

## **Step 6      Biochemistry and nutrition**

**Here is a review of the main concepts of this step!**

### **1      Introducing biochemistry**

Biochemistry studies chemical substances and processes within living organisms, emphasizing biomolecules like lipids, carbohydrates, and proteins. It explores their roles in building cellular structures and facilitating biological functions.

Biochemistry overlaps with molecular biology and genetics, which delve into molecular interactions, genetic information encoded in DNA and RNA, and processes such as replication, transcription, and translation.

Genetics further investigates genes, heredity, and variations across organisms. Together, these disciplines provide insights into fundamental biological mechanisms, from molecular interactions to genetic inheritance.

### **2      Focus on nutrients**

Nutrients, which are essential for the human organism, include carbohydrates, lipids, proteins, vitamins, minerals, fibre, and water. These substances are obtained from the environment as nutrients and are vital for various functions within the body.

#### **Macronutrients and micronutrients**

- Needed in large quantities, macronutrients include carbohydrates (starches and sugars), fats, and proteins. Carbohydrates provide energy, fats serve as a secondary energy source, and proteins maintain and repair tissues.
- Required in smaller amounts, micronutrients encompass vitamins and minerals. These substances control numerous bodily functions and contribute to overall health. For instance, minerals like calcium and iron are crucial for bone and blood health, respectively.

## The role of nutrients

- **Carbohydrates:** main energy source found in foods like rice, wheat, and fruits.
- **Lipids:** secondary energy source with higher calorie content, found in oils, butter, and meat.
- **Proteins:** essential for muscle, blood, skin, and organ maintenance, sourced from meat, dairy, and fish.
- **Vitamins and minerals:** support various bodily functions and tissue development, with minerals aiding in bone and blood health.
- **Fibre and water:** essential for maintaining a healthy diet and bodily functions.

### 3 Analyzing carbohydrates

Carbohydrates are the most prevalent class of organic compounds found in living organisms, encompassing sugars and starches, also known as saccharides or sugars. They are primarily composed of carbon, hydrogen, and oxygen, with hydroxyl groups (-OH) in abundance. Carbohydrates are produced through the endothermic process of photosynthesis.

Carbohydrates have the formula  $(\text{CH}_2\text{O})_n$ , where 'n' represents the number of carbon, hydrogen, and oxygen atoms. Glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ), a hexose sugar, is the most common carbohydrate.

#### Functions

- **Metabolic energy:** carbohydrates serve as a major source of energy for both plants and animals, crucial for metabolic processes.
- **DNA and RNA:** they are essential components of nucleic acids (DNA and RNA), with deoxyribose in DNA and ribose in RNA.
- **Macronutrients:** alongside fats and proteins, carbohydrates are vital macronutrients that provide energy for the human body.

Understanding carbohydrates is fundamental to understand their role in energy production, metabolic processes, and their significance as essential nutrients in living organisms.

## Classification

- **Monosaccharides:** simple sugars like glucose and fructose, which are sweet, soluble in water, and serve as the building blocks for larger carbohydrates.
- **Oligosaccharides:** these are short chains of monosaccharides (2-10 units), found in dietary fibre and as components of glycoproteins and glycolipids. Disaccharides like sucrose, lactose, and maltose are examples.
- **Polysaccharides:** large polymers of monosaccharides, such as cellulose, starch, and glycogen. Cellulose provides plant structure, starch is a storage form in plants, and glycogen serves as animal storage in the liver and muscles.

Each type of carbohydrate plays critical roles in energy storage, structural support, and nutrition across both plant and animal kingdoms.

## 4 Examining lipids

Lipids serve various functions including energy storage, vitamin and hormone provision, and structural roles in biological membranes. They are insoluble in water but soluble in non-polar solvents. Lipids encompass fats and oils, with fats being solid at room temperature and oils liquid.

Fatty acids are fundamental components of lipids, featuring a carbon chain with a carboxyl group. They can be saturated (no double bonds), monounsaturated (one double bond), or polyunsaturated (multiple double bonds). Omega-3 and Omega-6 polyunsaturated fatty acids are essential for human health, as they cannot be synthesized by the body and must be obtained from diet.

Omega-3 fatty acids, found in fish, seafood, and some plant oils, are critical for brain function, growth, and heart health.

Omega-6 fatty acids, derived from vegetable oils, are important for cholesterol regulation, skin health, bone maintenance, metabolism, and reproductive function. Balanced intake of these fatty acids supports overall health and well-being.

## **5 Exploring proteins**

Proteins are essential macromolecules composed of chains of amino acids. There are twenty amino acids that can combine in various sequences to form hundreds of thousands of different proteins in the human body. Amino acids contain carbon, hydrogen, oxygen, and nitrogen, and they link together through peptide bonds to form peptides (up to ten amino acids), polypeptides (10-50 amino acids), or proteins (more than 50 amino acids).

Proteins are broadly categorized into structural proteins, which form the solid material in the body like keratin and collagen found in hair, muscles, tendons, and skin, and functional proteins, which perform specific activities. Examples of functional proteins include haemoglobin for oxygen transport, myosin for muscle contraction, and insulin for glucose regulation. Enzymes are a critical subset of functional proteins that facilitate specific chemical reactions in the body.

During digestion, proteins from foods such as meat, fish, beans, eggs, and cheese are broken down into amino acids and small peptides by stomach acid and enzymes in the gastrointestinal tract. These amino acids and peptides are absorbed into the small intestine and then used in protein synthesis throughout the body to create specific proteins tailored to individual needs.

## **6 A balanced diet**

Since no single food can provide all necessary nutrients for the organism, a balanced diet is crucial for proper bodily function. It involves consuming a variety of foods in appropriate quantities and safe combinations. For instance, inadequate protein intake can hinder growth, while insufficient carbohydrates and fats can lead to fatigue.

Malnutrition, characterized by either insufficient or excessive nutrient intake, poses significant health risks. Overnutrition, prevalent in many developed countries due to excessive consumption of foods high in saturated fats, contributes to obesity and related health issues like heart disease and diabetes, especially among children. Conversely, undernutrition, marked by inadequate protein and vitamin intake, leads to low energy levels and susceptibility to diseases.

Efforts to combat malnutrition include improving food safety and knowledge globally, addressing hunger, undernutrition, and inappropriate dietary practices to enhance overall health and well-being.

## 7 Food problems: allergies and intolerances

Food allergies and intolerances are distinct conditions with differing mechanisms and effects on the body.

**Food allergies** involve an immune system response triggered by specific foods, leading to the production of antibodies (IgE). Symptoms can manifest rapidly, affecting various organs such as the skin (rash), gastrointestinal tract (abdominal pain, vomiting), and respiratory system (difficulty breathing). Severe allergic reactions, known as anaphylaxis, are possible and require immediate medical attention. Common allergens include peanuts, eggs, milk, wheat, fish, soy, and sesame.

In contrast, **food intolerances** do not involve the immune system. They are characterized by a non-allergic hypersensitivity reaction, primarily affecting the digestive system. Symptoms typically appear later and are confined to digestive discomfort like bloating, diarrhea, or abdominal pain. Causes include enzyme deficiencies (e.g., lactose intolerance), irritable bowel syndrome, sensitivity to food additives (e.g., sulphites), or psychological factors. While generally less severe than allergies, intolerances are increasingly common.

Celiac disease shares features with food allergies due to immune system involvement but primarily affects the gastrointestinal system. It is triggered by gluten consumption, found in wheat and related grains. Symptoms include gastrointestinal issues such as abdominal pain, diarrhea, and fatigue, along with other possible symptoms like headaches.