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Education in Chemical Science and Technology

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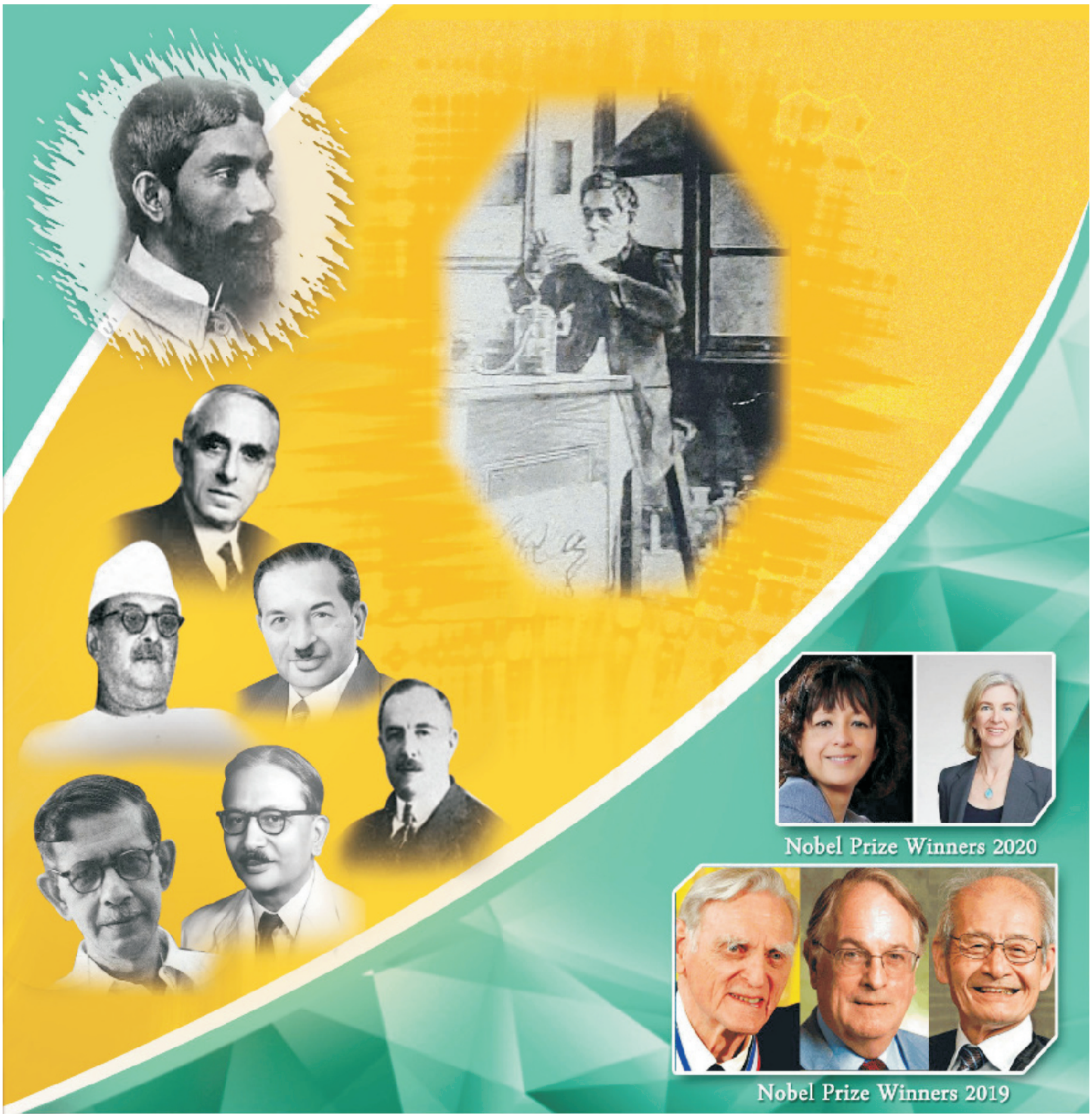

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PREFACE

The 7th and 8th issues of this book series of "**Education in Chemical Science and Technology**" is shaped with ten articles in the different domain which will be valuable literature for the students those who are willing to adopt Chemistry as a part of their career.

