

7. New Synthetic Methods

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7.1 Introduction:

New synthetic chemistry refers to an innovative approach in chemical synthesis that offers novel strategies, reagents or reaction pathways for the construction of the targeted molecules.

This technique involves the utilization of unique catalysts, functional or activation modes to enable efficient and selective bond formation.

These methods hold significant role in advancing the field of chemical synthesis by providing chemist with powerful tools to asses a complex molecular structure in a more sustainable manner. The integration of fresh synthetic techniques in chemistry plays a crucial role in propelling the field forward and tackling diverse obstacles.

The method arises from inventive methodologies, unique reactants technologies. Here's the brief overall:

A. C-H Activation: Organic synthesis often involves functionalizing carbon-hydrogen bonds which are abundant in organic molecules.

B. Cross-Coupling Reactions: Cross-Coupling reaction involve the joining of two different organic molecules using transition metal catalysts.

C. Photo redox Catalysis: Photo redox catalysis employs visible light to initiate redox reaction, facilitating the construction of molecular complexity under mild conditions.

D. Flow Chemistry: Flow chemistry involves conducting chemical reaction in continuous -flow system s rather than in traditional batch reactor.

E. Bio Conjugation Techniques: bio conjugation methods enable the precise modification of biomolecules such as proteins and nucleic acids with synthetic entities.

F. Directed Evolution: This approach has revolutionized enzyme catalysis and synthetic biology, enabling the creation of biocatalysts for challenging chemical transformations

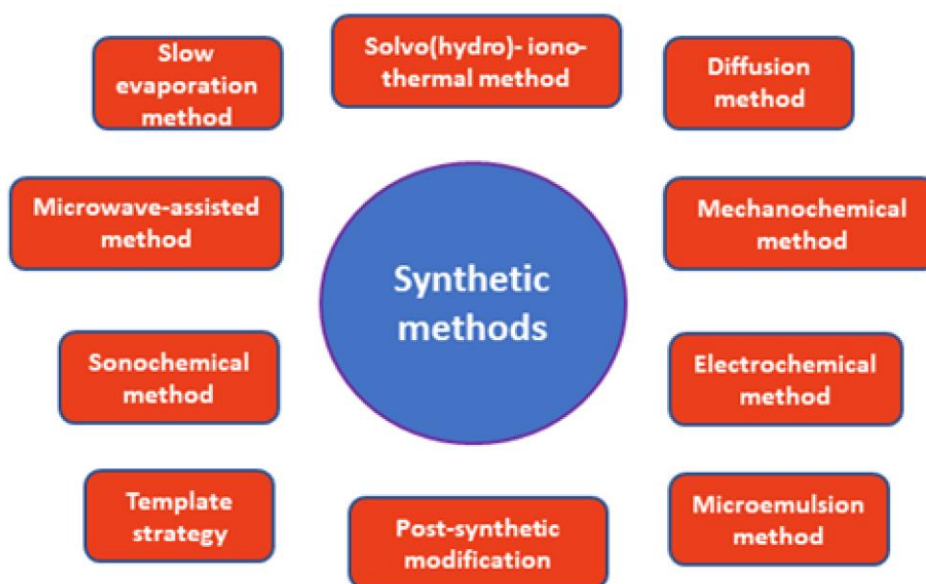


Figure 7.1: Synthetic Methods

7.2 Needs for The New Synthetic Method:

- A. New synthetic methods are needed due to various reasons, one of which is the quest for chemical processes that are both more efficient and sustainable.
- B. Need to address specific challenges such as selectivity, scalability and atom economy.
- C. Need for introducing novel synthetic approach can also enable the development of new material, pharmaceuticals and agrochemicals with improved properties and functionalities.

