

NOBEL LAUREATES OF CHEMISTRY ARE THE PLAYERS IN THE PLAYGROUND OF FUNCTIONAL GROUPS OF CHEMICAL MOLECULES

Shruti Rai and Prof. Dr. Dhrubo Jyoti Sen*

Shri Sarvajani Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana-384001, Gujarat, India.

*Corresponding Author: Prof. Dr. Dhrubo Jyoti Sen

Shri Sarvajani Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana-384001, Gujarat, India.

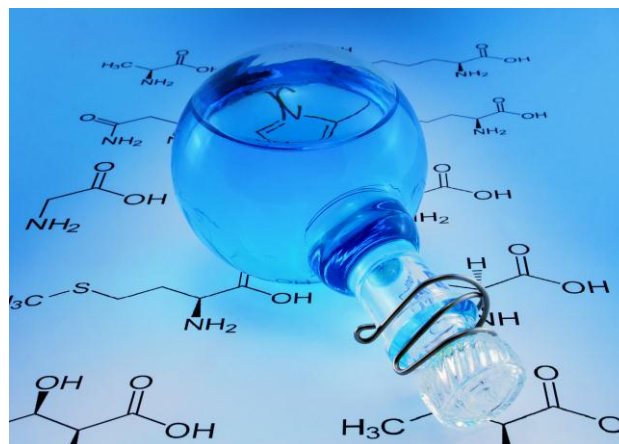
Article Received on 13/05/2016

Article Revised on 03/06/2016

Article Accepted on 24/06/2016

Preface: There is nothing in this world which is free from chemistry. Chemistry is such a subject which is standing on its four pillars: why, when, how & where. Why the reaction has taken place; When the reaction has taken place; How the reaction has taken place & Where the reaction has taken place. This subject focuses on the reactivity of two or more than two reactants according to the functional groups present in the molecule because in any chemical reaction the following five parameters are considered as the caretaker of the event: reagent, reactant, time, temperature & catalyst. Lacking of any one of these will hamper the chemical reaction with desired yield. It is a playground where the functional groups play a game by following why, when, how & where with reagent, reactant, time, temperature & catalyst. Most funny matter is the breaking of the word chemistry it gives: chemist+try because the last three words try gives indication to perform the reaction by try, try, try until you get the desired expectations.^[1-4]

Chemistry is a branch of physical science that studies the composition, structure, properties and change of matter. Chemistry includes topics such as the properties of individual atoms, how atoms form chemical bonds to create chemical compounds, the interactions of substances through intermolecular forces that give matter its general properties and the interactions between substances through chemical reactions to form different substances. Chemistry is sometimes called the central science because it bridges other natural sciences, including physics, geology and biology. Scholars disagree about the etymology of the word chemistry. The history of chemistry can be traced to alchemy, which had been practiced for several millennia in various parts of the world. Chemistry may be *in-vivo*, *in-vitro*, *in-situ* or *in-silico*; but everywhere it acts a playground of functional groups of playing chemicals.^[5-8]



Theoretical and practical molecules

Known as the central science, chemistry is integral to our understanding of the natural world around us. In this chapter, you'll be introduced to the field of chemistry, learning about its history and its modern applications. What Is Chemistry?

When you hear the word 'chemistry,' there are likely certain images that come to mind - molecules, test tubes, the periodic table, maybe even some cool explosions in a movie but chemistry is so much more than these things! In fact, chemistry is known as the central science because it touches all other natural sciences, like biology, physics, geology and more. Chemistry is a physical science, and it is the study of the properties of and interactions between matter and energy. In other words,

chemistry is a way to study the properties, characteristics, and physical and chemical changes of matter. Matter is pretty important because it's anything that has mass and takes up space - basically, all of the 'stuff' that makes up our world! Chemists study atoms, which are the basic building blocks of matter, as well interactions between atoms. They also study subatomic particles, which are smaller than atoms, and these include things like protons, neutrons, and electrons. Since everything on Earth is made of matter, and matter is made of atoms, you can see how this creates the overlap between chemistry and other sciences. You can't have 'stuff' to study if you don't have 'stuff' in the first place. In other words, matter really matters!^[9-12]

Chemistry Has a Rich History. Your understanding of chemistry may be shiny and new, but chemistry itself has been around for a very long time. Basic chemistry dates back to ancient times and is described as originating from alchemists who were very thorough scientists. They ran experiments and recorded their results, which is a key component of good science.

