

3. Classification and functions of nutrients

“Nutrients are specific chemical substances in foods that the body needs in appropriate amounts for energy, growth, maintenance, and regulation of vital processes.”

1 · Frameworks for Classifying Nutrients

Criterion	Classes	Key Points
Quantity required	Macronutrients (g level): Carbohydrates, Proteins, Fats, Water Micronutrients (mg / µg level): Vitamins, Minerals	Provide energy or mass; needed in relatively large amounts. Act mainly as catalysts, cofactors, or structural elements
Energy yield	Energy-yielding (4-9 kcal/g): Carbs, Proteins, Fats (Alcohol yields 7 kcal/g but is <i>not</i> a nutrient). Non-energy-yielding: Water, Vitamins, Minerals.	Supply ATP for basal metabolism & activity. Facilitate metabolism, maintain homeostasis
Essentiality	Essential (must come from diet): e.g., Linoleic acid, Leucine, Vitamin C, Calcium. Conditionally essential: Arginine (growth), Vitamin D (low sunlight)	Lack → deficiency disease. Needed in special states
Chemical nature	Organic: Carbs, Proteins, Lipids, Vitamins Inorganic: Water, Minerals	Contain carbon No carbon skeleton
Physiological role	Fuel, Structural, Regulatory, Protective	See Chapter 2 functions

2 · Macronutrients - Overview

Nutrient	Energy (kcal/g)	Key Biological Roles	Daily Requirement*	Major Dietary Sources
Carbohydrate	4	Primary fuel; spares protein; fibre → gut health; source of pentoses	≥130 g (45-60 % kcal)	Cereals, millets, fruits, tubers, sugars
Protein	4	Tissue synthesis & repair; enzymes, hormones; immune function; acid-base balance	0.8-1 g/kg (↑ in pregnancy, lactation, athletes)	Pulses, meat, fish, egg, milk, soy
Fat (Lipids)	9	Concentrated energy; cell membranes; carry fat-soluble vitamins; insulation; satiety	20-30 % kcal (≤10 % saturated)	Vegetable oils, ghee, nuts, seeds, fatty fish
Water	0	Solvent; medium for reactions; thermoregulation; transport of nutrients & waste	≈2-3 L total fluid	Water, beverages, soups, juicy fruits

“Macronutrients – Roles & Recommendations” for a comparative table of composition, daily needs, and food sources.

2.1 Carbohydrates

- **Types** – Simple (mono- & disaccharides), Complex (starch, glycogen) and Non-digestible (dietary fibre).
- **Primary functions** – Rapid ATP production, protein-sparing, formation of glycoproteins, bowel motility (fibre).
- **Quality markers** – Glycaemic index/load, whole-grain content, fibre ≥ 10 g/1000 kcal.

2.2 Proteins

- **Amino-acid profile** – 9 indispensable AA (e.g., leucine, lysine).
- **Functions** – Structural (muscle, collagen), functional (enzymes, hormones, antibodies), fluid balance (oncotic)

pressure), pH buffering.

- **Digestible Indispensable Amino Acid Score (DIAAS)** now recommended over PDCAAS to grade protein quality.

