STANDING SIDE BY SIDE: THE INSEPARABLE UNITY OF BASIC SCIENCES WITH BASIC MEDICAL SCIENCES

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Standing Side by Side: The Inseparable Unity of Basic Sciences with Basic Medical Sciences

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Abstract

Our research seeks to highlight the important role of interdisciplinary collaboration between basic sciences and medical sciences. Using a Scientometric approach, we meticulously analyzed the 50 thousand most cited scientific research articles in both basic science and medical basic science. These analyzes are based on a comprehensive data set containing the top 50,000 scientific articles with the highest citation rates on Web of Science, all categorized as articles. Using advanced social network analysis techniques, we identified the important roles of nodes within the network and applied advanced data visualization methodologies to explain complex interdisciplinary relationships. Our findings illuminate a rich landscape of collaboration between basic science and medical basic science; It sheds light on findings that demonstrate close integration with the health sciences and have a profound impact on a variety of fields from oncology, exemplified by the deep connections observed in fields such as biochemistry and molecular biology to neurology. Moreover, our study finds that elucidating genetics and genetic diseases is an important nexus where basic science meets health sciences, enabling groundbreaking advances in the diagnosis and treatment of inherited diseases. Moreover, the synergy between biotechnology and mathematical biology is poised to catalyze innovations in systems biology and personalized medicine. In this regard, our research underlines the indispensable nature of interdisciplinary collaboration between basic and medical sciences to advance the frontiers of medical research and healthcare delivery. These collaborative efforts serve as catalysts in translating scientific discoveries into concrete healthcare solutions, thus promoting the development of more effective strategies for diagnosis, treatment, and disease prevention.

Keywords

Basic Sciences, Medical Basic Sciences, Collaboration Patterns, Scholarly Communication, Bibliometrics

Introduction

In his study, Starr (2013) examined in detail the great advances made in the fields of basic sciences such as mathematics, astronomy, medicine, chemistry and physics in Central Asia from the 8th century to the 14th century and stated that the important scientific centers and e-educational institutions in Central Asia were from different cultures (Starr, 2013). It states that it brings together scientists and encourages the exchange of information and has become the center of scientific research. Emphasizing that the blending of Islamic, Persian, Turkish and Indian cultures accelerated the spread and development of scientific knowledge, Starr said that names such as Al-Khwarizmi, Ibn Sina and Biruni, who were among the important scientists of this period, made groundbreaking studies in the fields of algebra, medicine and astronomy, and modern scientific knowledge was established. states that they laid the foundations of the methods. The scientific methodology developed in Central Asia took great steps in putting theoretical knowledge into practice by adopting an approach based on observations and experiments, and later inspired the scientific revolutions of the Renaissance and Enlightenment periods in Europe. He states that the knowledge produced in Central Asia was influential not only in the Islamic world, but also in other parts of Europe and Asia, and that the studies carried out in this period are considered an important legacy in the development of basic sciences today. In the Islamic world, significant progress was made in science and technology during a period when convergence occurred between the fundamental sciences and other disciplines. During this process, fundamental sciences such as mathematics and astronomy developed in close relationship with applied sciences like geography, navigation, and optics. For instance, mathematical calculations and astronomical observations played a crucial role in navigation and the development of geographical maps. Similarly, the science of optics combined with geometric principles enabled the creation of more complex optical instruments. The interaction between these scientific fields allowed Islamic scholars to establish a comprehensive and integrated system of knowledge (Sezgin, 2018). Basic sciences cover a wide range of subjects such as physics, chemistry, biology and mathematics. These sciences aim to investigate the basic principles, concepts and methodologies for understanding the natural world. Basic medical sciences focus on the basic knowledge required for medical practice and research, such as anatomy, physiology, biochemistry and pharmacology. The unity between these two fields is vital in several respects. Basic sciences help us understand the biological, chemical and physical mechanisms of medical science by providing information about the fundamental processes occurring in the human body. It also contributes to sustained healing by guiding medical researchers in the development of treatments and interventions. Basic medical sciences also use the principles of basic science to advance medical knowledge and practice. Researchers and healthcare professionals use discoveries and innovations in basic science to provide diagnostic tools, treatments, and medical advances. The inseparability of these fields is evident in the way they complement each other; Discoveries in one field often lead to breakthroughs in another. We found it necessary to conduct a data-based analysis to closely understand this relationship between scientific fields that have been in such a relationship since the early times of history.

