

Hydrogen constitutes about 8% of cell dry weight and is derived primarily from carbon compounds, such as carbohydrates. Some bacteria such as methanogens can utilize hydrogen as an energy source.

Phosphorus constitutes about 3% of cell dry weight and is present in nucleic acids and in the cell wall of some gram-positive bacteria such as teichoic acids. Inorganic phosphate salts, such as KH_2PO_4 and K_2HPO_4 , are the most common phosphate salts. Glyceroephosphates can also be used as organic phosphate sources. Phosphorus is a key element in the regulation of cell metabolism. The phosphate level in the media should be less than 1 mM for the formation of many secondary metabolites such as antibiotics.

Sulfur constitutes nearly 1% of cell dry weight and is present in proteins and some coenzymes. Sulfate salts such as $(\text{NH}_4)_2\text{SO}_4$ are the most common sulfur source. Sulfur-containing amino acids can also be used as a sulfur source. Certain autotrophs utilize S^{2+} and S^0 as energy sources.

Potassium is a cofactor for some enzymes and is required in carbohydrate metabolism. Cells tend to actively take up K^+ and Mg^{2+} and exclude Na^+ and Ca^{2+} . The most commonly used potassium salts are K_2HPO_4 , KH_2PO_4 , and K_3PO_4 .

Magnesium is a cofactor for some enzymes and is present in cell walls and membranes. Ribosomes specifically require Mg^{2+} ions. Magnesium is usually $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ supplied as $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ or MgCl_2 .

Table 2.9 lists the eight major macronutrients and their physiological role.

2.3.3. Micronutrients

Trace elements are essential to microbial nutrition. Lack of essential trace elements increases the lag phase (the time from inoculation to active cell replication in batch culture) and may decrease the specific growth rate and the yield. The three major categories of micronutrients are discussed next.

TABLE 2.9 The Eight Macronutrient Elements and Some Physiological Functions and Growth Requirements

Element	Physiological function	Required concentration (mol l ⁻¹)
Carbon	Constituent of organic cellular material. Often the energy source.	$>10^{-2}$
Nitrogen	Constituent of proteins, nucleic acids, and coenzymes.	10^{-3}
Hydrogen	Organic cellular material and water.	—
Oxygen	Organic cellular material and water. Required for aerobic respiration.	—
Sulfur	Constituent of proteins and certain coenzymes	10^{-4}
Phosphorus	Constituent of nucleic acids, phospholipids, nucleotides, and certain coenzymes	10^{-4} to 10^{-3}
Potassium	Principal inorganic cation in the cell and cofactor for some enzymes.	10^{-4} to 10^{-3}
Magnesium	Cofactor for many enzymes and chlorophylls (photosynthetic microbes) and present in cell walls and membranes.	10^{-4} to 10^{-3}

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