2.3 Fats (Lipids)

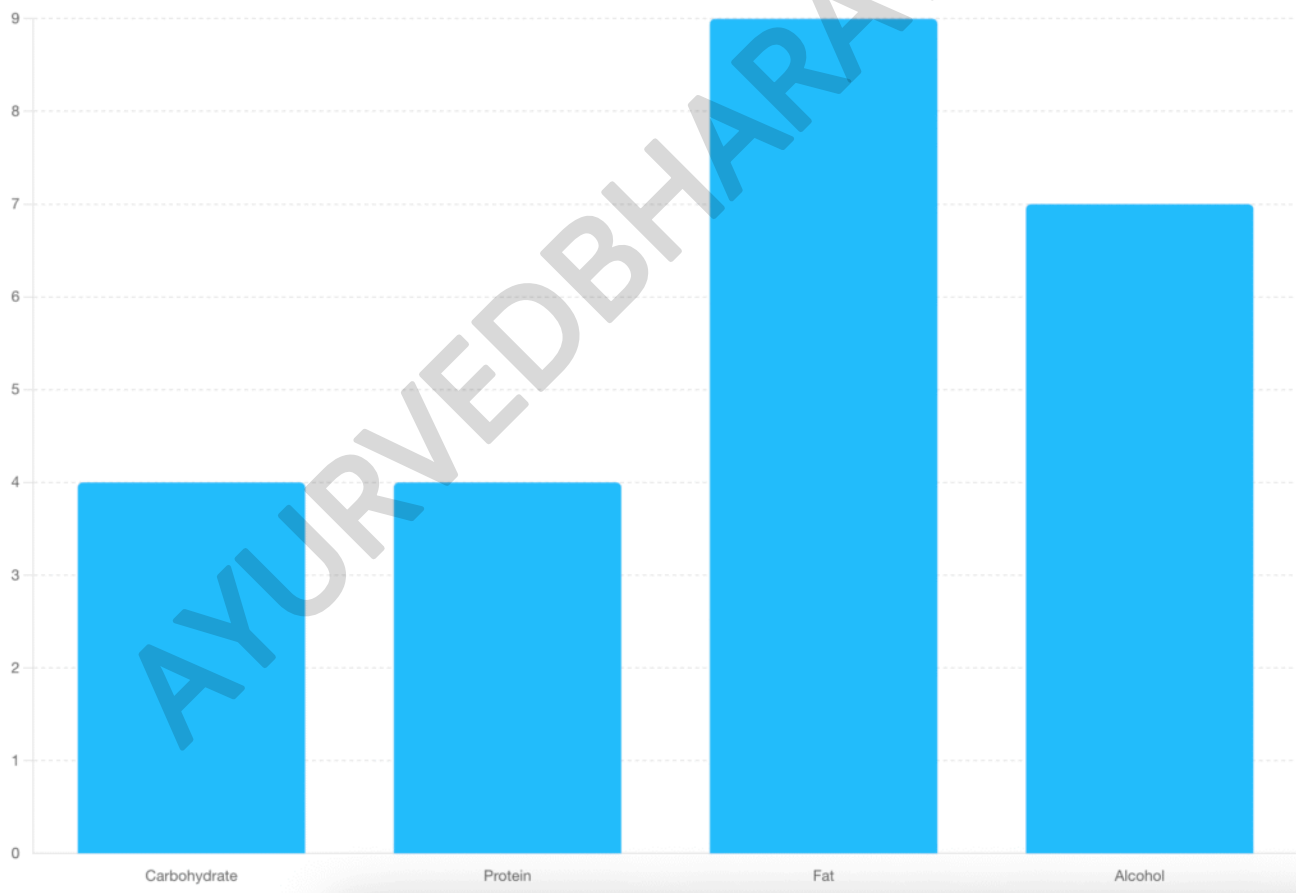
- **Categories** - Saturated (SFA), Monounsaturated (MUFA), Polyunsaturated (PUFA; ω -3 & ω -6), Trans fats, Phospholipids, Sterols.
- **Functions** - Dense energy store, membrane fluidity, eicosanoid synthesis, transport of vitamins A D E K, thermal insulation, satiety signals (CCK release).
- **Practical tips** - Maintain PUFA : SFA \approx 0.8-1, include α -linolenic sources (flax, walnuts), limit industrial trans fats < 1 % kcal.

2.4 Water

- **Roles** - Universal solvent, medium for enzyme action, temperature homeostasis, lubricant (synovial fluid), shock absorber (CSF, amniotic).
- **Adequate intake** - \approx 35 mL/kg (\approx 2-3 L/day in temperate climate, higher in heat/activity).

Energy Yield Per Gram

Y kcal per gram by X



(The bar chart "Energy Yield per Gram" visually contrasts the caloric density of the three macronutrients and alcohol.)