Classified chemistry: Analytical chemistry, Agrochemistry, Astrochemistry, Atmospheric chemistry, Biochemistry, Chemical biology, Chemical engineering, Cheminformatics, Combinatorial chemistry, Electrochemistry, Environmental chemistry, Femtochemistry, Flavor chemistry, Flow chemistry, Geochemistry, Green chemistry, Histochemistry,

Hydrogenation chemistry, Immunochemistry, Inorganic chemistry, Marine chemistry, Materials chemistry, Materials science, Mathematical chemistry, Mechanochemistry, Medicinal chemistry, Molecular biology, Molecular mechanics, Nanochemistry, Natural product chemistry, Neurochemistry, Nuclear chemistry, Oenology, Organic chemistry, Organometallic chemistry, Petrochemistry, Pharmacological chemistry, Photochemistry, Physical chemistry, Physical organic chemistry, Phytochemistry, Polymer chemistry, Radiochemistry, Solid-state chemistry, Sonochemistry, Supramolecular chemistry, Surface chemistry, Synthetic chemistry, Theoretical chemistry, Thermochemistry.

Modern chemistry dates back to the 17th century, and credited as one of the founders of this scientific field is Robert Boyle. Boyle is one of the developers of the scientific method, which is an organized set of steps to gain knowledge and answer questions. Boyle believed in rigorous, tested experimentation and was a strong advocate of proving scientific theories before calling them 'truths.' Though not always considered a formal science, chemistry has been performed throughout human history. People have been fermenting food and drink for centuries. Extracting metal from ores is another form of 'natural' chemistry, as is making glass, soap, and extracting plant components for medicinal purposes. Archaeologists find pottery at their dig sites, and both the pots and the glazes used to protect them come from knowledge of chemistry as well.^[13]

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
↓Period																			
1	1 H																	2 He	
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	*	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
			*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
			*	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

Periodic table: the origin of chemical molecules

List of Nobel Laureates in Chemistry (1901-2015)^[14]

