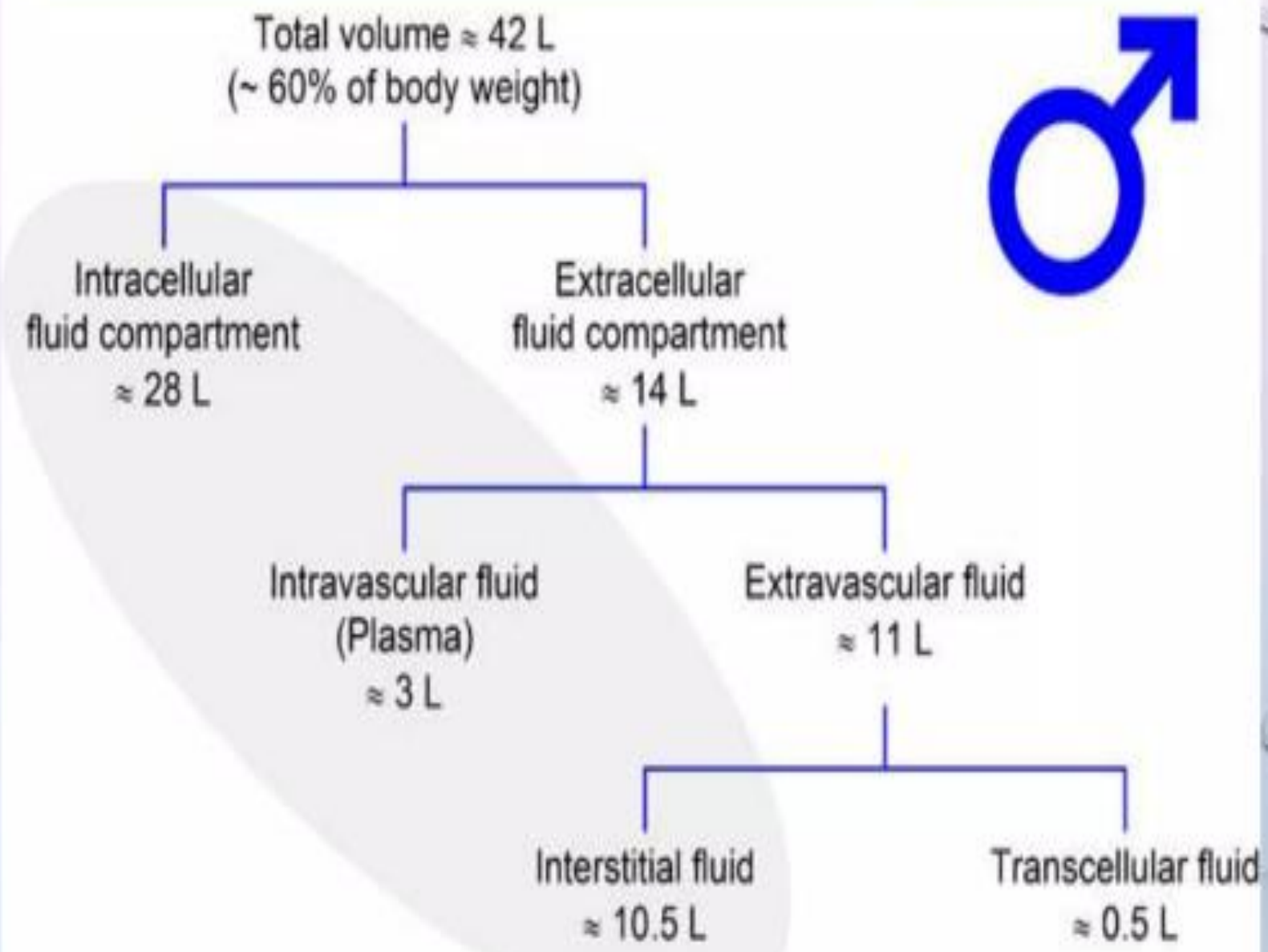
All the fluids outside the cells are collectively called extracellular fluid. These fluid account for about 20% of the total body weight.

Interstitial fluid: includes fluid between the cells. Eg. Fluid present in connective tissue.

