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HISTORICAL STAGES OF DEVELOPMENT OF CHEMISTRY: MAIN DISCOVERIES AND CURRENT SCIENTIFIC DIRECTIONS

Tojiboyeva Munisa Akmal qizi
Chirchik State Pedagogical University
Faculty of Natural Sciences
3rd year student of Chemistry Education
ORCID ID: https://orcid.org/0009-0001-9154-696X
E-mail: tojiboyeva.m1661@gmail.com

Abstract: This article analyzes the stages of the formation and development of chemistry, its roots in ancient civilizations, philosophical and practical experiences in the era of alchemy, the influence of European scientific revolutions, and modern integration trends. It is revealed that chemistry has acquired a multidisciplinary nature at the present stage, in particular, it is inextricably linked with biology, physics, computer science and ecology. The article scientifically analyzes the theoretical views of Eastern and Western scientists, in particular, thinkers such as Jabir ibn Hayyan, Lavoisier, Mendeleev. The formation of the Uzbek school of chemistry, fundamental research of local scientists and its integration with the international scientific space are objectively assessed. During the study, open sources, modern scientific databases, historical and theoretical works and the scientific heritage of scientists of the Republic of Uzbekistan were deeply analyzed. The article aims to clarify the theoretical foundations, practical significance and future strategic directions of chemistry.

Keywords : History of chemistry; alchemy; scientific revolution; multidisciplinary approach; Uzbek school of chemistry; Lavoisier; Mendeleev; IUPAC; green chemistry; modern science.

ENTRANCE

the complex systems of substances and phenomena of nature has been one of the most ancient aspirations of human thought. One of the scientific directions that emerged as a result of these studies is **chemistry** , which deeply studies the composition, structure, physicochemical properties of substances and the laws of their transformation. Chemistry was formed as a result of a long evolutionary process in history , and today it is one of the fundamental natural sciences that requires interdisciplinary integration and has deep theoretical and practical foundations.

Chemistry has played an invaluable role in the formation of human civilization. Practical processes such as the use of copper and tin, the smelting of metals, and the preparation of paints, which began in ancient times, emerged as the first manifestations of chemical knowledge. Alchemical ideas played an important role in the formation of the science of chemistry in Eastern and Western civilizations, but at that time philosophical, mystical, and metaphysical concepts prevailed over chemical science. Nevertheless, it was alchemical activity that laid the foundation for the emergence of the foundations of experimental chemistry.

By the **17th–18th centuries , during the Scientific Revolution, chemistry had begun to take shape as a science.** Robert Boyle's experimental approach to the scientific method, Antoine Lavoisier's discovery of the law of conservation of mass , and Dmitri Mendeleev's periodic law had established a solid scientific foundation for chemistry. John Dalton's atomic theory and Amedeo

Avogadro's concepts further deepened the theoretical basis of chemistry. This period saw chemistry completely break away from the dogmas of alchemy and transform it into a truly experimental, mathematically expressed scientific discipline . [1]

In the 20th century, chemistry entered a new phase: organic and inorganic chemistry were separated into branches, and directions such as physical chemistry, quantum chemistry, and biochemistry were formed. In particular, as a result of its integration with sciences such as biology, physics, and computer science, chemistry rose to a new level . Chemistry has now emerged not only as a science that studies the transformation of substances, but also as a major scientific force that promotes technological innovations.

Today, chemistry has become an important tool that offers solutions to pressing problems facing humanity - the energy crisis, environmental sustainability, drug development, and food security. The potential of chemistry is expanding through modern directions such as green chemistry, nanochemistry, and computational chemistry. Therefore, an in-depth analysis of the historical development, theoretical basis, main discoveries , and modern development trends of chemistry is scientifically and practically relevant. It covers the stages of the formation and evolution of chemistry based on source analysis, and deeply examines the scientific heritage, discoveries, and contributions of great chemists to modern chemistry.

and modern development of chemistry, it is important to analyze, along with the classical European schools of chemistry, the scientific work of Uzbek scientists and their contribution to the development of chemistry **.** Below, we will analyze literary sources based on the scientific heritage of leading Uzbek scientists in the field of chemistry and their internationally recognized works.