In the first article, Prof. D. V. Prabhu from Wilson College, Mumbai & General Secretary, Association of Chemistry Teachers explained the role of catalysts in green chemistry in his unique style of easiest explanation. He enlightened the role of catalysis towards better atom economy, minimum waste production, eco-friendly products and emissions, and reusability of catalyst materials.

Prof. Chittaranjan Sinha from Jadavpur University, Kolkata and Honorary Secretary, Indian Chemical Society who is popular as 'CRS Sir' among inorganic chemistry students, explained beautifully a very modern topic MOF (Metal-organic framework), and the chemistry behind it, in the second article. The uniqueness of this topic is the structural correlation between house frame and MOF frame which will be an easier tool to understand the topic.

In the third article, Prof. Sagar Pal, an Organic Chemist from IIT (ISM) Dhanbad has explained the formation of polysaccharide-based hydrogels in controlled drug delivery applications.

Prof. Pijush Khatua *et al.* from Haldia Institute of Technology, Haldia explained the role of polymers, resins, adhesive towards the formation of composite material in the fourth article of this book. He also emphasized "Why fiber-reinforced composites are impotent for surviving in the future?", which will promote higher learners to find their projects in this beautiful field.

In the fifth article, Dr. Tarun Kumar Barik *et al*. from IIT-Kharagpur explained the deeper understanding of Foam-Raman spectroscopic characterization and its applications in different fields.

Dr. Partha Pratim Bag from SRM University, Sikkim explored the correlation between the engineering techniques and the chemistry behind the crystal structure of the molecule in the sixth article.

In the seventh article, Prof. Radha Das *et al*. from Haldia Institute of Technology,

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Haldia reported an original project outcome on the adsorption performance of Indian neem leaf powder for the removal of cationic Methylene Blue dye from effluents of the dye industry, its kinetics, and reaction isotherm.

In the eighth article, Dr. Madhurima Jana *et al.*, NIT-Rourkela explained how alcohol as a co-solvent plays an important role in the structure and stability of proteins.

From personal experience of teaching for a long period of time and interacting closely with students at all levels, high school onwards, taking chemistry as a major subject in different parts of the country, Prof. Nitin Chattopadhyay, Jadavpur University, Kolkata illustrates the different aspects of imparting chemical education in the ninth article.

At the end, Dr. Aparna Das and Prof. Bimal Krishna Banik, Prince Mohammad Bin Fahd University, Kingdom of Saudi Arabia explained the fundamental aspects of cholesteroland its three crucial derivatives are explored. In the article, the cholesterol-related health issues and their possible controls are also covered.

We appreciate the academic contribution of all the authors who kindly responded to our invitation and contributed their articles. We are also thankful to all the council members and advisors of Indian Chemical Society for their valuable suggestions to bring this issue towards our readers.

Last but not least, the help of the Office Staff of the Society and Staff of the Press are thankfully acknowledged for their kind help in every aspect of this publication.

Inspite of our best efforts some unintended eorrors might have gatecrashed in for which we express our sincere apology.

We believe that the present issue would be warmly accepted by our readers. We shal be highly obliged to accept any suggestions and critisim from the readers for future improvement.

G. D. Yadav
President
Indian Chemical Society

C. R. Sinha
Honorary Secretary
Indian Chemical Society

Biswajit Pal
Gourisankar Roymahapatra
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C O N T E N T S

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Importance of catalysis in Green Chemistry

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Green Chemistry aims at the design of products that minimize the use and generation of harmful substances which harm the environment. Green Chemistry is based on the 12 Principles of Green Chemistry enunciated by Paul Anastas and John Werner in the '90s, which provide a blueprint for sustainable development. Among these, the use of catalysts to improve atom economy and yield of reactions is most important. Catalysts are the pillars of Green Chemistry and worldwide, there is a constant search for novel catalysts. Atom economy of a chemical reaction is a theoretical measure of the amount of starting material that has got converted into the desired useful product and is a reliable metric of the greenness of a reaction.