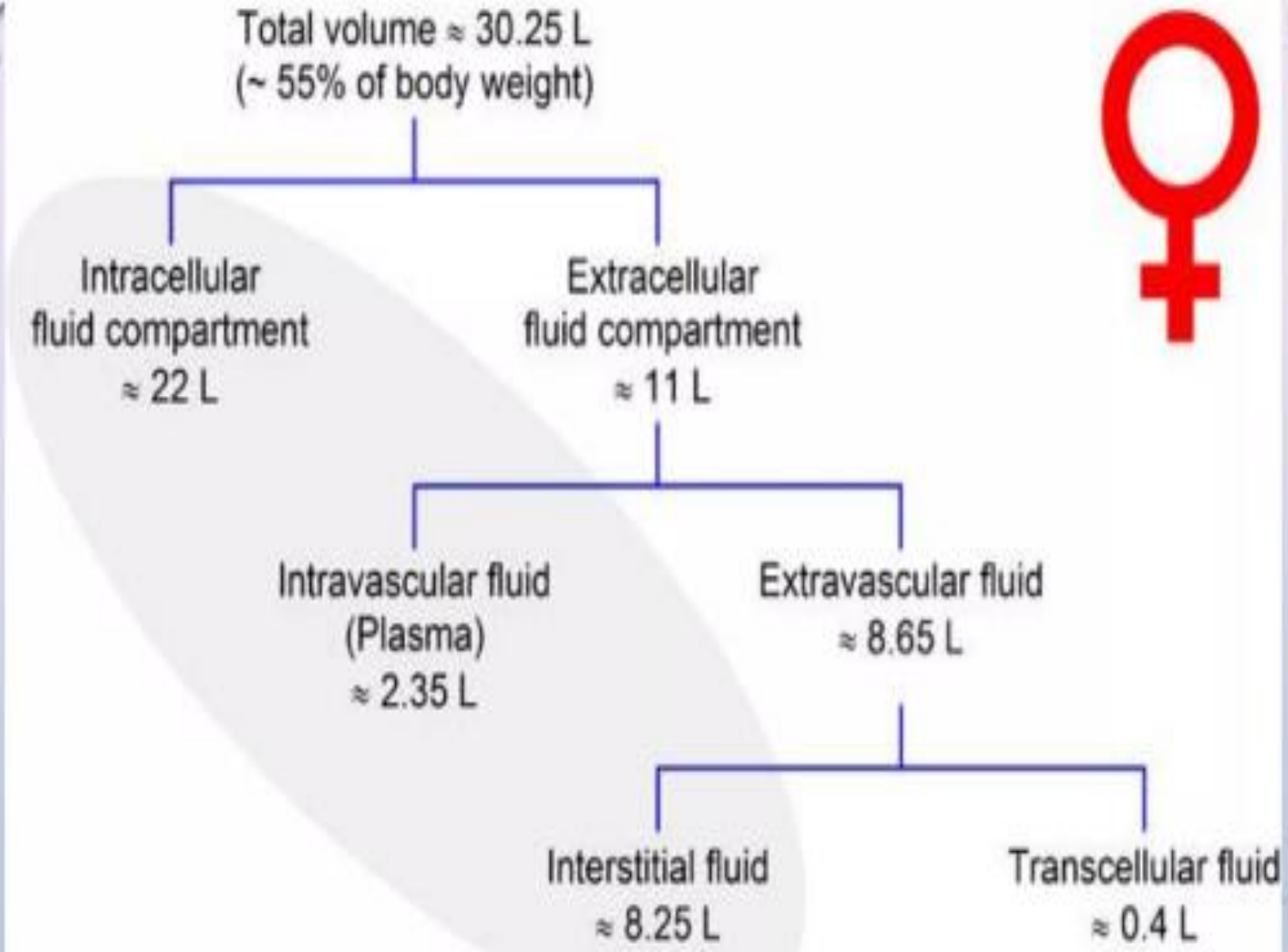
Intra- vascular fluid: includes plasma and lymph

Trans-cellular fluid: includes fluid present in serous and mucous membrane. Eg. Intra-ocular fluid, cerebrospinal fluid, synovial fluid, digestive juices, pleural fluid, pericardial fluid, peritoneal fluid, etc.

Body Fluid Compartments of a 70-kg Adult Man



Body Fluid Compartments of a 55-kg Adult Woman



What percentage of body weight is composed of fluid?

I. 40

II. 50

★ III. 60

IV. 70

Which of the following is not extracellular fluid?

I. Csf

II. Plasma

III. Peritoneal fluid

★ IV. Water in cell

Interstitial fluid (IF) is _____.

I. The fluid in the cytosol of the cells

II. The fluid component of blood

★ III. The fluid that bathes all of the body's cells except for blood cells

IV. The intracellular fluids found between membranes

Thank you