Ministry of Higher Education and Scientific Research
AL-Mustaqbal University College of Science
Department of medical systems

Biochemistry

Lecture 1

Introduction of Biochemistry
Water, Electrolyte and PH Balance

By
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What is Biochemistry?

- **Simplest definition: "Chemistry of the living cell"**

Uses basic laws of chemistry and biology to explain processes of living cells.

- **Biochemistry: is the science concerned with studying the various molecules that occur in living cells and organisms and with their chemical reactions.**
- It bridges the study of chemistry and biology.
- **Chemistry:** is the study of the structures and interactions of atoms and molecules.
- **Biology:** is the study of the structures and interactions of cells and organisms.
- Has aspects of many different disciplines
  - Cell biology, genetics, immunology, microbiology, pharmacology, and physiology…

Why study Biochemistry?

- Lead us to fundamental understanding of life.
- Understand important issues in medicine, health, and nutrition.
- Molecular understanding of diseases such as diabetes, sickle cell anemia, AIDS, cancer and Alzheimer's Disease.

- **Goals:**
- To describe life's processes using the language of molecules – applying the principles and methods of chemistry to determine molecular structure from which it is often possible to explain biological function.

What does Biochemistry study?

- **Three areas to study:**

1. **Structural and Functional Biochemistry:** Chemical structures and 3D arrangements of molecules.

2. **Informational Biochemistry:**

Language for storing biological data and for transmitting that data in cells and organisms.

3. **Bioenergetics:** The flow of energy in living organisms and how it is transferred from one process to another.

