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WHAT IS THE CHEMISTRY OF TOMORROW LIKE: AN ANALYSIS OF PERCEPTIONS AMONG STUDENTS

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As we delved into the study of chemistry, we became interested in its various branches. Indeed, 21st-century chemistry is no longer merely a “test-tube science.” Today, it has evolved into an intricate network where digital technologies intersect with quantum physics, and inspiration is drawn from the mechanisms of DNA. It encompasses not only the substances themselves but also the processes they undergo. We explored several branches of chemistry and developed a special interest in a few of them. We are especially drawn to interdisciplinary fields emerging at the intersection of chemistry, physics, biology, and ecology.

The aim of this study is to examine four modern branches − green chemistry, cosmochemistry, bioinorganic chemistry, and geochemistry − and to assess the level of awareness and preferences among students. The objectives are: 1) to provide a brief overview of each field; 2) to conduct a survey; 3) to compare what respondents consider important for humanity versus what they find personally interesting.

Upon reviewing the literature, we learned that “green chemistry” did not emerge as a chance discovery, but rather as a logical response from the scientific community to the ecological crisis that had been building toward the end of the 20th century [1]. Its development was driven by the realization that merely cleaning up the environment after pollutants are released is no longer sufficient. A fundamentally new approach was required: preventing pollution at the design stage of chemical processes. To this end, green chemistry advocates for pollution prevention at the synthesis stage itself, rather than relying on subsequent waste treatment [3]. Some of its key objectives include [3]:

- minimization of waste generation;
- atom economy;
- use of less hazardous substances;
- design of safer chemical products;
- use of safer solvents and reaction conditions.

Thus, “green chemistry” is a branch of chemistry focused on the design of processes and products that minimize negative impacts on the environment. It is a concept that emphasizes the thoughtful selection of raw materials and process pathways to exclude the use of hazardous substances [1].

We were also intrigued by what lies beyond our planet and therefore decided to explore cosmochemistry. We began with the definition of this field: cosmochemistry (or chemical cosmology) is the branch of chemistry that studies the chemical composition of matter in the Universe and the processes that have shaped this composition [9].

The history of cosmochemistry is particularly fascinating, with roots tracing back to the 17^{th}-18th centuries, when astronomers first began to ponder the nature of celestial bodies. However, the true birth of this science became possible only thanks to the development of two key methods: spectral analysis and the study of meteorites.

An important historical nuance: for a long time, scientists − including Lavoisier − denied the extraterrestrial origin of meteorites, considering them ordinary terrestrial rocks struck by lightning. The turning point came in 1803 following the meteorite shower in L'Aigle, France. Physicist Jean-Baptiste Biot demonstrated that their composition differed significantly from Earthly rocks − thus, humanity had its first “taste” of cosmochemistry [8]. Only after this discovery did the objectives of cosmochemistry take shape: studying isotopic ratios, investigating chemical differentiation in asteroids and planets, and examining organic matter of cosmic origin [8]. We were particularly surprised to learn that it was Cosmo chemists who modeled the composition of Martian dust and detected traces of aromatic compounds in it − specifically benzaldehyde (with its characteristic almond scent) and vanillin [7]. Of course, one could not breathe this atmosphere, but hypothetically, the aroma of the Red Planet would be sweetly bitter, reminiscent of a perfumer's workshop.

Geochemistry is fascinating because it examines the chemical composition of both planet Earth and the cosmos. The term “geochemistry” itself emerged long before space exploration began; it was first introduced in 1838 by the Swiss chemist Christian Friedrich Schönbein [4]. The foundation for the emergence of geochemistry was laid by discoveries made in the second half of the 19th century: spectral analysis (developed by R. Bunsen and G. Kirchhoff in 1859) and D. I. Mendeleev's Periodic Law of chemical elements (1869) [4]. Spectral analysis significantly expanded the possibilities for studying the chemical composition of Earth and the cosmos, including rare and trace elements. V. I. Vernadsky is regarded as the founder of geochemistry in Russia. He formulated the fundamental aims and objectives of the science, contributed to the systematization of mineral compositions, and advanced concepts of isomorphism [4]. In summary, geochemistry is the science concerned with the chemical composition of Earth and other planets, the laws governing the distribution and migration of elements and isotopes across various geological environments, and the processes involved in the formation of rocks, soils, and natural waters [4].