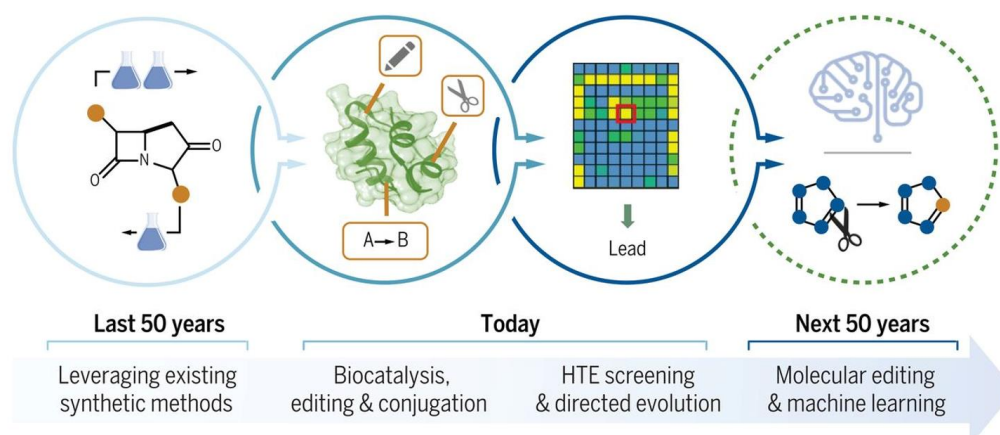


Figure 7.2: Evolution of Synthesis as A Driver of Innovation in Drug Discovery

7.3 Basic Component of Modern Synthetic Chemistry:

- A. Reactant:** These are the starting materials that undergo chemical transformation during a synthetic process. They can range simple molecule to the complex molecule.
- B. Reagent:** These are substance added to a reaction to facilitates or drive the desired chemical transformation. Reagents can include catalysts, solvent, acids, bases and other functional groups.
- C. Catalysts:** Catalysts are substance that accelerate chemical reaction by providing an alternative reaction pathway with lower activation energy.
- D. Reagent Condition:** These include factors such as temperature, pressure, and pH which influence rate and selectively of chemical reactions.
- E. Technique and Equipment:** Modern synthetic chemistry relies on a wide range of techniques and equipment for synthesis, purification and characterization of compounds.
- F. Computational Tools:** Computational chemistry plays an increasingly important role in modern synthetic chemistry, providing insights into reaction mechanisms, predicting the properties of new compound.
- G. Green Chemistry Principles:** With growing awareness of environmental sustainability, modern synthetic chemists also consider green chemistry principles to minimize waste, reduce hazardous substance, and improve the overall sustainability of chemical processes.

7.4 Importance of Synthetic Chemistry:

Synthetic chemistry holds immense importance across various fields for several reasons;

- A. Drug Discovery and Development:** Synthetic chemistry is crucial in the pharmaceutical industry for the synthesis of new drug candidates, allowing scientist to create molecules with desired biological activities and pharmacokinetics properties.
- B. Material Science:** Synthetic Chemistry plays avital role in crafting diverse material with customized characteristics suitable for use in electronics, energy storage. catalysis, coating and various other application.
- C. Agrochemicals and Crop Protection:** Synthetic chemistry aids in pesticides, herbicides and fertilizers, bolstering agriculture productivity and food security through effective pest, weed, and disease management while mitigating environmental harm.
- D. Fine Chemical and Specialty Product:** Synthetic chemistry is the instrumental in the production of a wide range of fine chemicals and specialty item, such as flavors, fragrance, dyes cosmetics etc.
- E. Biotechnology and Biomaterials:** Synthetic chemistry plays a critical role in biotechnology by synthesizing biomolecules like peptides, nucleotides and carbohydrates, which are integral in drug discovery, diagnostics and therapeutic uses.

F. Understand Natural Processes: Synthetic chemistry allows scientists to mimic and study natural processes, such as enzymes-catalyzed reaction and biosynthetic pathways. providing insights into biological system and enabling the synthesis of natural product with therapeutic potential.

7.5 Branches of Chemistry:

There is main 6 branches in chemistry, as they are represented in below flow chart;