Mathematics is the language of basic sciences. Mathematical models, theories, and calculations play a critical role in scientific research. Galileo's statement that "Nature is written in the language of mathematics" also emphasized the importance of mathematics in basic sciences (Galilei & Drake, 1990; Stillman, 1957). Mathematics provides the abstract structures and concepts necessary for theoretical physics and chemistry. For example, differential equations, probability theory, and linear algebra are basic tools used in modeling physical and chemical processes. Physics studies the fundamental laws and principles of nature. Fields such as mechanics, thermodynamics, electromagnetism and quantum mechanics form the basis of other branches of science such as chemistry and biology. Richard Feynman's statement "Physics is the basic science that is the basis of other sciences" also underlines the importance of this subject (Feynman, 1967). Physics is directly related to experimental methods and observations, just like chemistry and biology. It commonly plays a critical role in testing and validating theories. Chemistry deals with the composition, structure, properties and transformations of substances. This knowledge is essential for understanding processes in disciplines such as biology and materials science. Linus Pauling stated the importance of chemistry by saying, "Chemistry is the key to understanding biology and other natural sciences." (Hager & Hager, 2000). Chemistry provides the basis for other branches of science through the study of molecular structures and reaction mechanisms.

Convergence of Basic Sciences and Basic Health Sciences

Convergence between basic sciences (mathematics, physics, chemistry) and basic health sciences is possible if advances in the field of health are based on the principles of basic sciences. The interaction between these disciplines has played a critical role in diagnosis, treatment and disease management. When we look closely at this interaction, the provision, standardization and use of numerical values in clinical processes play a vital role in diagnosis and treatment processes. For example, accurately measuring and standardizing vital values such as blood pressure, pulse, and body temperature are critical in diagnosing and monitoring diseases (Pescatello et al., 2004). Calibration is necessary to ensure measuring devices provide accurate results (Greg Miller et al., 2011). Morphometric analysis, imaging methods (ultrasound, MRI, X-ray, CT) and interpretation of these images are of great importance in health sciences in terms of the data value of measurements. These technologies are important in that they enable the detection of anatomical and pathological changes (Bushberg et al., 2011). Applications such as remote consultation and robotic surgery improve healthcare using information technologies and artificial intelligence (Kwoh et al., 1988). It is used to monitor vital values such as EEG, EMG, ECG, pulse, pressure and blood pressure measurements, evaluate body functions and diagnose diseases (Teplan, 2002). These measurements enable patients' conditions to be monitored instantly and necessary interventions to be made in a timely manner (Izzo et al., 2008). Analysis of blood, urine and other body fluids is another issue of great importance in the diagnosis and treatment processes. Biochemistry, microbiology and molecular biology enable the detection of biological and chemical components in these fluids (Rifai, 2017). These analyzes are used to diagnose a variety of conditions such as infections, metabolic disorders and genetic diseases (Miller & Slovis, 2007). Radiology is used to image the internal structures of the body and detect diseases (Skundberg, 1998). Biochemistry investigates the causes and treatments of diseases by examining body chemistry and metabolic processes (Berg et al., 2015). Microbiology is used to identify microorganisms and determine the factors that cause diseases (Tortora et al., 1989). Molecular biology and genetics are critical for understanding diseases at the molecular level and developing treatment methods. Genetic analyzes identify genetic predispositions to diseases and enable personalized medicine practices (Alberts et al., 2014). Ecology studies the effects of environmental factors on human health. The body's metabolic activities interact with environmental factors, and monitoring these interactions is important in assessing health status (Odum