Year	Name	Country	Credit
1901	Jacobus Henricus van 't Hoff	Netherlands	for his work on discovery of the laws of chemical dynamics and osmotic pressure in solutions
1902	Hermann Emil Fischer	Germany	for his work on sugar and purine syntheses
1903	Svante August Arrhenius	Sweden	for his work on electrolytic theory of dissociation
1904	Sir William Ramsay	United Kingdom	for his work on discovery of the inert gaseous elements in air and his determination of their place in the periodic system
1905	Johann Friedrich Wilhelm Adolf von Baeyer	German	for his work on the advancement of organic chemistry and the chemical industry, through his work on organic dyes and hydroaromatic compounds
1906	Henri Moissan	France	for his work on investigation and isolation of the element fluorine and for the electric furnace
1907	Eduard Buchner	Germany	for his work on biochemical researches and his discovery of cell-free fermentation
1908	Ernest Rutherford	United Kingdom New Zealand	for his investigations into the disintegration of the elements, and the chemistry of radioactive substances
1909	Wilhelm Ostwald	Germany	for his work on catalysis and for his investigations into the fundamental principles governing chemical equilibria and rates of reaction"
1910	Otto Wallach	Germany	for his services to organic chemistry and the chemical industry by his pioneer work in the field of alicyclic compounds
1911	Maria Sklodowska-Curie	Poland France	for the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element
1912	Victor Grignard	France	for the discovery of the Grignard reagent
	Paul Sabatier	France	for his method of hydrogenating organic compounds in the presence of finely disintegrated metals
1913	Alfred Werner	Switzerland	for his work on the linkage of atoms in molecules especially in inorganic chemistry
1914	Theodore William Richards	United States	for his accurate determinations of the atomic weight of a large number of chemical elements
1915	Richards Martin Willstätter	Germany	for his researches on plant pigments, especially chlorophyll
1916			Not awarded
1917			
1918	Fritz Haber	Germany	for the synthesis of ammonia from its elements
1919			Not awarded
1920	Walther Hermann Nernst	Germany	for his work in thermochemistry
1921	Frederick Soddy	United Kingdom	for his contributions to our knowledge of the chemistry of radioactive substances, and his investigations into the origin and nature of isotopes
1922	Francis William Aston	United Kingdom	for his discovery, by means of his mass spectrograph, of isotopes, in a large number of non-radioactive elements and for his enunciation of the whole-number rule
1923	Fritz Pregl	Austria	for his invention of the method of micro-analysis of organic substances
1924			Not awarded
1925	Richard Adolf Zsigmondy	Germany Hungary	for his demonstration of the heterogeneous nature of colloids solutions and for the methods he used
1926	The (Theodor) Svedberg	Sweden	for his work on disperse system
1927	Heinrich Otto Wieland	Germany	for his investigations of the constitution of the bile acids and related substances
1928	Adolf Otto Reinhold Windaus	Germany	for his research into the constitution of the sterols and their connection with the vitamins
1929	Arthur Harden	United Kingdom	for their investigations on the fermentation of sugar and fermentative enzymes
	Hans Karl August Simon von	Sweden	

	Euler-Chelpin	Sweden	
1930	Hans Fischer	Germany	for his researches into the constitution of haemin and chlorophyll and especially for his synthesis of haemin
1931	Carl Bosch	Germany	for their contributions to the invention and development of chemical high pressure methods
	Friedrich Bergius	Germany	
1932	Irving Langmuir	United States	for his discoveries and investigations in surface chemistry
1933			Not awarded
1934	Harold Clayton Urey	United States	for his discovery of heavy hydrogen
1935	Frédéric Joliot	France	for their synthesis of new radioactive elements
	Irène Joliot-Curie	France	
1936	Petrus (Peter) Josephus Wilhelmus Debye	Netherlands	for his work on molecular structure through his investigations on dipole moments and the diffraction of X-rays and electrons in gases ¹
1937	Walter Norman Haworth	United Kingdom	for his investigations on carbohydrates and vitamin C
	Paul Karrer	Switzerland	for his investigations on carotenoids, flavins and vitamins A and B ₂
1938	Richard Kuhn	Germany	for his work on carotenoids and vitamins
1939	Adolf Friedrich Johann Butenandt	Germany	for his work on sex hormones
	Leopold Ruzicka	Switzerland	for his work on polymethylenes and higher terpenes
1940			Not awarded
1941			
1942			
1943	George de Hevesy	Germany	for his work on the use of isotopes as tracers in the study of chemical processes
1944	Otto Hahn	Germany	for his discovery of the fission of heavy nuclei
1945	Artturi Ilmari Virtanen	Finland	for his research and inventions in agricultural and nutrition chemistry, especially for his fodder preservation method
1946	James Batcheller Sumner	United States	for his discovery that enzymes can be crystallized
	John Howard Northrop	United States	
	Wendell Meredith Stanley	United States	
1947	Sir Robert Robinson	United Kingdom	for his investigations on plant products of biological importance, especially the alkaloids
1948	Arne Wilhelm Kaurin Tiselius	Sweden	for his research on electrophoresis and adsorption analysis, especially for his discoveries concerning the complex nature of the serum proteins
1949	William Francis GIAUQUE	United States	for his contributions in the field of chemical thermodynamics, particularly concerning the behaviour of substances at extremely low temperatures
1950	Otto Paul Hermann Diels	West Germany	for their discovery and development of the diene synthesis
	Kurt Alder	West Germany	
1951	Edwin Mattison McMillan	United States	for their discoveries in the chemistry of transuranium elements
	Glenn Theodore Seaborg	United States	
1952	Archer John Porter Martin	United Kingdom	for their invention of partition chromatography
	Richard Laurence Millington Synge	United Kingdom	
1953	Hermann Staudinger	West Germany	for his discoveries in the field of macromolecular chemistry
1954	Linus Carl Pauling	United States	for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances
1955	Vincent du Vigneaud	United States	for his work on biochemically important sulphur compounds, especially for the first synthesis of a polypeptide hormone
1956	Sir Cyril Norman Hinshelwood	United Kingdom	for their researches into the mechanism of chemical reactions
	Nikolay Nikolaevich Semenov	Soviet Union	
1957	Lord (Alexander R.) Todd	United Kingdom	for his work on nucleotides and nucleotide co-enzymes
1958	Frederick Sanger	United Kingdom	for his work on the structure of proteins, especially that of insulin
1959	Jaroslav Heyrovský	Czechoslovakia	for his discovery and development of the polarographic

