Biophysics

Lecture 2: Physical Units, Measurements, and Unit Systems

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Course Information

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1 Introduction

Measurement is the foundation of all physical and biological sciences. Biophysics relies on accurate quantitative descriptions of biological phenomena. Every experimental observation, clinical measurement, or theoretical model must be expressed using appropriate physical units.

Incorrect use of units or improper unit conversion can lead to serious errors in biomedical research, diagnosis, and treatment. Therefore, understanding physical units and measurement systems is essential for students of medical biotechnology.

2 Physical Quantities

A **physical quantity** is any measurable property of a system that can be expressed numerically along with a unit. Examples include length, mass, time, temperature, pressure, energy, and electric potential.

Each physical quantity has two essential components:

- Numerical magnitude
- Unit

Writing a numerical value without a unit has no scientific meaning and cannot be used in calculations or comparisons.

3 Role of Measurement in Biophysics

Measurements allow scientists to quantify biological processes, compare results, and test hypotheses. In biophysics, measurements are crucial for:

- Monitoring physiological parameters

- Designing biomedical devices
- Evaluating drug effectiveness
- Diagnosing diseases

Precision and accuracy are essential aspects of scientific measurement.

4 Scientific Unit Systems

A unit system is a standardized set of units used for measurement. The most common systems are:

- SI (International System of Units)
- CGS (centimeter–gram–second) system
- English (Imperial) system

The **SI system** is the globally accepted standard and is used extensively in biophysics, medicine, and medical biotechnology.

5 SI Base Units

The SI system consists of seven fundamental base units:

- Length: meter (m)
- Mass: kilogram (kg)
- Time: second (s)
- Electric current: ampere (A)
- Temperature: kelvin (K)
- Amount of substance: mole (mol)
- Luminous intensity: candela (cd)

All other physical units are derived from these base units.

6 Derived Units

Derived units are formed by combining SI base units mathematically. Important examples in biophysics include:

$$\text{Velocity} = \frac{\text{m}}{\text{s}}$$

$$\text{Force} = \text{kg} \cdot \text{m} \cdot \text{s}^{-2} = \text{newton (N)}$$

$$\text{Energy} = \text{newton} \cdot \text{meter} = \text{joule (J)}$$

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \text{pascal (Pa)}$$

7 Types of Physical Units

Physical units are classified into:

- **Fundamental units**: independent base units
- **Derived units**: obtained from base units
- **Supplementary units**: angular units such as radian
- **Practical units**: commonly used in medicine (mmHg, liter)

Practical units are widely used in clinical practice for convenience.

8 SI Prefixes

SI prefixes represent powers of ten and simplify the expression of very large or very small quantities:

- kilo (k) = 10^3
- milli (m) = 10^{-3}
- micro (μ) = 10^{-6}
- nano (n) = 10^{-9}

Example:

$$1 \text{ mm} = 10^{-3} \text{ m}$$

9 Unit Conversion

Unit conversion is the process of expressing a quantity in a different unit. Before performing calculations, all quantities must be converted to SI units.

Example:

$$150 \text{ cm} = 1.5 \text{ m}$$

Failure to convert units correctly is a common source of error in biomedical calculations.

10 Dimensional Analysis

Dimensional analysis is a powerful method used to verify the correctness of equations. Both sides of an equation must have the same dimensions.

Example:

$$v = \frac{d}{t} \Rightarrow [v] = \frac{L}{T}$$

This method helps identify mistakes in equations and unit conversions.

11 Units in Medicine and Biotechnology

In medical biotechnology, commonly used units include pressure (Pa, mmHg), energy (J), electric potential (V), electric current (A), concentration (mol/L), and radiation dose (Gy).

Correct unit usage ensures safe and effective medical applications.

12 Multiple Choice Questions (MCQs)

Q1. A physical quantity must include
A- a number only
B- a unit only
C- numerical magnitude and unit
D- a symbol only
E- None of them

Q2. Which of the following is NOT a physical quantity?
A- Length
B- Mass
C- Time
D- Beauty
E- None of them

Q3. The standard unit system used in biophysics is
A- CGS system
B- English system
C- SI system
D- Astronomical system
E- None of them

Q4. The SI base unit of length is
A- centimeter
B- meter
C- kilometer
D- millimeter
E- None of them

Q5. The SI base unit of mass is
A- gram
B- kilogram
C- milligram
D- ton
E- None of them

Q6. Which of the following is an SI base unit?
A- newton
B- joule
C- second
D- pascal
E- None of them

Q7. The SI unit of electric current is
A- volt
B- coulomb
C- ampere
D- ohm
E- None of them

Q8. Derived units are
A- independent of base units

B- combinations of base units
C- used only in biology
D- dimensionless
E- None of them

Q9. The SI unit of force is
A- joule
B- pascal
C- newton
D- watt
E- None of them

Q10. The joule (J) is the SI unit of
A- force
B- pressure
C- energy
D- power
E- None of them

Q11. Pressure in the SI system is measured in
A- newton
B- joule
C- pascal
D- watt
E- None of them

Q12. The prefix milli (m) represents
A- 10^{3}
B- 10^{-1}
C- 10^{-3}
D- 10^{-6}
E- None of them

Q13. The prefix micro (μ) corresponds to
A- 10^{-3}
B- 10^{-6}
C- 10^{-9}
D- 10^{6}
E- None of them

Q14. One centimeter is equal to
A- 10^{-1} m
B- 10^{-2} m
C- 10^{-3} m
D- 10^{2} m
E- None of them

Q15. Which conversion is correct?
A- 1 mm = 10^{-2} m
B- 1 cm = 10^{-3} m
C- 1 mm = 10^{-3} m
D- 1 cm = 10^{-1} m
E- None of them

Q16. Before using equations, quantities should be

A- ignored
B- written without units
C- converted to SI units
D- rounded only
E- None of them

Q17. Dimensional analysis is used to

A- measure quantities
B- find numerical values
C- check equation correctness
D- convert prefixes
E- None of them

Q18. The dimensions of velocity are

A- LT
B- L/T
C- T/L
D- L^2/T
E- None of them

Q19. Blood pressure is commonly measured in

A- pascal only
B- joule
C- mmHg
D- watt
E- None of them

Q20. A common mistake in unit usage is

A- checking units
B- converting to SI units
C- mixing different unit systems
D- writing units clearly
E- None of them