% Atom economy = [Mass of desired product]/[Total mass of all products]×100

Thus, 100% atom economy means 0% waste.

Green catalysts are preferred because of their distinct advantages:

(I) better atom economy,

(II) minimum waste production,

(III) eco-friendly products and emissions,

(IV) reusability.

Some examples of Green catalysts which are widely used are biocatalysts which include enzyme catalysts, phase transfer catalysts, and nano catalysts.

Keywords: Green Chemistry, sustainable development, Green catalysts, atom economy, reaction yield, bio-catalysts, enzyme catalysts, phase transfer catalysts, nano catalysts.

Introduction

In the last few years, there has been a constant and vigorous debate between the Development and Conservation of the environment. Man has been using

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Framework Chemistry renovating our insight into the Chemical Sciences

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Introduction

A 'frame' is a structure (rigid or flexible) in a definite pattern that surrounds something such as a picture, door, plot etc., and 'Framework' is an important supporting structure of a building, vehicle, or geometrical object. In Chemistry 'Framework' refers to the solid-state structure of the molecules/materials, surface morphology, and different synonymous terminology is used such as Covalent organic frameworks (COFs), Coordination Polymers, Coordination Network, Coordination Framework, Metal-Organic Framework (MOF), Metal-organic coordination networks (MOCNs)[1–5]. MOFs are the coordination polymer with sizeable porosity and crystalline geometry and dimensionality. These polymeric coordination networks significantly extended along with one (1D)-, two (2D)- and three (3D)-dimensioning by the repeating unit of coordination sphere (Fig. 1). The components under certain experimental conditions (heat, light, pressure, solvent, catalyst) are orderly organized to generate oriented. In this contrast, coordination compounds are aggregated via coordinate bonds, and weak chemical bonds (secondary forces) in the infinite array lead to fabricating coordination polymers.

A coordination polymer is an inorganic or organometallic polymer structure containing metal ions linked by organic bridging ligands with repeating coordination entities extending in 1, 2, or 3 dimensions.[1]solids.

Organic polymers (Fig. 3) are typically macromolecules with high molecular weight and are associated with the repeating unit of monomer or oligomers through covalent bonds. Moreover, secondary forces like hydrogen bonds or van der Waals contacts are associated to exhibit the structural directionality in the coordination polymer which is much weaker than the coordinate bonds.

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Polysaccharide based hydrogels in controlled drug delivery applications

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In recent years, polymeric hydrogels received noteworthy attention in the field of biomedical applications[1,2]. The term 'hydrogel' was first reported in 1894 as a colloidal gel of inorganic salts[3]. For the first time, crosslinked polymeric hydrogel derived from poly(vinyl alcohol) was reported[4]. Later in 1960, Wichterle and Lim were introduced as poly(hydroxyethyl methacrylate) based hydrogel that was used in contact lens application (Fig. 1)[5].