Upon reviewing the literature, we identified the most significant objectives of this field: studying the chemical composition of Earth and its spheres; investigating the processes of element migration and concentration; and analyzing geochemical barriers and matter fluxes [7]. These objectives − ranging from examining the composition of Earth's spheres to analyzing geochemical barriers − are inherently interconnected. Addressing them enables us to predict the locations of ore deposits, assess environmental pollution, and even reconstruct the climate of past geological eras [4].

Bioinorganic chemistry attracted our interest not only because of its name but also due to the presence of biology within it. Initially, we assumed that these two fields were scarcely related.

Bioinorganic chemistry (also known as inorganic biochemistry) is a branch of chemical science that studies, at the molecular level, the role of metals and their compounds in biological processes [5].

This field emerged in the second half of the 20th century at the intersection of biology and inorganic chemistry. Research in bioinorganic chemistry is closely linked to biochemistry, molecular biology, enzymology, organic and physical chemistry, coordination chemistry, pharmacology, medicine, and other scientific disciplines.

The key objectives of bioinorganic chemistry include [5]:

studying the role of metals and their compounds in living organisms and in the environment;

- investigating the reactivity of metals and their compounds toward biological substrates;
- modeling the structure of enzymes and enzyme-mediated processes, including biomimetic catalysis;
- development of pharmaceutical agents;
- design of biomaterials.

What particularly impressed us is that bioinorganic chemistry provides answers to everyday questions. Why is spinach considered healthy? It contains abundant iron, yet its absorption is limited due to the presence of oxalic acid. Why shouldn't milk be consumed together with oysters? Calcium from milk and zinc from oysters compete for the same transporter proteins [6]. And the well-known vitamin B_{12} − the only vitamin that contains a metal (cobalt) − is essential for maintaining the myelin sheath of nerves; without it, this protective layer deteriorates [10].

It turns out that our nervous system literally depends on “inorganic” components. hus, bioinorganic chemistry challenges the stereotype that “living matter” consists solely of organic compounds. Metals are not merely impurities but active participants in respiration, nerve impulse transmission, and enzyme function. Without them, life as we know it would be impossible [5].

We have come to understand that 21st-century chemistry is erasing the boundaries between traditional disciplines. Today, developing a new pharmaceutical requires an understanding of the physics of metals, while addressing environmental challenges demands insights into the mechanisms of living systems. The four fields we have discussed − green chemistry, cosmochemistry, bioinorganic chemistry, and geochemistry − do not simply exist in parallel. Rather, they intertwine, giving rise to technologies at their intersections that would have seemed like science fiction just two decades ago. It appears that the most remarkable discoveries await us precisely where these boundaries dissolve completely.

To assess interest in various branches of chemistry, we conducted a survey among school students, undergraduates from Kuzbass State Technical University (Institute of Continuing Education and bachelor's programs), and students from a medical university. We aimed to determine how popular geochemistry and other specialized fields are compared to those we initially considered most engaging.

Figure 1, which displays the distribution of responses to the question about preferred branches of chemistry, revealed a pronounced disparity in awareness of chemical disciplines. An absolute majority of respondents (64.2 %) were uncertain and selected the option “I don't know.” Among informed preferences, organic chemistry and green chemistry ranked highest (10.0 %), followed by biochemistry paired with organic chemistry (8.0 %), and molecular chemistry paired with analytical chemistry (7.0 %). The least interest (ranging from 1 % to 5 %) was shown toward fields such as analytical chemistry, geochemistry, marine chemistry, aquatic chemistry, and nanomaterials chemistry.

Thus, more than two-thirds of the respondents lack clear preferences regarding chemical disciplines. This finding is particularly noteworthy given that the survey included students from technical and medical fields—disciplines for which chemistry is a core subject.

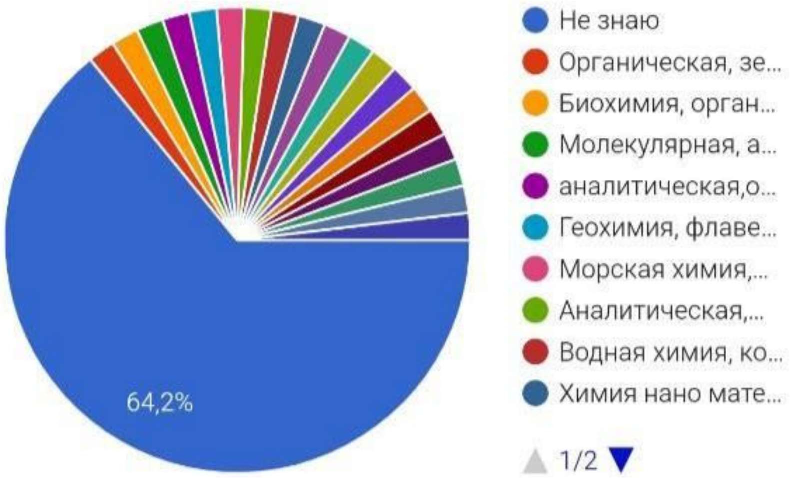

Figure 1. Distribution of responses to the question about preferred branches of chemistry