			methods of analysis
1960	Willard Frank Libby	United States	for his method to use carbon-14 for age determination in archaeology, geology, geophysics, and other branches of science
1961	Melvin Calvin	United States	for his research on the carbon dioxide assimilation in plants
1962	Max Ferdinand Perutz	United Kingdom	for their studies of the structures of globular proteins
	John Cowdery Kendrew	United Kingdom	
1963	Karl Ziegler	West Germany	for their discoveries in the field of the chemistry and technology of high polymers
	Giulio Natta	Italy	
1964	Dorothy Crowfoot Hodgkin	United Kingdom	for her determinations by X-ray techniques of the structures of important biochemical substances
1965	Robert Burns Woodward	United States	for his outstanding achievements in the art of organic synthesis
1966	Robert S. Mulliken	United States	for his fundamental work concerning chemical bonds and the electronic structure of molecules by the molecular orbital method
1967	Manfred Eigen	West Germany	for their studies of extremely fast chemical reactions, effected by disturbing the equilibrium by means of very short pulses of energy
	Ronald George Wreyford Norrish	United Kingdom	
	George Porter	United Kingdom	
1968	Lars Onsager	United States	for the discovery of the reciprocal relations bearing his name, which are fundamental for the thermodynamics of irreversible processes
1969	Derek H. R. Barton	United Kingdom	for their contributions to the development of the concept of conformation and its application in chemistry
	Odd Hassel	Norway	
1970	Luis F. Leloir	Argentina	for his discovery of sugar nucleotides and their role in the biosynthesis of carbohydrates
1971	Gerhard Herzberg	Canada West Germany	for his contributions to the knowledge of electronic structure and geometry of molecules, particularly free radicals
1972	Christian B. Anfinsen	United States	for his work on ribonuclease, especially concerning the connection between the amino acid sequence and the biologically active conformation
	Stanford Moore	United States	for their contribution to the understanding of the connection between chemical structure and catalytic activity of the active centre of the ribonuclease molecule
	William H. Stein	United States	
1973	Ernst Otto Fischer Geoffrey Wilkinson	West Germany United Kingdom	for their pioneering work, performed independently, on the chemistry of the organometallic, so called sandwich compounds
1974	Paul J. Flory	United States	for his fundamental work, both theoretical and experimental, in the physical chemistry of macromolecules
1975	John Warcup Cornforth	Australia United Kingdom	for his work on the stereochemistry of enzyme-catalyzed reactions
	Vladimir Prelog	Yugoslavia Switzerland	for his research into the stereochemistry of organic molecules and reactions
1976	William N. Lipscomb	United States	for his studies on the structure of boranes illuminating problems of chemical bonding
1977	Ilya Prigogine	Belgium	for his contributions to non-equilibrium thermodynamics, particularly the theory of dissipative structures
1978	Peter D. Mitchell	United Kingdom	for his contribution to the understanding of biological energy transfer through the formulation of the chemiosmotic theory
1979	Herbert C. Brown	United States	for their development of the use of boron- and phosphorus-containing compounds, respectively, into
	Georg Wittig	West Germany	