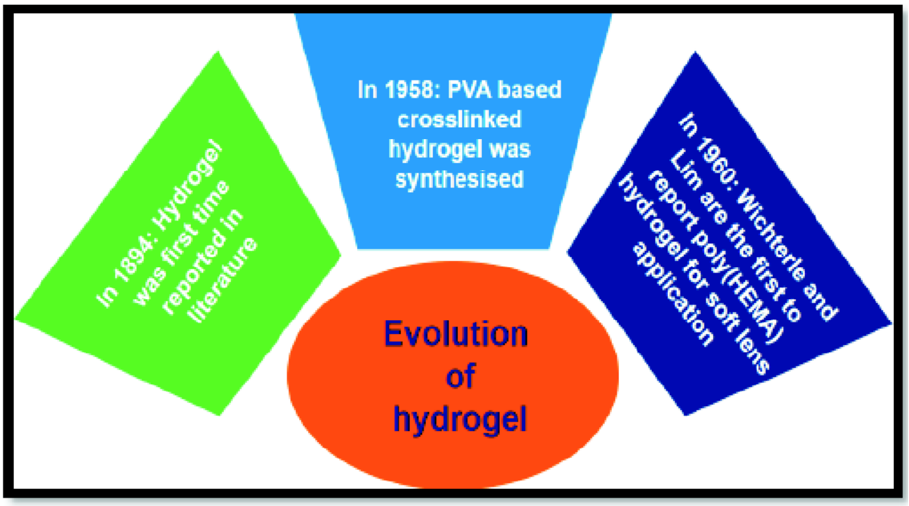

Fig. 1. Evolution of hydrogel.

Hydrogels are usually hydrophilic, physically/chemically crosslinked, three-dimensional polymeric networks, which can absorb a large amount of water and get

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An introduction to composite material

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Conservation of the natural resources of our planet has become an issue of prime importance all over the world. Due to rapid urbanization, metal and wood are abundantly use in industry for development of building and household furniture. Metal is limited where as wood is renewable but to grow it requires huge time. For this reason, we are facing scarcity of metal as well as wood (not only used as building material but majorly used in furniture industry, paper industry and several other purposes). Global environmental consciousness induced us to use the other materials which are not metal and wood but have equivalent properties like metal and wood, called composite – a material. Most of the metals are non-biodegradable and they need huge energy for production and process. On the other hand wood collect from tree has a great roll on the ecosystem. In this situation fiber reinforced polymer matrix composite plays great roll as substitute of metal and wood in numerous applications because of its some extraordinary strength properties. Here, a preliminary and easy attempt has been taken for development of different composite materials, there properties, application, merits and demerits as substitute of metal and wood. Due to its high specific stiffness and strength, composite could be an ideal solution of metal and wood which indirectly will save our natural wealth and forest reserves.

Keywords: Metal, wood, material, composite, matrix, reinforcing agent.

Introduction

Due to continuous increase in gap between demand and supply of metal and wood, we are passing through a critical state as they are not only limited in this world at the same time play a massive roll in our ecosystem. Due to unbound use

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Basics of foam-Raman spectroscopic characterization

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Wet foam is a very common example of soft matter. In wet foam, molecules are more structured than in liquids but more random than they are in solids. Recently, the physics of foam has become a rapidly developing branch in science and engineering. A deeper understanding is crucial for many technological applications of wet foam. Hence, in this article, the basic structure and properties of the foam are reviewed based on the literature survey of published research work. Some research works, available in the literature, in which optical probes have been used to study the structure, properties, and dynamics of foam. In this article, wet foam is used to study the basic structure and properties of foam for better understanding. Raman spectroscopy and diffusing wave spectroscopy have been used on wet foam to establish its structure and properties are also reported. Finally, in conclusion, recent scientific, technological, and commercial applications and future prospects of wet foam are proposed to build impulse on the wet foam science more to enrich our day to day life with the modern concepts of nanofoam technology. Recently, due to rapid increase of nanotechnology, different metallic (Cu, Au, Ni, Pt, Pd, etc.) or nonmetallic (Carbon), solvent-assisted nanofoam has modernized the structure, properties of foam science, and hence have accelerated its day to day technological applications.

Keywords: Wet foam, rheology, coarsening, liquid drainage, collapse, Raman spectroscopy, diffusing wave spectroscopy, nanofoam.

Introduction

Imagine opening a carbonated cold drink bottle or a soda can after shaking it: almost instantaneously, gas bubbles rise and crowd together at the surface of the liquid forming a soft foam. Inside the bottle or can, carbon dioxide is dissolved in

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Crystal engineering: The chemistry behind molecular structure

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Crystals are formed by the aggregation of molecules in solution. This phenomenon encourages several questions. Among them few are, how do these aggregations happen to form crystals? Why do the same molecules adopt more than one crystal structure? Why does solvent occupy some crystal structures? How does crystal structure can be designed with specified coordination of molecules and/or ions with a specified property? What are the relationships between crystal structures and properties, for molecular crystals? At present several queries are being resolved by the crystal engineering community; a larger community constructed by organic, inorganic, and physical chemists, crystallographers, and solid-state scientists. This article provides a brief idea to provide a basic introduction to crystal engineering and this fascinating and important subject that has moved from the fringes into the mainstream of chemistry.