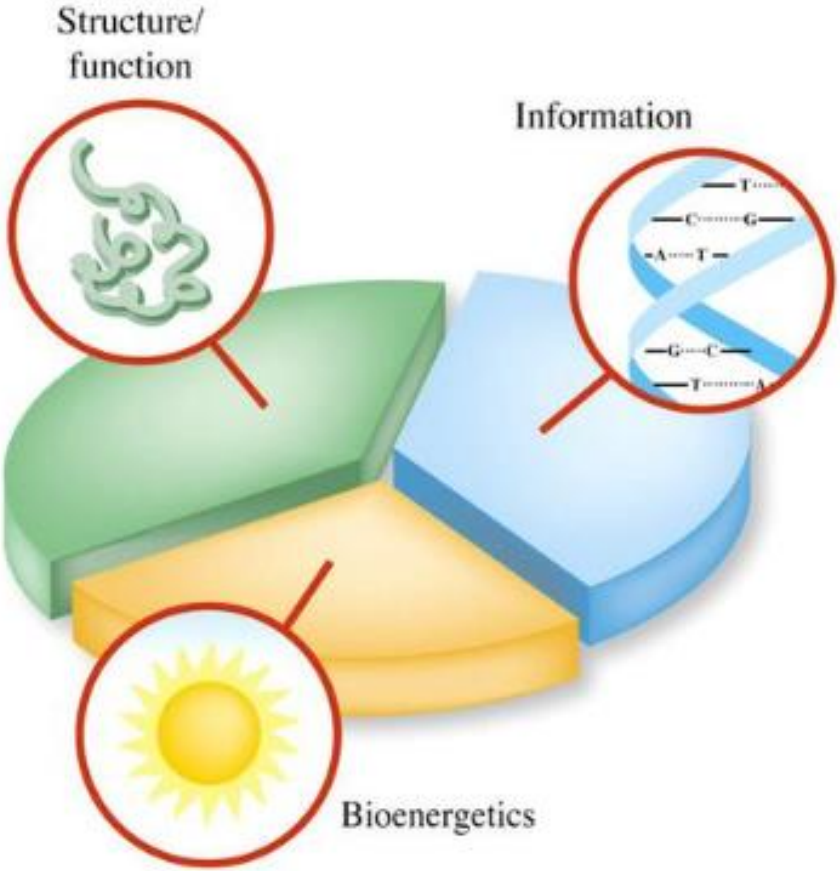

Figure 1-1 Concepts in Biochemistry, 3/e
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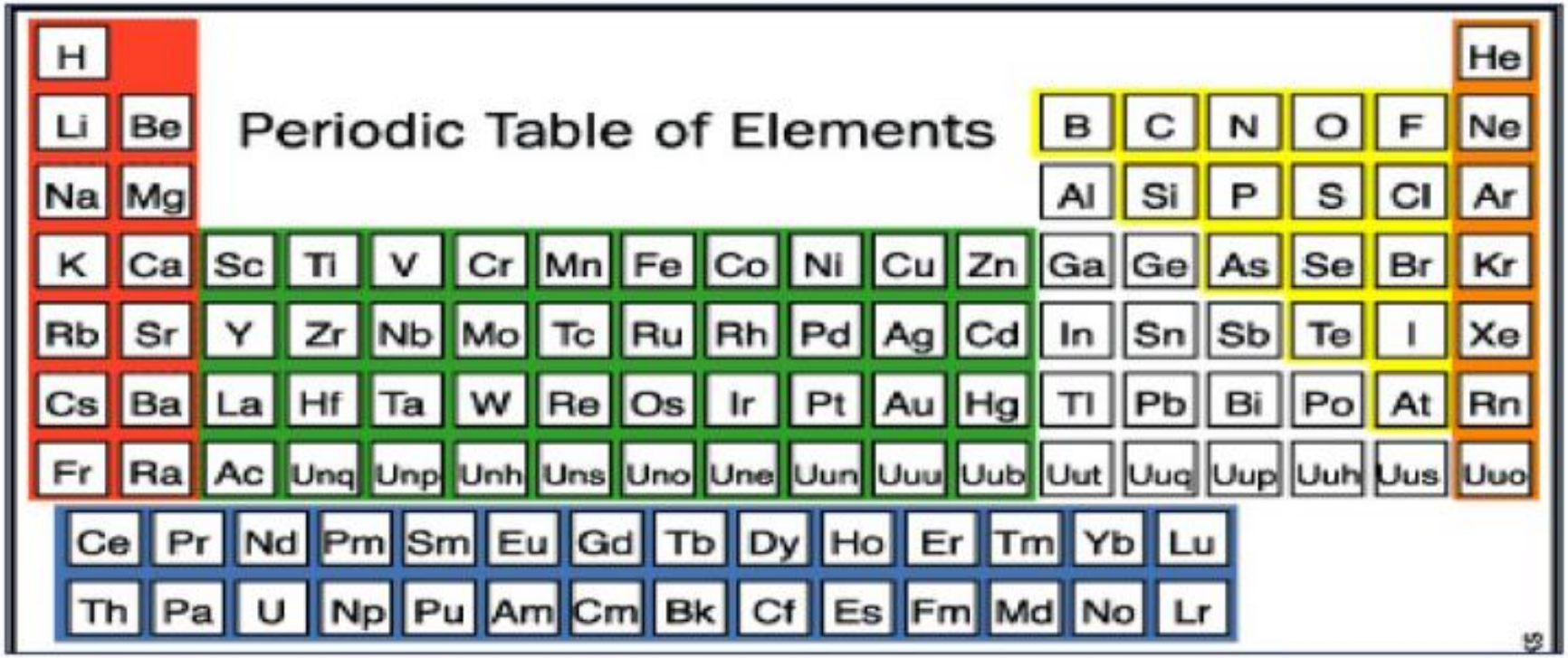
Tools to study Biochemistry

- Know chemical structures and reactivates of molecules that participate in cellular reactions.
- Know biological function of cellular molecules.
- Know how all of the pieces and different pathways fit together.
- Use knowledge from general chemistry, organic chemistry, and biology and apply it to biological systems.

Biochemistry and Organization of Cells

- Complex living organism originate from simple elements. Carbon, hydrogen, oxygen, sulfur, and nitrogen combine to make up many different kind of biomolecules such as carbohydrates, fatty acids, amino acids which combine to make proteins.
- In turn phosphorus is the most ingredients for making DNA and RNA. A collection of interacting molecules, becomes a cell the basic unit of life.

Elements of Life



- Most abundant, essential for all organisms: C, N, O, P, S, H
- Less abundant, essential for all organisms : Na, Mg, K, Ca, Cl
- Trace levels, essential for all organism: Mn, Fe, Co, Cu, Zn
- Trace levels, essential for some organisms: V, Cr, Mo, B, Al, Ga, Sn, Si, As, Se, I.