			important reagents in organic synthesis
1980	Paul Berg	United States	for his fundamental studies of the biochemistry of nucleic acids, with particular regard to recombinant-DNA
	Walter Gilbert	United States	for their contributions concerning the determination of base sequences in nucleic acids
	Frederick Sanger	United Kingdom	
1981	Kenichi Fukui	Japan	for their theories, developed independently, concerning the course of chemical reactions
	Roald Hoffmann	United States	
1982	Aaron Klug	United Kingdom	for his development of crystallographic electron microscopy and his structural elucidation of biologically important nucleic acid-protein complexes
1983	Henry Taube	United States	for his work on the mechanisms of electron transfer reactions, especially in metal complexes
1984	Robert Bruce Merrifield	United States	for his development of methodology for chemical synthesis on a solid matrix
1985	Herbert A. Hauptman	United States	for their outstanding achievements in developing direct methods for the determination of crystal structures
	Jerome Karle	United States	
1986	Dudley R. Herschbach	United States	for their contributions concerning the dynamics of chemical elementary processes
	Yuan T. Lee	United States Taiwan	
	John C. Polanyi	Canada Hungary	
1987	Donald J. Cram	United States	for their development and use of molecules with structure-specific interactions of high selectivity
	Jean-Marie Lehn	France	
	Charles J. Pedersen	United States	
1988	Johann Deisenhofer	West Germany	for their determination of the three-dimensional structure of a photosynthetic reaction centre
	Robert Huber	West Germany	
	Hartmut Michel	West Germany	
1989	Sidney Altman	Canada United States	for their discovery of catalytic properties of RNA
	Thomas Cech	United States	
1990	Elias James Corey	United States	for his development of the theory and methodology of organic synthesis
1991	Richard R. Ernst	Switzerland	for his contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy
1992	Rudolph A. Marcus	United States Canada	for his contributions to the theory of electron transfer reactions in chemical systems
1993	Kary B. Mullis	United States	for contributions to the developments of methods within DNA-based chemistry for his invention of the polymerase chain reaction (PCR) method
	Michael Smith	Canada	for contributions to the developments of methods within DNA-based chemistry for his fundamental contributions to the establishment of oligonucleotide-based, site-directed mutagenesis and its development for protein studies
1994	George A. Olah	United States Hungary	for his contribution to carbocation chemistry
1995	Paul J. Crutzen	Netherlands	for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone
	Mario J. Molina	Mexico	
	F. Sherwood Rowland	United States	
1996	Robert F. Curl Jr.	United States	for their discovery of fullerenes
	Sir Harold W. Kroto	United Kingdom	
	Richard E. Smalley	United States	
1997	Paul D. Boyer	United States	for their elucidation of the enzymatic mechanism underlying the synthesis of adenosine triphosphate (ATP)
	John E. Walker	United Kingdom	
	Jens C. Skou	Denmark	for the first discovery of an ion-transporting enzyme, Na ⁺ ,

