

Interdisciplinary Research in Iran VII: The Convergence of Biology and Artificial Intelligence

In previous editorials, we emphasized the critical role of interdisciplinary research in addressing complex scientific challenges,^[1] with a focus on bioinformatics,^[2] image processing,^[3] and medical signal analysis.^[4,5] In this issue, we turn our attention to systems biology, as a convergence of biology, data science, advanced technologies, and artificial intelligence. Our aim is to highlight its transformative potential for advancing the future of medical research and precision medicine.

Reductionism is a concept related to reducing and simplifying the complex behavior of phenomena into their fundamental components and principles.^[6] Isaac Newton and René Descartes, along with many other notable scientists, agreed to the idea that we could explain the behavior of the whole system by studying its individual parts and components. The remarkable growth of biomedical knowledge in recent centuries has been largely based on such approach.^[7,8] However, it is now well understood that biological systems would only be best inspected using a more holistic approach, which is incompatible with the reductionist point of view.^[9] Biological systems are composed of interconnected components that not only link to each other, but also interact and communicate, and it is the nature and extent of these interactions that ultimately define the properties and functions of that system. A more holistic perspective is therefore required to help us define and recognize biological systems as a unified entity.^[10] Systems biology is often seen in opposition to reductionist approaches because it is based on the idea that a whole system is greater than just the sum of its individual parts. Hence, the behavior of a system cannot be fully understood or predicted by examining the individual components in isolation. It instead focuses on the complex interactions between these components to gain a more comprehensive understanding of the system as a whole.^[11]

Modern systems biology can be considered as a combined and holistic study of biological systems based on analysis of very large data sets by complex mathematical models, computational methods, and bioinformatics and artificial intelligence tools. This interdisciplinary approach could lead to significant discoveries in various industries such as food, pharmaceutical, and biotechnology sections.^[12,13] It also results in a major shift in the way we view biology and subsequently in medicine and healthcare systems, towards enabling personalized (precision) medicine in the near future.^[14] Indeed, artificial intelligence will not revolutionize biomedical sciences without the adoption of a holistic approach known as systems biology. This approach integrates complex biological data to provide a comprehensive understanding of biological systems. As a

result of the interdisciplinary nature of this field, various subfields have been defined, each with its own specific focus. A brief overview of the most important subfields of systems biology is presented in Table 1.

In recent years, the growth of medical research has been accompanied by two important factors. The first is the ability to rapidly and inexpensively produce large volumes of health-related big data, including the omics revolution and other types of relevant big data. The second is the knowledge and capability to analyze such big data using a wide spectrum of statistical methods, mathematical algorithms, and artificial intelligence software. The convergence of these two aspects, together with the systems biology approaches in biology, has led to a transformation of the theoretical and practical frameworks of biomedical sciences, to the extent that some consider it the latest paradigm shift in biomedical sciences.^[15-17]

Despite the progress made in systems biology, there are still several challenges that researchers must overcome to achieve better results in the near future. One of the biggest challenges is the need for further research to develop new and innovative methods that can better capture the complex interactions that occur within biological systems. To this end, researchers must develop new technical methods, particularly in the field of network topology, network dynamics, biological functions, etc.^[18-20] Moreover, data quality and standardization are prerequisites of systems biology research.^[21,22] Since systems approaches rely heavily on data, mostly as public databases, data validation is crucial to ensure that the information being used is accurate and reliable. Sensitive tools and hardware are also required to generate high-resolution dynamic data, such as quantifying the concentrations of various molecules in space and time.^[23] The overall aim of this editorial is to argue that while systems biology has made significant progress in recent years, there are still numerous challenges that must be addressed.

This issue contains a paper titled “Roadmap for a Systems Biology Initiative in Iran” which reports a roadmap to improve systems biology in Iran.^[24] Although this roadmap is developed for Iran but may provide implications for other countries as well. In this spirit, we are pleased to announce that starting from the next issue Journal of *Medical Signals* and Sensors will be hosting a new section dedicated to the latest findings in the field of “Biomedical Informatics and Artificial Intelligence.” Authors are welcome to submit their research papers and we believe this will provide a platform for researchers to share their new discoveries and insights. We hope that our future publications will be a valuable resource for the

Table 1: A brief overview of the most important subfields of systems biology

Discipline	Short description
Systems medicine	Looks at the systems of the human body as part of an integrated whole, incorporating biochemical, physiological, and environmental interactions. The final aim is a measurable improvement of patient health through systems-based approaches and practices. ^[25-28]
Systems biomedicine	Understanding and modulation of developmental and pathological processes in humans, animals and cellular models. ^[29]
Systems pharmacology	Aims to view the human body as a complex system and understand how drugs interact within this system. Rather than focusing on individual drug-protein interactions, it considers the collective network of interactions to better comprehend the drug's impact. ^[30-32]
Systems genetics	Used to study common complex traits and diseases. It analyzes intermediate molecular phenotypes, such as transcript, protein, or metabolite levels, to connect DNA variation with the traits being studied. This approach is frequently combined with genome-wide association studies to identify the genes responsible for the traits and their associated functions. ^[33]
Cancer systems biology	Used for various purposes, including identifying predictive biomarkers of tumor response to drugs using a systems-based approach that integrates genomic data with medical records, gaining insight into the molecular mechanisms that govern cancer progression and metastasis through the construction of networks and computational models, and aiding in the selection of anti-cancer drugs and optimizing treatment strategies. ^[34]
Systems immunology	It seeks to understand the signaling pathways that are critical for the proper functioning of the immune system, with a focus on the involved cells and molecules. ^[35-37]
Systems microbiology	Employed to develop a comprehensive model of how microbial cells or communities function. This can provide valuable insights into how these organisms can be harnessed for a variety of purposes, including biotechnology, agriculture, and medicine. Such approach has the potential to yield a range of applications, from better management of bacterial infections to the commercial-scale generation of hydrogen by microorganisms. ^[38]
Systems virology	Aims to achieve a comprehensive understanding of viral infection by examining the dynamic interplay between the virus and its host. It encompasses a broad range of topics related to viruses and viral diseases, with the goal of advancing our understanding of viral pathogenesis and improving the diagnosis and treatment of viral infections. ^[39,40]
Systems psychology	It views both individuals and groups as systems in a state of homeostasis, or balance, and seeks to understand how various factors interact to shape behavior and cognition. It can provide a more holistic understanding of human behavior, potentially leading to more effective psychological interventions and therapies. ^[41-43]
Systems physiology	It can be thought of as an extension of systems biology, with a focus on the functional aspects of biological systems. By examining the complex interactions and feedback mechanisms that underlie physiological processes, systems physiology can provide valuable insights into how living organisms maintain homeostasis, respond to environmental cues, and adapt to changing conditions ^[44]

scientific community and inspire further research in the field of systems biology and bioinformatics.

Financial support and sponsorship

This work was partly supported by Isfahan University of Medical Sciences, Isfahan, Iran (62994).

Conflicts of interest

There are no conflicts of interest.

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Submitted: 26-Oct-2024

Revised: 10-Nov-2024

Accepted: 16-Nov-2024

Published: 01-Sep-2025

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Access this article online	
Quick Response Code:	Website: www.jmssjournal.net
	DOI: 10.4103/jmss.jmss_68_24

How to cite this article: Ani A, Vaez A. Interdisciplinary research in Iran VII: The convergence of biology and artificial intelligence. *J Med Signals Sens* 2025;15:25.