After assessing the overall level of interest in various branches of chemistry, we proceeded to more specific questions. We aimed to determine how familiar a broader audience is with modern interdisciplinary fields such as “Green Chemistry” and “Cosmochemistry”, and which of these directions’ respondents consider most important and personally interesting. Based on the data obtained, we compiled Table 1.

Table 1. Summary of survey results by question

Question	Answer options	Percentage of respondents%
1. Have you heard of “Green Chemistry”?	Yes / No / I don't know	13,2 % / 41,5 % / 45,3 %
2. Have you heard of “Cosmochemistry”?	Yes / No / I don't know	45,3 % / 39,6 % 15,1 %
3. Chemistry can study the composition of distant planets?	Yes / No / I don't know	78 % / 0 % / 22 %
4. The most important direction for the future	1. green chemistry 2. coal coking chemistry	54,7 % 20,8 %

	3. bioinorganic chemistry	22,6 %
5. The most interesting for personal study	1. green chemistry 2. coal coking chemistry 3. bioinorganic chemistry	32,1 % 49,1 % 15,1 %
6. Would you like more lectures on interdisciplinary fields?	Yes / No / I have no preference	41,5 % / 22,6 % 35,8 %

Thus, we have confirmed that 21st-century chemistry is not merely a collection of isolated disciplines, but rather a complex network of knowledge where the boundaries between physics, biology, ecology, and even astronomy are increasingly blurred. Studying such interdisciplinary fields not only broadens one's perspective but also helps us understand how science addresses real-world challenges − from environmental conservation to space exploration.

References:

1. Yale University Library. Green Chemistry for Climate and Sustainability: Websites [Электронный ресурс] // Yale Library Research Guides. – URL: https://guides.library.yale.edu/green-chemistry-certificate/on-the-web (дата обращения: 12.03.2026).
2. Великородов, А. В. Зеленая химия. Методы, реагенты и инновационные технологии : монография / А. В. Великородов, А. Г. Тырков. – Астрахань : Сорокин Р. В., 2016. – 260 с. [Электронный ресурс]. – URL: http://cat.gpntb.ru/index.php?id=EC/ShowFull&irbDb=ESVODT&bid=10060c71bc8f240e278d572888978c62 (дата обращения: 12.03.2026).
3. GeoScienceWorld (GSW) [Электронный ресурс] // Зональная научная библиотека Южного федерального университета. – URL: https://library.lib.sfedu.ru/news/313/ (дата обращения: 12.03.2026).
4. Бертини, И. Биологическая неорганическая химия: структура и реакционная способность : в 2 т. Т. 1 / И. Бертини, Г. Грей, Э. Стифель, Дж. Валентине. – Москва : Лаборатория знаний, 2021. – 506 с. [Электронный ресурс]. – URL: https://books.mipt.ru/book/301651 (дата обращения: 10.03.2026).
5. IntechOpen. Bioinorganic Chemistry [Электронный ресурс] // IntechOpen. – URL: https://www.intechopen.com/subjects/489 (дата обращения: 22.03.2026).
6. Wörner, G. GEOROC 2.0: A Globally Connected Geochemical Database to Facilitate Interdisciplinary, Data-Driven Research / G. Wörner, M. Klöcking, A. Sturm [et al.] [Электронный ресурс] // EGU General Assembly 2024. – Vienna, 2024. – URL: https://publications.goettingen-research-online.de/ID-149206 (дата обращения: 22.03.2026).
7. OUCI. Cosmochemistry Publications [Электронный ресурс] // OUCI. – URL: https://ouci.dntb.gov.ua/en/?backlinks_to=10.1016%2F0016-7037%2880%2990259-8 (дата обращения: 10.03.2026).
8. Российская академия наук. Космохимия [Электронный ресурс] //

Российская академия наук : официальный сайт. – URL: https://new.ras.ru/search/?q=космохимия (дата обращения: 12.03.2026).

9. Библиотека МПГУ. Бионеорганическая химия [Электронный ресурс] // Электронный каталог МПГУ. – URL: https://ecat.mpgu.info/Opac/app/webroot/index.php?url=/matieres/view/5656/source:default (дата обращения: 13.03.2026)