Introduction

What is Crystal engineering?

The modern definition according to Gautam Desiraju, is “the understanding of intermolecular interactions in the context of crystal packing and the utilization of such understanding in the design of new solids with desired physical and chemical properties[1]. So it offers a good opportunity the design molecular crystals for a wide variety of physical and chemical purposes. Crystal engineering is quite resembling organic chemistry based on two components, analysis, and synthesis. For designing a crystal and predict the structure experimentation and computation are equally important[2]. Because with the help of experiment, structural information of supramolecular architecture could be obtained by further application of single-crystal X-ray diffraction and computational approach could be helpful to enumerate the interactions for crystal packing in terms of thermodynamically stable product.

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Adsorption performance of Indian Neem leave powder for removal of cationic Methylene Blue dye from dying industry effluents: Kinetics and isotherms

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Industrial effluents containing hazardous chemicals and complex metal dyes are highly toxic and carcinogenic. Being toxicological, these dyes not only harm humans, even more, but they also bio-accumulate in wildlife and build hazardous situations in water and thus contaminate the eco-system. Many dyes used in dying industries are stable to light and resistant to aerobic digestion. Thus, the elimination of complex dyes from dyeing industry effluent is a most challenging problem today. To find out a cost-effective and eco-friendly bio-adsorbent have growing demand to save the environment. In this paper Neem leaf powder (NLP) obtained from the local area has been used for the removal of Methylene Blue (MB) dye. The effect of solute concentration, adsorbent amount, contact time, pH, and temperature on the removal of dyes has been observed. It was observed that a higher amount of adsorbent and lower concentrations of dyes favor the higher percentage of adsorption. The applicability of the rearranged Langmuir isotherm model for this adsorption process shows the maximum adsorption capacity of the activated NLP was 188.7 mg/gm. Helfferich first order kinetics and pseudo-second order reaction kinetics has also been fitted to find out the reaction constants for these adsorption process. Results confirmed that Indian NLP has excellent potential as a low-cost adsorbent for the removal of carcinogenic and complex dyes from various industrial wastes.

Keywords: Adsorption, Neem leaf, Methylene Blue, Freundlich isotherm, Langmuir isotherm.

Introduction

Among the different pollutants of aquatic ecosystems, synthetic dyes are a very important group of industrial chemicals that are used in many industries like paints, pharmaceuticals, paper, leather, cosmetics, plastics, waxes, and espe-

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Protein structure, dynamics and stability in alcohols

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Introduction

Proteins, the most abundant biological polymers of living systems are made of amino acid residues that are connected through peptide bonds (CO–NH). There are four levels of structural organization in proteins namely, primary, secondary, tertiary, and quaternary structure[1] as shown in Fig. 1. The sequence of amino acids in proteins determines its structure and biological function[2]. The primary structure of the protein is the simplest one made up of the linear amino acid sequence, which undergoes twist and turns to form local structural conformations such as, turn, α-helix or β-sheet to develop the secondary structure.

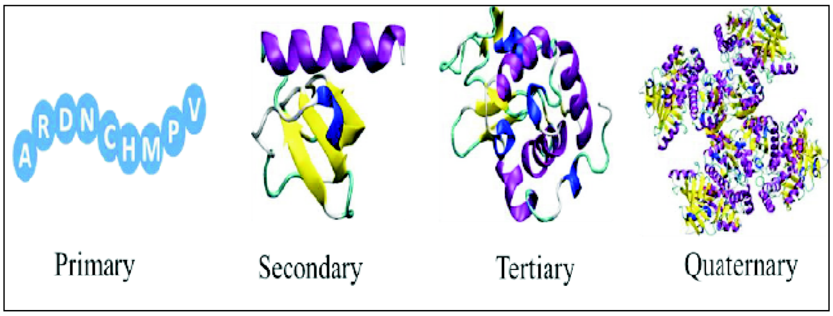

Fig. 1. The four levels of structural organization in proteins.

