



The Role of Chemistry in Daily Life: Impacts on Health, Nutrition, and Hygiene

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Abstract

Chemistry plays a central role in shaping daily life by influencing health, nutrition, and hygiene through essential molecular and biochemical processes. In health, chemistry governs metabolic pathways, pharmaceutical actions, and the body's biochemical balance, enabling diagnosis, therapy, and disease prevention. Understanding chemical interactions within biological systems helps ensure the safety and effectiveness of medicines and provides insight into physiological indicators such as glucose levels and biomarker fluctuations. In nutrition, chemistry explains the structure, function, digestion, and metabolism of macronutrients and micronutrients, while also supporting food preservation, additive safety, and contaminant risk assessment. These principles ensure a safe, balanced, and reliable food supply. Hygiene further relies on chemistry through surfactants, detergents, disinfectants, and water-purification technologies that control microbial contamination and maintain environmental cleanliness. Chemical mechanisms drive surface cleaning, sterilization, and water-quality assessment, forming the foundation of public health. Together, these domains illustrate chemistry's interdisciplinary significance in improving quality of life, reducing disease burden, and guiding safer practices at household, community, and industrial levels. Continued research into environmental chemicals, health impacts, and domestic chemical processes remains vital for strengthening global health and sustainability.

Keywords: Chemistry in daily life; Health chemistry; Nutritional chemistry; Hygiene and sanitation; Environmental chemistry; Public health safety.

Introduction

Chemistry plays a vital role in daily life, influencing health, nutrition, and hygiene. Biochemical processes sustain life, pharmaceuticals prevent and cure disease, and environmental chemistry monitors pollutants. Each link relies on chemical mechanisms to connect chemicals with biological or epidemiological outcomes. Materials enter the body to sustain life or cause harm, yet chemistry is often overlooked in public discourse about food, food chain safety, and environmental pollutants. A clear understanding of chemistry helps individuals make informed decisions about health, nutrition, and hygiene. Chemical principles underpin processes governing health maintenance, dietary safety, and hygienic practices. The role of chemistry in these aspects may therefore be crucial for effective action against multiple global challenges, including pandemics, obesity, malnutrition, food safety, and chemical pollution.

Health is essential to well-being and social advancement, and chemistry strongly influences health and its determinants through biochemistry, pharmacology, and toxicology. Nutrients

provide energy, matter, and regulatory molecules for life, and chemistry governs their safe and sufficient supply through the food chain and nutrient cycling. Hygiene—cleanliness of body, home, and surroundings—protects against disease, and chemicals are integral to water purification, cleaning agents, and sterilization methods.

Chemistry and Health

Living organisms constantly undergo biochemical changes requiring healthful chemical substances, energy, and water to maintain their existence (J. Weschler et al., 2005). These requirements are termed biochemical health necessities and transpire via various chemical pathways involving numerous chemicals inside the organism. To supply these needed health substrates, they must exist externally. This section focuses on the chemicals involved in medicine and their relationship to health. Chemicals play a strong role in human health, with pharmaceuticals being a key contributing factor. Medicines must undergo multiple assessments regarding their biochemistry effects inside the body to determine their suitability in use (Velazquez et al., 2019). Many medicine candidates are rejected due to their negative interaction toward human biochemistry. Even approved medicines must undergo clinical trials to assess their actual impact in humans and analyze multiple health metrics.

(i) Biochemical Foundations of Health: Biochemical processes lie at the heart of some of the most prominent chemical activities in daily life. The human body continuously carries out an extensive array of these processes that use energy and materials to maintain health. Energy is extracted from food and stored in specific biological compounds; metabolites and biomolecules are manufactured from food; and the body's internal environment is continuously monitored and regulated. Biochemical processes are executed with high efficiency and selectivity, permitting health maintenance with relatively small amounts of materials and energy.