& Barrett, 1971) (Odum & Barrett, 2005). Hemostasis encompasses the biological processes that enable the body to maintain its internal balance. Monitoring these processes is important in managing bleeding disorders, clotting problems, and other related conditions (Hoffbrand et al., 2016). The nervous system analyzes the information coming from the body's internal and external receptors and allows the body to respond with this information. Information technologies and artificial intelligence contribute significantly to a better understanding of these processes and the development of treatment methods. For example, it is possible to identify and treat diseases by analyzing EEG and MRI data in the diagnosis of neurological disorders (Fisch & Spehlmann, 1999). In this context, the convergence between basic sciences and basic health sciences enables the development of modern medicine and the improvement of health services. While mathematics, physics and chemistry form the basis of measurement and analysis methods used in health sciences, the interdisciplinary collaboration is critical for more accurate diagnosis of diseases, development of treatment methods and increasing the overall quality of health services.

Our study aims to highlight the importance of collaboration and synergy between basic sciences and basic medical sciences by encouraging researchers, educators, and students to recognize and embrace the unity of these disciplines. It is critical for both fields to advance through joint efforts. In this context, in our study, we analyzed the 50 most frequently cited scientific research documents in the fields of basic sciences and medical basic sciences from a scientometric perspective. We performed cluster analysis, and the relationships between areas of scientific activity were visualized with a chord diagram. Interdisciplinary connections between various scientific fields are incredibly valuable for understanding complex and multifaceted topics, as these clusters demonstrate. Such connections create a collaborative environment where experts from different fields can address challenging problems by combining their knowledge, methodology, and insights. These collaborations often lead to groundbreaking discoveries, innovative solutions, and a more holistic view of the subject. In the context of the intersection between basic sciences and basic medical sciences, interdisciplinary connections may be particularly useful. It allows researchers to bridge the gap between basic scientific principles and practical applications in the medical field.

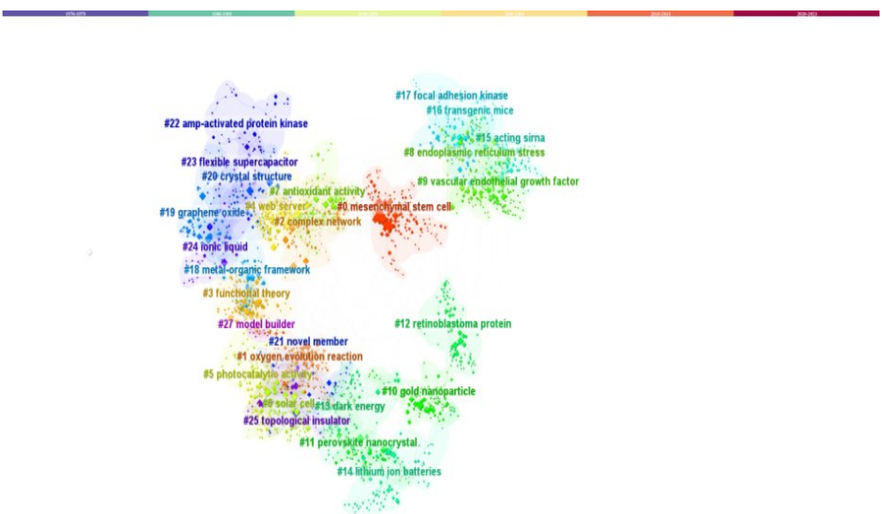
Our study aims to encourage researchers, educators, and students to recognize and embrace the unity of these disciplines by emphasizing the importance of cooperation and synergy between these two fields of scientific activity; It is critical for the advancement of both basic sciences and basic medical sciences through joint efforts. In this context, in our study, the 50 most frequently cited scientific research documents in the fields of basic sciences and medical basic sciences were analyzed from a scientometric perspective. Clustering analysis was carried out and the relationships between scientific activity areas were visualized with a chord diagram.