The three-dimensional tertiary structure of protein forms through several non-local interactions such as hydrogen bonds, disulfide bonds, and hydrophobic and

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Imparting Chemical Education

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Introduction

From personal experience of teaching in a University for a long period of more than thirty years and interacting closely with students at all levels, high school onwards, taking chemistry as a major subject in different parts of the country, I realize that a sizeable section of the students do not take this subject out of their love and passion. Rather, in many cases they judge it profitable to be in chemical science considering its wider opening and greater prospect for securing a job. It is also our general experience that although kids ask a lot of questions, with their growth going through the schools they gradually stop asking questions. Similar realizations have been recorded more than a decade ago in the December 2009 issue of the Journal of Chemical Education. In the Editorial message[1] "Especially for HS Teachers" of the issue Professors L. E. Slocum and E. K. Jacobsen expressed their concerns and views in this regard. They have especially referred to another article[2] of Professors B. B. Widanski and W. C. McCarthy published in the same issue in the same context. In the latter article the authors have reported on "Chemistry Anxiety". As teachers of chemistry we must consider the scenario grave and should be prompted to take measures to make the subject enjoyable and lovable to the students at the high school as well as college levels. Since "education in chemical science" is the basis of sustainable development of any society or country, we need to give proper emphasis on it. To impart a meaningful chemical education the primary requirement is that the learners must be interested in the subject. The teachers have a profound role in this respect.

In the present article an endeavor has been made to share my concerns and views on the issue with my young students as well as my esteemed colleagues in the entire teaching fraternity to find a way out of this unhealthy academic situation. I sincerely feel that it is the "attitude" (of both teachers and students) that plays the pivotal role and if we can tune the "attitude" properly, "chemical educa-

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Life's molecule cholesterol

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The importance of cholesterol in human life is most significant. Cholesterol makes various impacts on the human body. Most of the fundamental aspects of cholesterol and its three crucial derivatives are explored. The cholesterol-related health issues and their possible controls are also covered.

Keywords: Cholesterol, bile salts, steroid hormones, vitamin D.

1. Introduction

Cholesterol is an organic molecule. The IUPAC name of this compound is cholest-5-en-3β-ol. It is also known as Cholesterin or Cholesteryl alcohol. Cholesterol is basically a sterol or modified steroid, a type of lipid, waxy, and fat-like substance. Cholesterol is an essential structural component of animal cell membranes. All animal cells are able to make cholesterol by the biosynthetic method. In vertebrates, mostly the hepatic cells synthesize cholesterol in large quantities. It is found in the body tissues and blood plasma. Especially, large concentrations of cholesterol are found within the liver, brain, spinal cord, and in animal fats or oils. It is the main constituent of gallstones. It also plays an important role for the immune system as well as in the brain synapses. Even though cholesterol is not present in most of the prokaryotes (for example in bacteria and archaea), *Mycoplasma* requires cholesterol for its growth[1]. Besides, cholesterol also works as a major precursor for the biosynthesis of other important biological compounds such as steroid hormones, vitamin D, and bile acid[2].

The cholesterol was first identified in solid form in gallstones by a French doctor and chemist, François Poulletier de la Salle, in about 1769. Later, the chemist, Michel Eugène Chevreul, named the compound "cholesterine" in 1815[3,4].

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"While a student at Edinburgh I found to my regret that every civilized country including Japan was adding to the world's stock of knowledge but unhappy that India was lagging behind. I dreamt a dream that, God willing, a time would come when she too would contribute her quota. Half-a-century has since then rolled by. My dream I have now the gratification of finding fairly materialized. A new era has evidently dawned upon India. Her sons have taken kindly to the zealous pursuit of different branches of science. May the torch thus kindled burn with greater brilliance from generation to generation "

Acharya Prafulla Chandra Ray

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