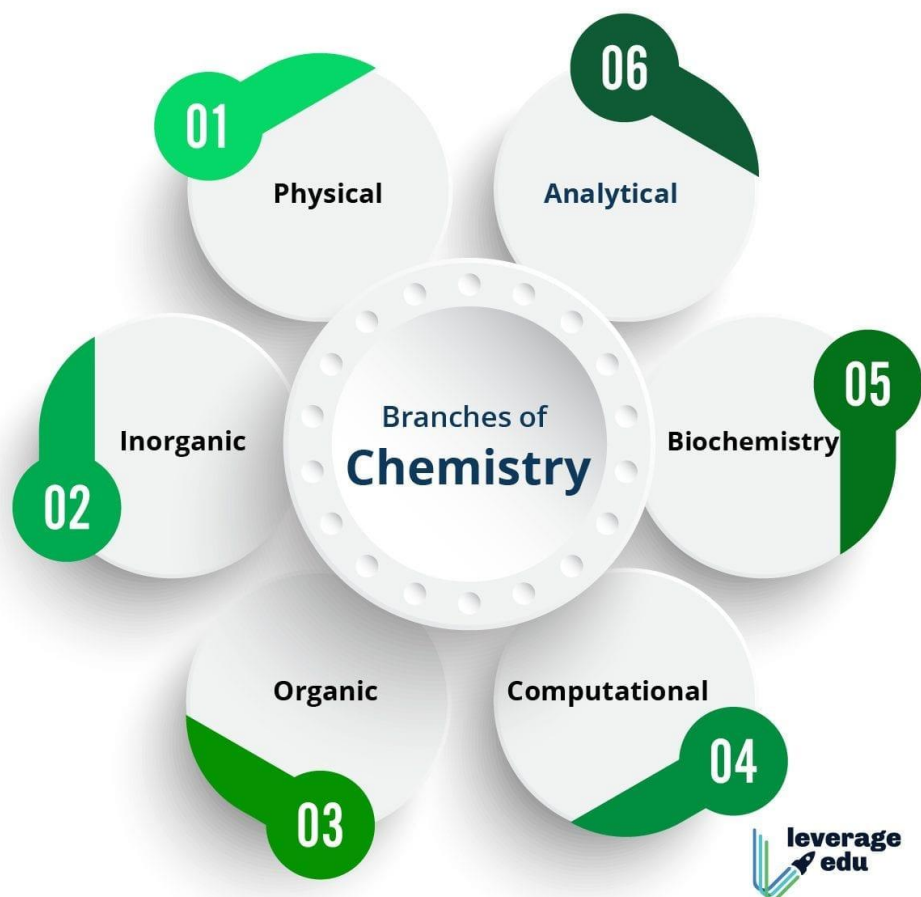


Figure 7.3: Branches of Chemistry

- A. Physical Chemistry
- B. Inorganic chemistry
- C. Organic chemistry
- D. Computational chemistry
- E. Biochemistry
- F. Analytical chemistry

7.5.1 Physical Chemistry:

Physical chemistry is a branch of chemistry that deals with the study of the physical principles and properties underlying chemical systems and processes. It seeks to understand the behavior of matter at the atomic and molecular levels through the application of principles from physics and mathematics. Here's a brief overview:

- **Thermodynamics:** Thermodynamics explores the relationships between heat, energy, and work in chemical systems. It encompasses concepts such as entropy, enthalpy, Gibbs free energy and phase transitions, providing insights into the spontaneity and equilibrium of chemical reactions.
- **Chemical Kinetics:** Chemical Kinetics examine the rate at which chemical reaction occur and the factors influencing reaction rates, such as temperature, concentration, and catalysts. It involves the study of reaction mechanism, reaction dynamics, and the interpretation of experimental data.
- **Quantum Chemistry:** Quantum chemistry applies quantum mechanism to understand the electronic structure and behavior of atoms and molecules. It involves solving the Schrodinger equation to calculate properties such as molecular orbitals, energy levels and spectroscopic transitions.
- **Statistical Mechanism:** Statistical mechanism bridges the microscopic behavior of individual practical with macroscopic properties of bulk matter.
- **Electrochemistry:** Electrochemistry studies the interconversion of chemical and electrical energy in redox reaction. It explores topics such as electrolysis, electrochemical cells, electrode kinetics, and application in barriers, corrosion prevention and electroplating.
- **Surface chemistry:** Surface chemistry focuses on the behavior of interface and surfaces, including adsorption, catalysis and surface reactions. It plays a crucial role in heterogeneous catalysis, materials science, and the design of functional materials.
- **Spectroscopy:** Spectroscopy involves the study of interaction of matter with electromagnetic radiation.
- **Chemical Thermodynamics:** Chemical thermodynamics applies thermodynamics principles to chemical systems, including phase equilibria, solution and reaction equilibria.

7.5.2 Inorganic Chemistry:

Inorganic chemistry is a branch of chemistry is a branch of chemistry that focuses on the study of inorganic compounds, which are substance that do not contain carbon-hydrogen (C-H) bonds. It encompasses wide range of chemical systems, including metals, minerals, coordination compounds, organometallic complexes and solid-state materials. Here's overall brief:

- **Coordination Chemistry:** Coordination chemistry deals with the structure, bonding and properties of coordination compounds, which consist of metal ions bound to ligand through coordinate covalent bond.
- **Organometallic Chemistry:** Organometallic chemistry studies compound containing metal-carbon bonds, known as organometallic complexes.
- **Bioinorganic Chemistry:** Bioinorganic chemistry examines the role of metal ions in biological system, including metalloproteinase, metalloenzymes, and metal ion transport.
- **Solid-State Chemistry:** Solid-State chemistry focuses on the synthesis, structure, and properties of solid materials, including metals, ceramics and semiconductors.
- **Descriptive Inorganic chemistry:** Descriptive inorganic chemistry catalogs and organizes the properties and reactions of inorganic compounds, providing a systematic overview of their chemical behavior.
- **Environmental Inorganic chemistry:** Environmental inorganic chemistry examines the behavior and fate of inorganic pollutants in natural and engineered systems. It investigates processes such as adsorption, precipitation, and redox reactions that affect the mobility and toxicity of inorganic contaminants.
- **Main group chemistry:** Main group chemistry encompasses the chemistry of elements in the s- and p-blocks of the periodic table, excluding transition metals. It investigates the synthesis, structure, and reactivity of main group compounds, including elements such as boron, silicon, nitrogen, and sulfur.