The core activities fundamental to daily biochemical processes are the catabolism of carbohydrates, lipids, and proteins; the anabolism of sugar, lipids, and DNA; the synthesis of hormones, vitamins, pigments, and other small biomolecules; the conversion of monosaccharides into energy; and the mobilization of components and energy via transport molecules and carriers. In healthy metabolism, carbohydrates, lipids, and proteins from food are broken down into smaller, more manageable compounds; these metabolic substrates are transformed into energy and into precursors used to synthesize biomolecules that are not obtained from food. Every active organism absorbs compounds from its surroundings, converts them into useful materials, and reverts unwanted, unmanageable by-products back to the environment.

(ii) Pharmaceuticals and Therapeutics: Chemistry informs health in a measurable way. Each of the chemical species, biologically active compounds, and nutrients involved in biological activities demonstrates a defined transport and transformation pathway. Each one of them helps to spark and sustain biochemical processes. Similarly, pharmaceuticals act through a variety of molecular interactions and biochemical pathways, which can be monitored and quantified. Historic human health datasets provide information on health benefits associated with pharmaceutical intakes, while implementations of various medications and widespread health monitoring provide detailed insights into the impact of these species on health.

Health is determined by physiological, biochemical, and physicochemical aspects. Each of them corresponds to a particular discipline of chemistry and disciplines associated with chemistry: biochemistry, environmental chemistry, and physiological chemistry. Biochemical health, defined as the body's state of all biomarkers, is at the core of human health and therefore is the first to be presented. Each health biomarker is related to one or more biochemical processes, which can be further studied in terms of the chemicals involved, metabolic pathways, physiological enabling, and finally political, sociological, geographical,

or human crisis and progress. A few of the most frequently monitored health indicators, such as heightened glucose level, are addressed accordingly.

(iii) Environmental Chemistry and Public Health: Human activities are a continuous source of environmental contamination. Substances intentionally used can migrate during application, manufacturing, or use, and unintentional contaminants arise from processes such as garbage incineration, industrial combustion, and water purification. Consequently, pollutants permeate the air, soil, and aquifers, leading to their incorporation into the food chain. Chemical exposure occurs in workplaces, atmospheres, and locations such as homes, gardens, freshwater systems, and outdoor lakes. The transportation of chemical contaminants between various environments perpetuates this cycle. Although deteriorating environmental conditions can impact health, other disturbances are known to cause a rise in chemical levels in the household (J. Weschler et al., 2005). People now often spend about 90% of their lives indoors. Environmental pollutants constitute a considerable portion of human exposure to chemicals (R Zota et al., 2017). National databases in countries like the USA demonstrate that certain oils, plastics, coatings, and household products produce an extraordinary quantity of chemicals. Thus, exposures to these compounds in dwellings require intensive action.

Chemistry in Nutrition

Chemistry is central to all living organisms and plays a crucial role in nutrition at both the molecular and cellular levels. Nutrients (macronutrients, micronutrients, dietary components, food additives) are the cornerstones of nutrition. The following summarizes the nutrient chemistry of common dietary macronutrients and micronutrients, their digestion, absorption, biological roles, and metabolic fates in the human body. The chemistry of food additives (e.g., sweeteners, colors, preservatives) applied to diverse food formulations during preparation and cooking, along with safety standards and regulations, is discussed next. Finally, insights into the nature, sources, types, uncertainties, and risk assessments of diverse dietary contaminants are provided (Santini & Cicero, 2020) (Wilson & Bendich, 2022).

(i) Nutrient Chemistry and Metabolism: Nutrients are substances that are ingested by living organisms to support numerous cellular functions essential for growth, reproduction, maintenance, they are the fundamental components of biological metabolism. The human body's metabolism converts ingested food into building blocks and energy for growth and nourishment while forming waste substances to be excreted. Food provides three key structural and energetic types of nutrients: carbohydrates, lipids, and proteins, as well numerous micronutrients such as vitamins, minerals, and phytonutrients (Houston Price, 1968). The chemistry of nutrients focuses on the molecular structure of nutrients, the metabolic fates of food nutrients and their key biochemical pathways, dietary-food sources, and their physiological significance for human health (Edgar Cook, 1965).