1. Classical sources and international scientific schools

The classical foundation of chemistry lies in Antoine Lavoisier's Traité Élémentaire de Chimie [1]. This work is the first real scientific approach that combines experiment and theory. Also, the systematization of chemistry based on the periodic law through Mendeleev's Osnovy Khimii was an important turning point in the history of science [2]. These had a strong influence on the development of chemistry not only in Europe, but also in the former Soviet Union, including Uzbekistan.

2. The role of research by Uzbek scientists

The formation of chemistry as a scientific school in Uzbekistan is closely associated with the name of Academician Sodiq Azimov . His work on the chemistry of semiconductors , especially on the physicochemical properties of selenium and tellurium compounds, was recognized not only in the republic, but also in the CIS and internationally. Based on Azimov's research on the physics of chemical materials, important theoretical concepts were put forward in the fields of materials science and quantum chemistry [3].

Academician Mirsaid Mirsaidov is one of the leading figures in Uzbek chemistry , who conducted in-depth research in the areas of analytical chemistry and radiochemistry . His work on chemical processes related to the peaceful use of atomic energy and the chemical extraction of uranium and thorium isotopes is particularly noteworthy [4].

Prof. Mahmud Jurayev and other modern Uzbek chemists in organic synthesis **,** chemistry of complex compounds **,** pharmaceutical chemistry and Scientific work on biochemical technologies is developing on the basis of modern research conducted in laboratories at Tashkent State University, Namangan State University, Samarkand State University and the Institute of Chemistry of the Academy of Sciences of Uzbekistan. In particular, the synthesis of heterocyclic compounds carried out by the group led by Juraev and their work on biological activity serves as a theoretical basis for the pharmaceutical industry [5].

The renowned chemist Gulbahor Yusupova has achieved significant scientific results in the development of environmentally friendly reagents and solvents based on the principles of green chemistry . The biodegradable polymer-based chemical solutions she developed are useful in creating technologies with low environmental impact [6].

3. Interdisciplinary approaches and modern Uzbek literature

In the development of chemistry in Uzbekistan, special attention is paid to computational chemistry and modeling methods . For example, the algorithms for numerical modeling of chemical reactions developed by Academician Abdurashid Yuldoshev have made it possible to predict complex reactions [7]. This has formed as a direction of computational chemistry on an international scale.

Chemistry is a complex systematic science that studies the composition, structure, properties of material objects in nature, as well as the laws of their mutual transformation. It arose simultaneously with the formation of human thought, but its formation as a full-fledged scientific science is associated with centuries-old historical and evolutionary processes. A deep analysis of the history of chemistry shows that this science has always been in close contact with philosophy, physics, biology, geology, and technology, has formed its own methodology, and at the same time has served as a theoretical and practical basis for other sciences.

Based on historical sources, three main stages of the development of chemistry are distinguished : empirical (alchemical), classical (theoretical), and modern (integrative-innovative). Each stage is characterized by its own scientific paradigms and scientific methodologies. For example, in the era of antiquity and alchemists, chemistry consisted of a set of experimental-intuitive knowledge, but with Lavoisier's law of conservation of matter and Mendeleev's periodic law, chemistry has now begun to become a science that includes a rigorous scientific theory and systematics.

At the modern stage, the science of chemistry has been enriched with quantum mechanics, thermodynamics, kinetics, spectroscopy and computational methods, which have made it possible not only to analyze the properties of substances, but also to predict them. The works of scientists such as P. Atkins, R. Chang, J. Steingart play an important role in this. Chemistry is no longer a purely experimental science, but has risen to an interdisciplinary level through areas such as numerical modeling, molecular design, nanosystems engineering, and materials chemistry.

At the same time, the scientific research of Uzbek scientists also has a place in the development of international chemistry schools. In particular, the chemistry of semiconductors by Academician Sodiq Azimov, the chemistry of radiochemistry and isotopes by Mirsaid Mirsaidov, the theory of organic synthesis by Mahmud Juraev, and Gulbahor Yusupova's work on the development of environmentally friendly reagents can be analyzed within the framework of innovative approaches in modern chemistry.