Common Functional Groups

TABLE 1-1 | Common Functional Groups and Linkages in Biochemistry

Compound Name	Structure[a]	Functional Group
Amine[b]	RNH_2 or RNH_3^+ R_2NH or $R_2NH_2^+$ R_3N or R_3NH^+	—N< or —$^+$N— (amino group)
Alcohol	ROH	—OH (hydroxyl group)
Thiol	RSH	—SH (sulfhydryl group)
Ether	ROR	—O— (ether linkage)
Aldehyde	R—C(=O)—H	—C(=O)— (carbonyl group), R—C(=O)— (acyl group)
Ketone	R—C(=O)—R	—C(=O)— (carbonyl group), R—C(=O)— (acyl group)
Carboxylic acid[b] (Carboxylate)	R—C(=O)—OH or R—C(=O)—O$^-$	—C(=O)—OH (carboxyl group) or —C(=O)—O$^-$ (carboxylate group)
Ester	R—C(=O)—OR	—C(=O)—O— (ester linkage)

[a]R represents any carbon-containing group. In a molecule with more than one R group, the groups may be the same or different.
[b]Under physiological conditions, these groups are ionized and hence bear a positive or negative charge.

Common Functional Groups

TABLE 1-1 | Common Functional Groups and Linkages in Biochemistry

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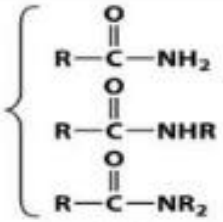
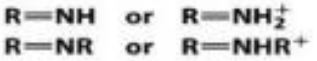
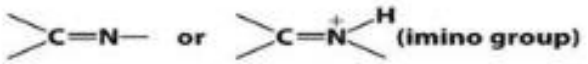
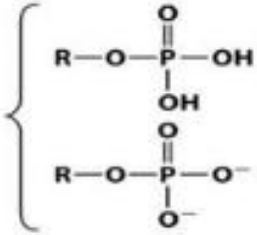
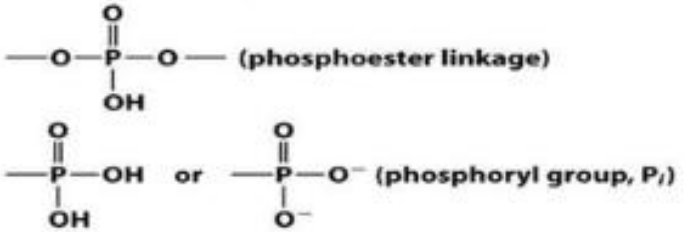
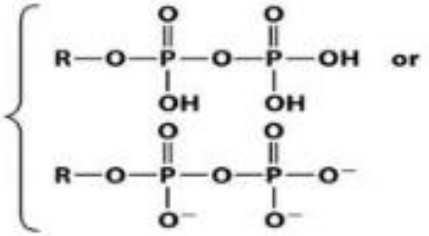
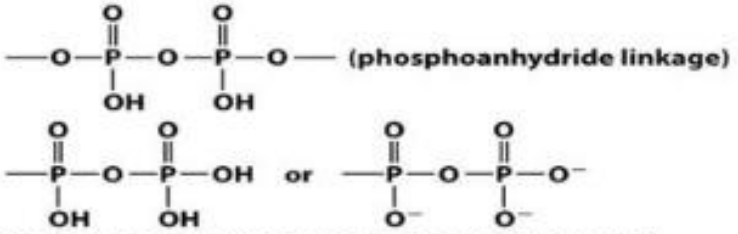
Amide		 (amido group)
Imine[b]		 (imino group)
Phosphoric acid ester[b]		 (phosphoester linkage); (phosphoryl group, P_i)
Diphosphoric acid ester[b]		 (phosphoanhydride linkage); (diphosphoryl group, pyrophosphoryl group, PP_i)