(ii) Food Additives, Preservation, and Safety: Food additives help maintain the quality of food. They are preservatives, sweeteners, coloring agents, flavoring agents, stabilizers, emulsifying agents, and thickeners. In cooking and food preparation, food additives undergo various reactions and processes that alter the texture, taste, and flavor of food. Four common types are emulsifiers, stabilizers, preservatives, and sweeteners. Emulsifiers maintain emulsion systems by reducing tension between interfaces. Stabilizers enhance texture and act as a vehicle for the emulsion. Food safety is a primary concern in food management, and food additives play a vital role in ensuring food safety through consumption of a variety of food. Food safety policies and protection and enforcement agencies monitor food safety regulations and standards. Regulatory bodies promulgate laws to establish safe food containing food additives. Inspection and evaluating agencies periodically review the safety of food additives and ensure compliance (Modi et al., 2021).

Chemistry in Hygiene

Maintaining hygiene is fundamental for health; hygiene practices help to prevent the spread of microbes and contamination in the environment and in food and water supplies. Chemicals play a significant role in hygiene. A variety of chemical compounds are used to clean surfaces and objects or do laundry; these compounds include surfactants, builders, solvents, antiredeposition agents, bleach, and other additives (Velazquez et al., 2019). Time and temperature are also crucial parameters for ensuring effectiveness of surface cleaning and disinfection. Aqueous cleaning solutions must have sufficient surface tension reduction to allow access of the solvent to the surface. In addition, a clear specification of what a “clean” surface is must be maintained (depending on acceptable level of microbes, organic matter, etc.). The properties of water are also important. Water is crucial for hygiene practices. It constitutes about 70%–75% of the body; serves as the main solvent for biological reactions; helps regulate temperature in perspiration; and is used for preparation, cooking, and drinking. The quality of water plays a significant role in hygiene practices and environmental health. Water for drinking must be free from both pathogenic microorganisms and harmful chemicals (including pesticides, heavy metals, and organic substances). The community level of water-supply depends on the presence of biological, chemical, and physical contaminants (M. Abu Shmeis, 2018). Different water-purification systems are employed (e.g., filtration, distillation) and water quality is assessed in terms of chemical composition and microbiological organisms.

(i) Aqueous Chemistry and Water Quality: Safe drinking water is essential for human health. Water must be free from physical, chemical, biological, and radiological agents that may compromise quality or pose health hazards. Physical agents influence appearance, taste, and odor, with particulates responsible for turbidity (M. Abu Shmeis, 2018). Chemical factors encompass dissolved minerals, metals, and contaminants. For many chemists, water quality refers mainly to water chemistry, encompassing dissolved inorganic and organic substances, microbial content, pH, turbidity, electrical conductivity, and the solubility of gases such as oxygen and carbon dioxide. These parameters can be determined via field tests, chemical analyses, or instrumental methods (Anandet, 2019).

(ii) Detergents, Cleaning Agents, and Surface Chemistry: Surfactants are widely utilized in detergents, cleaning agents, and disinfectants. Detergents are effective against many types of surfaces, providing cleansing properties for humans and equipment. Cleaning agents are classified into surfactant cleaning agents and specific cleaning agents, such as oil cleaning agents. Surfactants reduce the surface tension of solutions, causing them to spread more easily. Surfactants are known for their critical micelle concentration (CMC) (Cong Cheng et al., 2020). The CMC is the surfactant concentration at which micelles start to form. As the concentration increases, the surface tension of the solution decreases until the CMC is reached. Once the CMC is reached, the surface tension remains constant, and the surfactants start to form micelles.

Surfactants can be classified into four categories: nonionic, anionic, cationic, and amphoteric. Nonionic surfactants do not dissociate in solution, while anionic surfactants contain negatively charged hydrophilic head groups. Cationic surfactants have positively charged groups, and amphoteric surfactants contain both positive and negative charges (Velazquez et al., 2019). Surfactants can also be classified as hydrophilic, lipophilic, and zwitterionic based on their individual structures and characteristics. Hydrophilic surfactants have polar or ionic groups. Lipophilic surfactants comprise long hydrophobic tails. Zwitterionic surfactants have both polar and nonpolar groups.