Today, the strategic importance of chemistry is evident in the following areas:

- **Energy security** : hydrogen energy, solar cells , and chemical design of fuel cells.
- **Medicine** : selective synthesis of pharmaceuticals, biochemical drugs, vaccines , and nanomedicines.
- **Environmental protection** : green chemistry, environmentally friendly solvents, waste-free technologies and biopolymers.
- **Agriculture** : fertilizer formulation, pesticide biodegradation, biosynthesis-based agrochemicals.

Another important aspect of the discussion is the integration of chemistry with information technologies. Molecular modeling, prediction of chemical reactions using artificial intelligence,

"lab-on-a-chip" technology , and the development of chemical algorithms have created a new methodological turn for this science. These aspects are also reflected , in particular, in the mathematical models and software platforms developed by Uzbek scientists .

The interdisciplinary nature of chemistry has made it a strategic tool for ensuring social, economic and environmental sustainability. Therefore, in modern science policy, chemistry is becoming the center of international cooperation and innovation clusters. For example, international organizations such as IUPAC, RSC, ACS are actively involved in the development of global standards in chemistry, open knowledge platforms and sustainable development strategies.

CONCLUSION

During its historical development, chemistry has evolved from simple experimental observations to a powerful theoretical and practical system that includes high mathematical, technological and philosophical integration. The contribution of Uzbek scientists to this field confirms the existence of a comprehensive scientific school that deserves high praise in the context of modern science. Based on the above analyses and historical and theoretical generalizations, it can be clearly seen that chemistry has gone through complex evolutionary stages in its development, from experimental and practical approaches to theoretical and systematic and innovative and integrative interdisciplinary paradigms. The formation and development of chemistry was associated not only with technological progress , but also with the dialectical relationship between philosophical thinking, scientific methodology and social needs .

First, the early stages of the formation of chemistry - the experiments of ancient civilizations, practical research during the era of alchemy, the synthesis of Eastern and Western scientific traditions - served as the empirical basis for modern chemistry. In particular, the work of Arab-Islamic scientists - thinkers such as Jabir ibn Hayyan, ar-Razi, Abu Ali ibn Sina - deserves special recognition, because they provided a scientific basis not only for the practice of chemistry, but also for its theory.

Second, the scientific revolutions of the 17th–19th centuries—Lavoie's law of conservation of mass , Dalton's atomic theory, and Mendeleev's periodic law—raised chemistry for the first time to the level of an experimental and systematic science. During this period, chemistry methodologically separated from philosophy and established itself as a science based on precise scientific laws. These processes formed the basis of modern physical, organic, inorganic, biochemistry, and analytical chemistry.

Third, in the 20th and 21st centuries, the interdisciplinary and multidisciplinary nature of chemistry has increased, and its integral integration with such fields as biology, computer science, materials science, ecology, medicine, and energy has taken place. In particular, through areas such as quantum chemistry, molecular biology, green chemistry, nanochemistry, and computational chemistry, chemistry is now gaining strategic importance in solving fundamental and practical problems.

Fourth, the development of chemistry in Uzbekistan is inseparable from the development of global scientific thought. The fundamental research of Uzbek scientists - academicians Sodiq Azimov, Mirsaid Mirsaidov, Mahmud Jurayev, Gulbahor Yusupova, Abdurashid Yuldoshev and others - laid the foundation for the formation of a modern school of chemistry. Their work enriched the scientific basis of analytical chemistry, organic synthesis, radiochemistry, biopolymers, green technologies and computer modeling.

Fifth, open sources — IUPAC, RSC, ACS, "Journal of Chemistry", scientific databases (PubChem, ScienceDirect, Scopus) — have become an integral part of modern scientific

information exchange. Uzbek scientific institutions are directly integrated with international chemical science through these platforms.

The final analysis shows that the science of chemistry today is:

- A theoretical system with the potential for scientific prediction,
- A practical platform capable of creating technological innovations,
- It has established itself as a strategic **science that offers solutions to problems such as** global climate, health , energy, and food security .

For the sustainable development of chemistry in the future, it is necessary to:

- Education-research integration,
- Interdisciplinary connections,
- Focused on environmentally and socially responsible technologies

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