[a]R represents any carbon-containing group. In a molecule with more than one R group, the groups may be the same or different.
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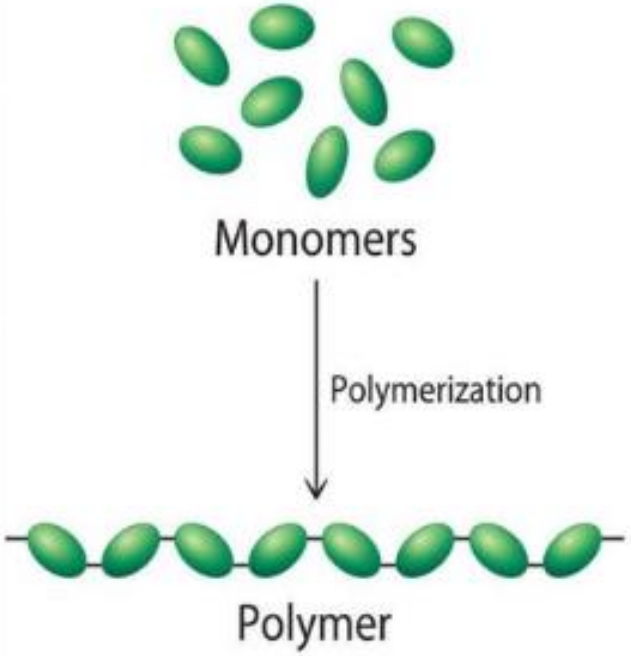
4 Major Macromolecules

Macromolecules are polymers that are assembled from single units called monomers.

Macromolecules	Monomers
Proteins	Amino Acids
Carbohydrates	Monosaccharide
Nucleic Acids (DNA & RNA)	Nucleotides
Lipids (non-polymeric molecules with large molecular mass)	Hydrocarbon chains



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

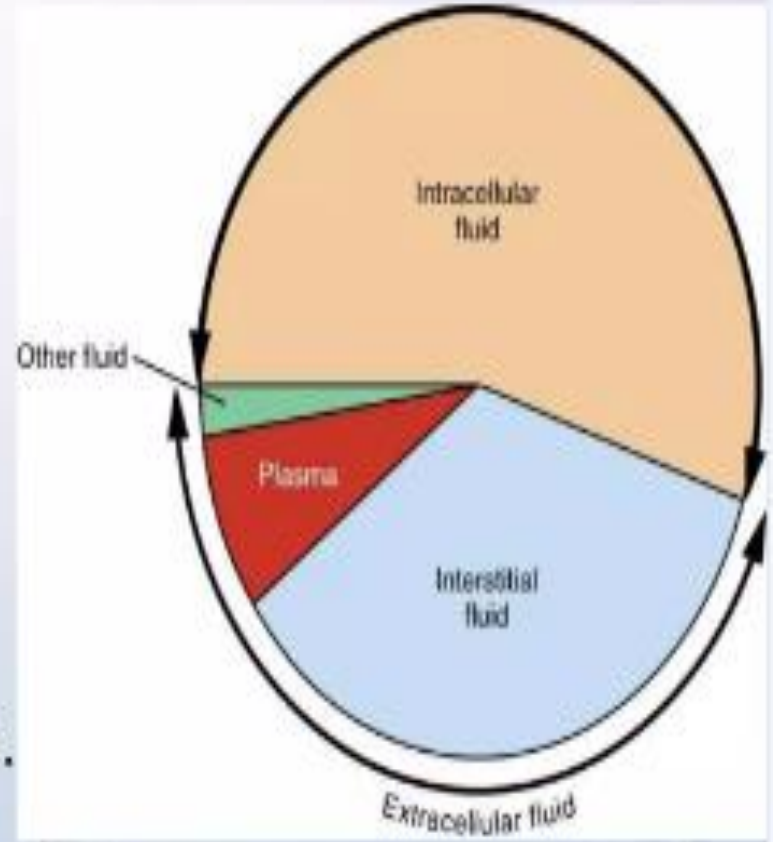
- Electrolytes are minerals found in bodily fluid that carry an electric charge.
- Electrolytes in living system includes Sodium, Potassium, Chloride, Bicarbonate, Calcium, Phosphate, Magnesium, Copper Zinc, Iron, Manganese, Molybdenum And Chromium.
- In terms of body function, six electrolytes are most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