			K ⁺ -ATPase
1998	Walter Kohn	United States	for his development of the density-functional theory
	John A. Pople	United Kingdom	for his development of computational methods in quantum chemistry
1999	Ahmed Zewail	Egypt	for his studies of the transition states of chemical reactions using femtosecond spectroscopy
2000	Alan J. Heeger	United States	for their discovery and development of conductive polymers
	Alan G. MacDiarmid	United States New Zealand	
	Hideki Shirakawa	Japan	
2001	William S. Knowles	United States	for their work on chirally catalysed hydrogenation reactions
	Ryōji Noyori	Japan	
	K. Barry Sharpless	United States	
2002	John B. Fenn	United States	for the development of methods for identification and structure analyses of biological macromolecules for their development of soft desorption ionisation methods for mass spectrometric analyses of biological macromolecules
	Koichi Tanaka	Japan	for the development of methods for identification and structure analyses of biological macromolecules for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution
	Kurt Wüthrich	Switzerland	
2003	Peter Agre	United States	for discoveries concerning channels in cell membranes for the discovery of water channels
	Roderick MacKinnon	United States	for discoveries concerning channels in cell membranes for structural and mechanistic studies of ion channels
2004	Aaron Ciechanover	Israel	for the discovery of ubiquitin-mediated protein degradation
	Avram Hershko	Israel	
	Irwin Rose	United States	
2005	Yves Chauvin	France	for the development of the metathesis method in organic synthesis
	Robert H. Grubbs	United States	
	Richard R. Schrock	United States	
2006	Roger D. Kornberg	United States	for his studies of the molecular basis of eukaryotic transcription
2007	Gerhard Ertl	Germany	for his studies of chemical processes on solid surfaces
2008	Osamu Shimomura	Japan	for the discovery and development of the green fluorescent protein, GFP
	Martin Chalfie	United States	
	Roger Y. Tsien	United States	
2009	Venkatraman Ramakrishnan	United States India United Kingdom	for studies of the structure and function of the ribosome
	Thomas A. Steitz	United States	
	Ada E. Yonath	Israel	
	Richard F. Heck	United States	
2010	Ei-ichi Negishi	Japan	for palladium-catalyzed cross couplings in organic synthesis
	Akira Suzuki	Japan	
	Dan Shechtman	Israel	
2012	Robert Lefkowitz	United States	for studies of G-protein-coupled receptors
	Brian Kobilka	United States	
2013	Martin Karplus	United States Austria	for the development of multiscale models for complex chemical systems
	Michael Levitt	United States United Kingdom Israel	
	Arieh Warshel	United States Israel	

2014	Eric Betzig	United States	for the development of super-resolved fluorescence microscopy
	Stefan W. Hell	Germany Romania	
	William E. Moerner	United States	
2015	Tomas Lindahl	Sweden United Kingdom	for mechanistic studies of DNA repair
	Paul L. Modrich	United States	
	Aziz Sancar	Turkey United States	

CONCLUSION

Chemistry is no doubt a vast subject which focuses on various molecules either inorganic or organic. These molecules are classified into laboratory chemicals, biomolecules, pharmaceuticals, warfare agents, domestic chemicals, industrial chemicals, cosmetics, dyes and so many ingredients. All the molecules are structurally frameworked from Mendeleev's periodic table elements which are again sub-classified into metals and non metals which joins with each other by catenation property by either electrovalent bond, coordinate bond and covalent bond by hybridization rule of s, p, d & f atomic orbital theory.



Chemistry is a playground of functional groups

Each and every element has its original chemical property which forms the compound having individual characteristics: Molecular Formula, Formula Weight, Composition (elemental percentage), Molar Refractivity, Molar Volume, Parachor, Index of Refraction, Surface Tension, Density, Dielectric Constant, Polarizability, Monoisotopic Mass, Nominal Mass and Average Mass. These individual chemicals react with other chemicals either *in-vivo* (inside the living system), *in-vitro* (outside the living system), *in-situ* (inside the reaction vessel) and *in-silico* (inside the computational software) to develop the new entity through the functional group attached with it which may of single step or multi step synthesis or biosynthesis. Playground means the domain where the chemicals react with each other which may be in-house (domestic sector) or out-house (overall sector).