Cluster Analysis

Interdisciplinary connections among various scientific areas, as demonstrated by these clusters, are incredibly valuable for advancing our understanding of complex and multifaceted topics. Such connections foster a collaborative environment where experts from different fields can combine their knowledge, methodologies, and insights to address challenging problems. These collaborations often lead to groundbreaking discoveries, innovative solutions, and a more holistic perspective on the subject matter. In the context of the intersection between basic sciences and medical basic sciences, interdisciplinary connections can be particularly beneficial. They allow researchers to bridge the gap between fundamental scientific principles and their practical applications in the medical field (Figure 1).

Figure 1.

Major Clusters on the intersection of basic sciences between medical basic sciences



For example, the study of mesenchymal stem cells in Cluster 0 may have implications for regenerative medicine and tissue engineering, potentially leading to new treatments for various medical conditions. Furthermore, interdisciplinary connections promote cross-pollination of ideas, which can lead to the development of new research paradigms and the emergence of entirely new fields of study. In this age of rapidly advancing scientific knowledge, the ability to collaborate across disciplines is essential for tackling complex global challenges, such as healthcare, sustainability, and technology (Table 1).

Table 1.
Major Clusters

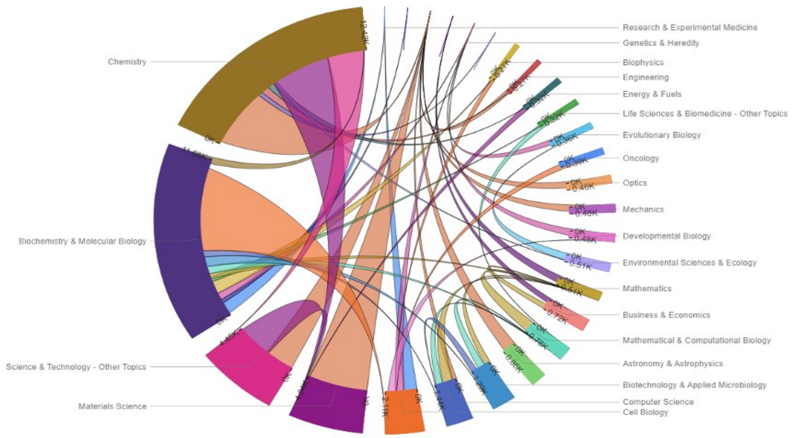
ClusterID	Size	Silhouette	Label (LLR)	Average Year
0	142	0.925	mesenchymal stem cell (62369.32, 1.0E-4)	1995
1	128	0.926	oxygen evolution reaction (20053.77, 1.0E-4)	2005
2	119	0.883	complex network (40258.84, 1.0E-4)	2007
3	118	0.942	functional theory (102156.16, 1.0E-4)	1992
4	116	0.888	web server (76543.49, 1.0E-4)	1997
5	98	0.879	photocatalytic activity (29492.65, 1.0E-4)	1999
6	98	0.861	solar cell (219814.75, 1.0E-4)	1999
7	96	0.898	antioxidant activity (115248.42, 1.0E-4)	1995
8	91	0.839	endoplasmic reticulum stress (22417.1, 1.0E-4)	1995
9	90	0.882	vascular endothelial growth factor (13128.83, 1.0E-4)	1992
10	86	0.862	gold nanoparticle (58295.91, 1.0E-4)	1999
11	85	0.868	perovskite nanocrystal (55852.69, 1.0E-4)	1998
12	81	0.916	retinoblastoma protein (18946.63, 1.0E-4)	1994
13	81	0.916	dark energy (41370.62, 1.0E-4)	1994
14	80	0.929	lithium ion batteries (22249.39, 1.0E-4)	2007
15	76	0.9	acting sirna (15744.19, 1.0E-4)	1996
16	68	0.919	transgenic mice (22514.15, 1.0E-4)	1993
17	60	0.885	focal adhesion kinase (21429.71, 1.0E-4)	1993
18	60	0.914	metal-organic framework (64099.98, 1.0E-4)	2003
19	58	0.861	graphene oxide (117374.06, 1.0E-4)	1997
20	57	0.914	crystal structure (80179.16, 1.0E-4)	1998
21	46	0.974	novel member (10512.55, 1.0E-4)	1989
22	43	0.908	amp-activated protein kinase (10376.6, 1.0E-4)	1992
23	33	0.935	flexible supercapacitor (9048.64, 1.0E-4)	2003
24	33	0.929	ionic liquid (45502.64, 1.0E-4)	2003
25	25	0.972	topological insulator (18143.62, 1.0E-4)	1994
27	10	0.997	model builder (391.59, 1.0E-4)	2010