(iii) Sterilization, Disinfection, and Microbial Control: Microbially mediated infections constitute a major public health threat, capable of inflicting extensive morbidity and mortality in both developed and developing countries. Microbial pathogens are a considerable concern

in all environments, particularly hospital settings with increased amounts of vulnerable patients. Maintaining a controlled equilibrium within human microbial communities is crucial to limit disease susceptibility. Specific pathogens can proliferate rapidly, and efficient measures are necessary to eradicate them before they move to other environmental niches or host organisms.

Sterilization and disinfection are fundamental processes to eliminate pathogens and limit disease propagation, based on distinct biochemical mechanisms of action (Exner et al., 2020). Sterilants encompass a vast group of chemical agents effective against all microorganisms, including bacterial spores; however, their effectiveness is dependent on physical and chemical factors, environmental conditions, and time of exposure, influencing action spectra, afterward and recovery phases. Although spores of some organisms or specific bioburden residues may resist established chemistries, the majority still conform to this global classification. Chemical disinfection is the ablation process of vegetative organisms on inanimate surfaces. Disinfectants can be classified into three categories of action spectrum according to pathogen resistance, allowing the selection of a product defined by the biocontaminant to be eliminated. In the absence of active organic residues, disinfectants also maintain a clear potency definition; otherwise, the efficacy may be altered and product evaluation methods become necessary.

When considering sterilization or disinfection techniques, it is vital to assess the target carrier's compatibility to avoid damaging articles or creating problematic toxic by-products as residues (Velazquez et al., 2019). Harmful contamination of laboratory or surgical waste can propagate at a higher risk than the infection agent itself. Three main carrier groups must be evaluated: porous material, personal care items and medical devices made of common plastics, and small electronic devices. Additionally, biostatic microbicides and their multivalent interaction with carriers are evaluated alongside disinfectant product type. To validate that the carried microorganism is compliant with compatibility and has been eliminated, kinetic action patterns and sporicidal properties of the disinfectant are used.

A further evolution in biocide evaluation is the multipart cell-selective non-toxic or biostatic microbicides, generated to keep drinking water free from harmful single-celled organism growth and environmental water microbiology control. The primary advantage of this arrangement is the unceasing prevention of living residue from remaining on contaminated surfaces.

Interdisciplinary Perspectives and Practical Implications

Chemistry, the broad foundation of natural science, plays an essential role in human activity, technology, and the understanding of nature (A. Khan, 2018). The topics of health, nutrition, and hygiene, which all play critical roles in an individual's well-being, also demonstrate the importance of chemistry by representing its direct implications on human quality of life. Health introduces the foundational relationships between chemistry and biology that are critical to understanding living systems. Knowledge of chemistry and biochemistry provides insight into these relationships and how they influence health and the effectiveness of pharmaceuticals. Nutrition conveys chemistry's role in ensuring adequate and safe nourishment through an understanding of food composition, additives, preservation, contaminants, and risk assessment. Hygiene emphasizes the significance of chemistry in providing uncontaminated water supplies, as well as chemical agents and techniques for effective cleaning and microbial control.

Health, nutrition, and hygiene acknowledge the necessity of chemistry across distinct disciplines. The discipline of chemistry plays an essential role in the fundamental understanding of chemical reactions, materials, and processes involved in these health-related topics and helps assess human exposure and risk and identify preventative measures. Chemical actions influence human health directly through environmental exposure to risks and indirectly through nutrition and pharmacy.

Because chemistry is so significant in these essential domains, it is necessary to develop

practical applications, such as water-test kits, analytical tools, and efficient treatment methods, that leverage chemistry to protect well-being. The capacity to discern both advantages and disadvantages surrounding any chemical product can influence demand and stimulate research that gravely impacts industry and quality—effects widespread in domestic life and the economy.

Conclusion

The above findings affirm the conclusion that chemistry broadly influences everyday life. Chemistry governs fundamental health processes, shapes dietary safety, and remains integral to hygiene practices. An interdisciplinary perspective interconnects the diverse domains of health, nutrition, and hygiene while also exposing complex government policies and public questions. Research still needs to further explore the role of chemistry in various everyday activities, examine the global movement of environmental chemicals and their health consequences, and analyse the chemistry underlying domestic tasks such as cooking, laundry, and cleaning.

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