Functional group means the active part in the molecule which takes part in extracurricular activities to focus on the chemical reactivity. Chemistry is a playground of functional groups focuses on this topic along with the Nobel Laureates who achieved the accolade of Nobel Prize in Chemistry (1901-2015) by playing games with chemical molecules.^[15]

REFERENCES

1. Ashish M. Parmar, Keyur D. Patel, Nilang S. Doshi, Girish M. Kapadiya, Bhavesh S. Patel and Dr. Dhrubo Jyoti Sen; Correlation approach between shotgun sequencing with DNA sequencing in molecular genomics: World Journal of Pharmacy and Pharmaceutical Sciences., 2014; 3(11): 963-995.
2. Hardik H. Chaudhary and Prof. Dr. Dhrubo Jyoti Sen; Isothermal titration calorimetry, confocal laser microscopy and atomic force microscopy in latest supramolecular ligand technology: World Journal of Pharmacy and Pharmaceutical Sciences., 2014; 3(8): 341-363.
3. Vikramkumar Vishnubhai Patel, Prof. (Dr.) Dhrubo Jyoti Sen and Prof. (Dr.) Satyanand Tyagi; Correlation between cheminformatics and bioinformatics in drug discovery: a farsight of pharmacy-the millennium oath: Journal of Drug Discovery and Therapeutics., 2013; 1(5): 47-54.
4. Parimal M Prajapati, Yatri Shah, D J Sen and C N Patel; Combinatorial chemistry: a new approach for drug discovery: Asian Journal of Research in Chemistry., 2010; 3(2): 249-254.
5. Priya R. Modiya, Palakben K. Parikh, Deepa R. Parmar, Dhrubo Jyoti Sen and Vidhi R. Patel; 10-15~Femto chemistry: New frontier exponent after nanochemistry: Asian Journal of Research in Chemistry., 2010; 3(4): 840-846.
6. Dr. Dhrubo Jyoti Sen; Esters, terpenes and flavours: make the mood cheers by three musketeers!: World Journal of Pharmaceutical Research., 20154; 4(8): 01-40.
7. Debojyoti Basu and Prof. Dr. Dhrubo Jyoti Sen; Organoleptic agents: adaptability, acceptability and palatability in formulations: World Journal of Pharmacy and Pharmaceutical Sciences., 2015; 4(10): 1573-1586.
8. Kartik R. Patel, Dr. Dhrubo Jyoti Sen and Viraj P. Jatakiya; Atom economy in drug synthesis is a playground of functional groups: American Journal of Advanced Drug Delivery., 2013; 1(1): 142-150.

9. Nadim M. R. Chhipa, Viraj P. Jatakiya, Piyush A. Gediya, Sachin M. Patel and Dhrubo Jyoti Sen; Green chemistry: an unique relationship between waste and recycling: International Journal of Advances in Pharmaceutical Research., 2013; 4(7): 2000-2008.
10. Hinal S. Mehta, Neha A. Bhatt and Prof. Dr. Dhrubo Jyoti Sen; Enteroclysis and computed tomographic enterography in medical imaging: European Journal of Pharmaceutical and Medical Research., 2015; 2(3): 691-705.
11. Girish M. Kapadiya, Ashish M. Parmar and Dr. Dhrubo Jyoti Sen; Western blotting: an unique technology for detection of proteins by antigen-antibody interaction: World Journal of Pharmacy and Pharmaceutical Sciences., 2014; 3(10): 1810-1824.
12. Dron P. Modi, Sunita Chaudhary, Ragin Shah and Dhrubo Jyoti Sen; Gold nano shells: the advancing nanotechnology to fight against cancer: British Biomedical Bulletin., 2013; 1(1): 023-034.
13. Ravi G. Patel and Dr. Dhrubo Jyoti Sen; Biodegradable polymers: An ecofriendly approach in newer millennium: Internationale Pharmaceutica Scientia., 2011; 1(3): 29-44.
14. https://en.wikipedia.org/wiki/List_of_Nobel_laureates_in_Chemistry
15. Dhrubo Jyoti Sen and Shruti Rai; Chemistry is a playground of functional groups: Lambert Academic Publishing GmbH & Co. KG, Germany., 2016; 1-373. (ISBN: 978-3-659-90892-7)