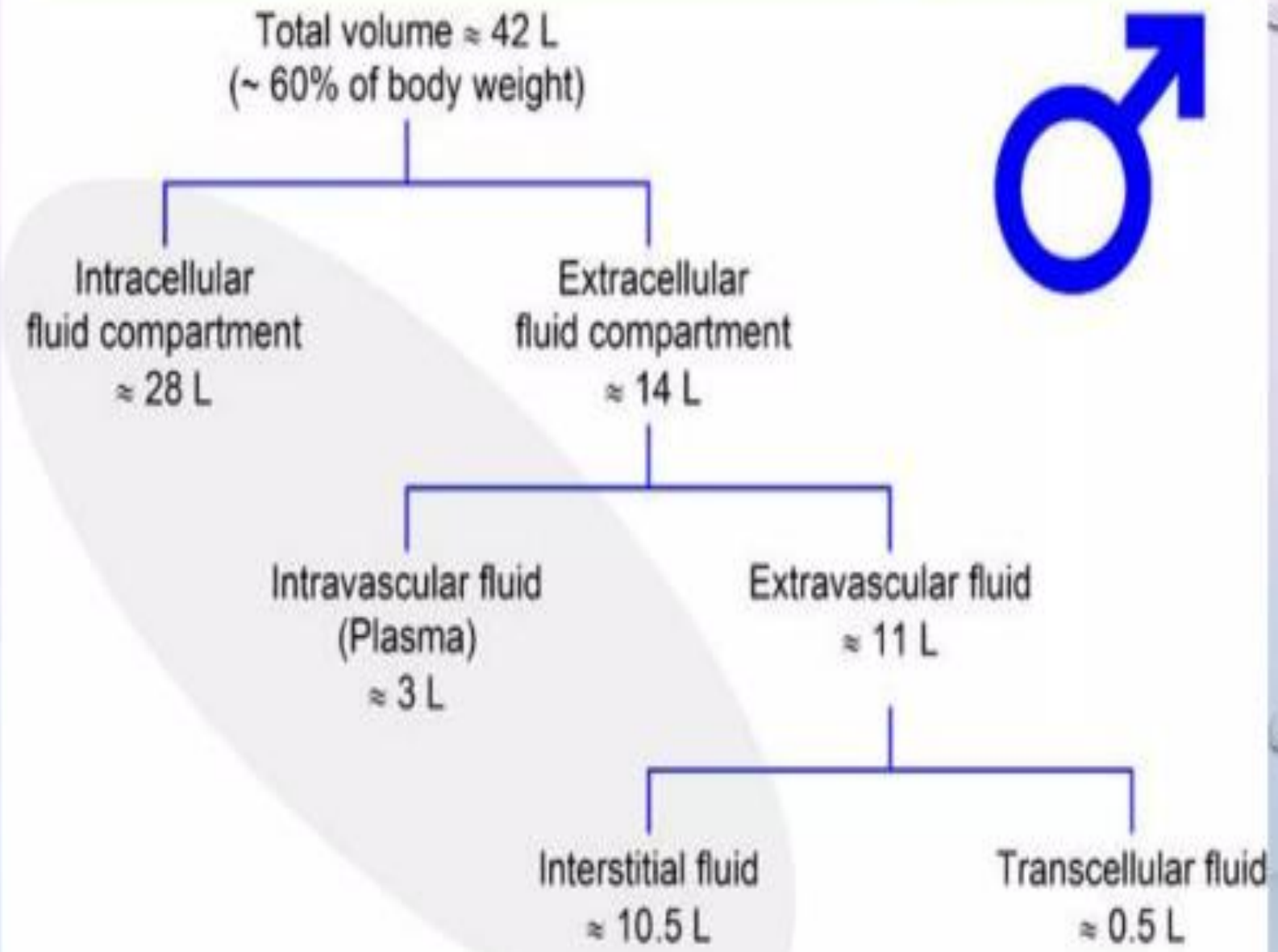
All the fluids outside the cells are collectively called extracellular fluid. These fluid account for about 20% of the total body weight.