3 · Micronutrients - Overview

Vitamins - Key Functions & Deficiencies

Vitamin	Solubility	Adult RDA*	Principal Functions	Deficiency Highlight
A	Fat	600-800 µg RE	Vision, epithelial integrity	Night blindness
D	Fat	10-15 µg	Ca/P homeostasis, bones	Rickets/Osteomalacia
E	Fat	10 mg	Membrane antioxidant	Hemolysis (rare)
K	Fat	65 µg	Blood clotting	Bleeding diathesis
C	Water	80 mg	Collagen synthesis, antioxidant	Scurvy
B1	Water	1.1-1.3 mg	CHO metabolism (TPP)	Beriberi
B2	Water	1.3-1.6 mg	Electron transfer (FAD/FMN)	Angular stomatitis
B3	Water	14-16 mg NE	NAD/NADP cofactor	Pellagra
B5	Water	5 mg	CoA component	Fatigue
B6	Water	1.3-1.7 mg	AA metabolism, neurotransmitters	Microcytic anemia
B7	Water	30 µg	Carboxylation reactions	Dermatitis
B9	Water	400 µg DFE	DNA synthesis, methylation	Megaloblastic anemia
B12	Water	2.4 µg	Methionine & nerve maintenance	Pernicious anemia

Minerals - Roles & Deficiencies

Mineral	Class	Adult RDA*	Key Roles	Deficiency
Calcium	Macro	1000 mg	Bones, muscle contraction	Osteoporosis
Phosphorus	Macro	700 mg	Bone matrix, ATP	Bone pain
Magnesium	Macro	400 mg	Enzyme cofactor	Cramps/arrhythmia
Sodium	Macro	1500 mg AI	ECF volume & nerves	Hyponatremia
Potassium	Macro	3500 mg AI	ICF volume, heart rhythm	Arrhythmia
Chloride	Macro	2300 mg AI	Gastric acid & fluid balance	Alkalosis
Iron	Trace	17-21 mg	O ₂ transport (Hb)	Anemia
Zinc	Trace	12 mg	Immunity, wound heal	Growth failure
Iodine	Trace	150 µg	Thyroid hormones	Goitre
Selenium	Trace	40 µg	Antioxidant enzyme	Cardiomyopathy
Copper	Trace	900 µg	Redox enzymes	Anemia
Fluoride	Trace	3-4 mg	Enamel hardening	Dental caries

Key orientation points:

3.1 Vitamins

- **Fat-soluble** – A D E K; absorb with lipids, stored in liver/adipose; toxicity risk if chronically excessive.
- **Water-soluble** – B-complex & C; limited storage (except B12 in liver), excess excreted; need regular supply.
- **Functional highlights** –
 - A – vision and epithelial health
 - D – endocrine-like hormone regulating calcium absorption
 - E – chain-breaking lipid antioxidant
 - K – γ-carboxylation of clotting factors
 - C – collagen synthesis, regenerates vitamin E
 - B-group – coenzymes in energy and one-carbon metabolism

3.2 Minerals

- **Macro-minerals** – Required ≥ 100 mg/d (Ca, P, Mg, Na, K, Cl).
- **Trace elements** – Needed in µg-to-mg amounts (Fe, Zn, I, Se, Cu, F, Cr, Mn, Mo, Co).



• **Functional themes -**

- Electrolytes (Na⁺, K⁺, Cl⁻) govern fluid balance and nerve conduction.
- Bone matrices (Ca-P-Mg).
- Oxygen transport (Fe in haem).
- Antioxidant enzymes (Se in glutathione peroxidase).
- Hormone synthesis (I in thyroxine).

4 · Putting It All Together

Nutrient synergy means the body never utilises them in isolation:

- Vitamin D enhances calcium absorption; adequate protein plus vitamin C accelerates wound healing; Fe absorption rises with vitamin C but falls with phytate.
- Excess energy from carbohydrate or fat without matched micronutrients may lead to “hidden hunger” despite normal calories.

Hence **diet planning** must balance *quantity* (meeting macro energy needs) with *quality* (micronutrient sufficiency) using varied, minimally processed foods across all food groups.

Self-Test Questions

1. List three physiological consequences when dietary protein is adequate but energy intake is insufficient.
2. Why is vitamin E deficiency uncommon in healthy adults despite low dietary intake?
3. Construct a sample breakfast that provides complete protein, MUFA-rich fat, and at least 25 % of the RDA for vitamin C and calcium.

*RDA/ Adequate Intakes are averaged adult values (Indian context, 2024 revision). Adjust for age, sex, physiological state, and physical activity when applying in practice.