7.5.3 Organic Chemistry:

Organic chemistry is a branch of chemistry that focuses on the study of carbon-containing compound containing, which forms the basis of life and plays crucial roles in many aspects of science and industry. Here's the below overview;

- **Structure and bonding:** Organic chemistry investigates the structure and bonding of carbon compounds, including the various types of bonds formed by carbon, as well as the geometry and stereochemistry of molecules.
- **Functional Groups:** Organic molecules often contain specific functional groups, such as alcohols, aldehydes, ketones, carboxylic acids and amines.
- **Reaction and mechanism:** Organic chemistry studies the chemical reactions that organic molecules undergo, including mechanisms that describe the step-by-step processes by which these reactions occur.
- **Synthesis:** Organic synthesis involves the design and execution of chemical reactions to prepare target molecules from simpler starting materials.
- **Natural Product Chemistry:** Natural products chemistry focuses on the study of compounds derived from living organisms, such as plants, animals, and microorganisms.

- **Medicinal chemistry:** Medicinal chemistry involves the design, synthesis, and optimization of chemical compounds for use as pharmaceutical drugs. It combines principles from organic chemistry, biochemistry, and pharmacology to develop new therapeutic agents and improve existing drugs.
- **Polymer chemistry:** Polymer chemistry studies the synthesis, structure, and properties of polymers, which are large molecules composed of repeating units.
- **Spectroscopy and Spectrometer:** Organic chemistry utilizes various spectroscopic techniques, such as infrared spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, and mass spectrometry, to analyze the structure and composition of organic compounds
- **Physical Organic Chemistry:** Physical organic chemistry investigates the relationship between the structure and reactivity of organic molecules, using principles from both organic and physical chemistry to understand reaction mechanisms, kinetics, and thermodynamics.

7.5.4 Computational Chemistry:

Computational chemistry is a branch of chemistry that utilizes computer simulations and theoretical methods to understand chemical systems, predict molecular properties, and simulate chemical processes. Here's a brief overview:

- **Molecular Modeling:** Computational chemistry involves the use of mathematical models and algorithms to simulate the behavior and properties of molecules at the atomic and molecular levels.
- **Quantum Chemistry:** Quantum chemistry is a fundamental aspect of computational chemistry that applies quantum mechanical principles to study the electronic structure, energetics, and properties of molecules.
- **Molecular Dynamics:** Quantum chemistry is a fundamental aspect of computational chemistry that applies quantum mechanical principles to study the electronic structure, energetics, and properties of molecule.

7.5.5 Biochemistry:

Biochemistry is a multidisciplinary field that explores the chemical processes and molecules that occur within living organisms. It combines principles from biology, chemistry and physics to understand the molecular basis of life. Here's the brief about it;

- **Macromolecules:** Biochemistry studies the structure, function, and interactions of biological macromolecules, including proteins, nucleic acids, carbohydrates, and lipids.
- **Enzymes and Metabolism:** Enzymes are biological catalysts that facilitate biochemical reactions by lowering the activation energy.

- **Gene Expression and Regulation:** Biochemistry examines the molecular mechanisms underlying gene expression, including transcription, translation, and post-translational modifications.
- **Cellular signaling:** Cellular signaling involves communication between cells through signaling molecules, receptors, and signal transduction pathways.
- **Bioenergetics:** Bioenergetics studies the flow of energy in biological systems, including the conversion of energy from nutrients into cellular energy currency (e.g., ATP) through processes such as glycolysis, oxidative phosphorylation, and photosynthesis.
- **Medicinal Biochemistry:** Medical biochemistry applies biochemical principles to understand the molecular basis of human health and disease.

7.5.6 Analytical Chemistry:

Analytical Chemistry is a branch of chemistry that focuses on the qualitative and quantitative analysis of chemical compounds and their properties.

- It involves the development and application of techniques and methods to identify, separate and quantify substances in various samples.
- Analytical chemistry works across diverse fields such as environmental monitoring, pharmaceutical, forensics, food and beverage industry and material science. Key aspects of analytical chemistry include sample preparation, instrumental.
- Analysis, data interpretation, and method validation. This field plays a crucial role in ensuring the safety, quality, and efficacy of products, as well as in advancing scientific research and innovation.