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

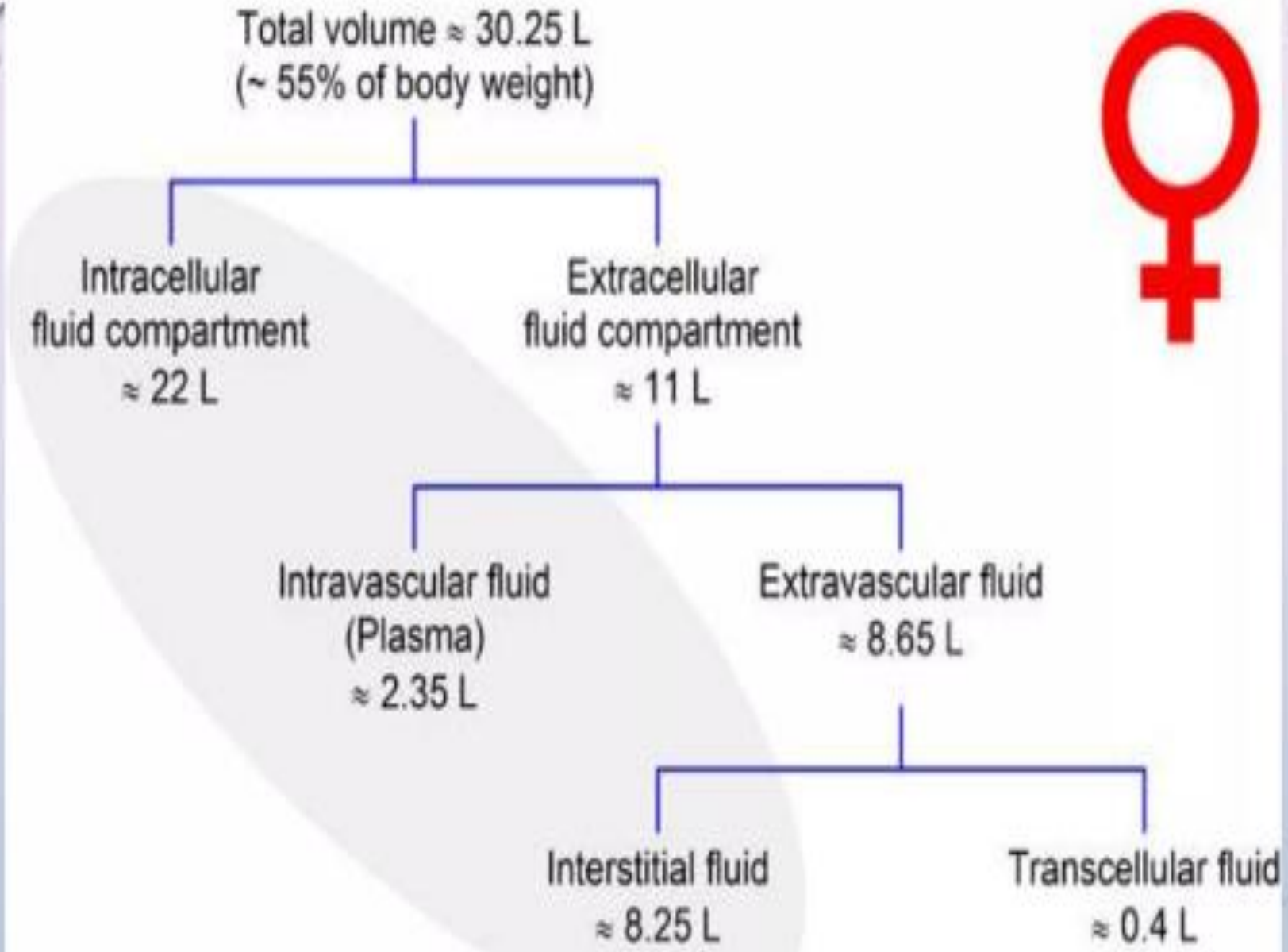
Intra- vascular fluid: includes plasma and lymph

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

★ 60

IV. 70

Which of the following is not extracellular fluid?

I. Csf

II. Plasma

III. Peritoneal fluid

★ Water in cell

Interstitial fluid (IF) is _____.

I. The fluid in the cytosol of the cells

II. The fluid component of blood

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

IV. The intracellular fluids found between membranes

Thank you