Based on the data in the table, it seems that collaboration between basic sciences and basic sciences in the field of health is quite diverse and widespread. Biochemistry and molecular biology are especially closely associated with health sciences. While this discipline investigates the fundamentals of biological processes at the molecular level, it collaborates with other fields such as cell biology and biophysics to understand how these fundamental processes operate at the cellular level. These collaborations are important as they have a huge impact on many healthcare fields, from cancer research to neurological diseases and genetic disease research. Moreover, understanding genetics and genetic diseases can be called an important intersection of basic sciences and health sciences. Genetic research provides the basis for investigating the causes of genetic diseases and the potential to develop gene therapies. This has the potential to lead to major advances in the diagnosis and treatment of hereditary diseases. On the other hand, collaboration between biotechnology and applied microbiology, as well as mathematical and computational biology, is important in using genetics to analyze big data and mathematically model biological systems. This can be positioned among the important scientific developments that support the development of systems biology and personalized medicine. In conclusion, the data in the table show that collaboration between basic sciences and basic sciences in the field of health plays a fundamental role in the development of medical research and health care. In this regard, it can be said that the identified cooperation allows the transformation of scientific discoveries into health applications and will contribute to the development of more effective diagnosis, treatment, and disease prevention strategies.

All Degree is an indicator representing the number of connections within a network of a discipline. Higher All Degree values indicate more collaboration opportunities (Savanur & Srikanth, 2010; Wang et al., 2014). For example, "Biochemistry & Molecular Biology" and "Mathematics" have high All Degree values, suggesting that these disciplines are likely to collaborate frequently with Mathematics. Betweenness Centrality is used to identify key nodes in a network that facilitate communication between other disciplines. In this context, high Betweenness Centrality values indicate a discipline's potential to act as a bridge between other disciplines (Acedo et al., 2006; Goldman, 2014; Kong et al., 2019).

Collaboration Patterns Between Basic Sciences and Medical Basic Sciences

Figure 1.
Collaboration patterns among scientific research areas



Therefore, the high Betweenness Centrality value between "Physics" and "Ophthalmology" suggests a high potential for these two disciplines to bridge the gap between the health field and physics. High Aggregate Constraints indicate factors that limit a discipline's potential to collaborate with other disciplines (Ahuja, 2000; Burt, 2018; Lin et al., 2021). For instance, the high Aggregate Constraints between "Biochemistry & Molecular Biology" and "Acoustics" suggest limited collaboration potential between these two disciplines. Low Aggregate Constraints point to factors that do not limit, or even suggest a higher potential for, collaboration between disciplines. For example, the low Aggregate Constraints between "Neurosciences & Neurology" and "Psychiatry" indicate a high potential for collaboration between these two health-related disciplines (Table 2).

Table 2.
Social Network Analysis Parameters

All Degree	Betweenness centrality	High Aggregate constraints	Low Aggregate constraints
Biochemistry & Molecular Biology	Biochemistry & Molecular Biology	Mathematics	Acoustics
Chemistry	Chemistry	Behavioral Sciences	Parasitology
Cell Biology	Mathematics	Environmental Sciences & Ecology	Orthopedics
Mathematics	Cell Biology	Marine & Freshwater Biology	Microscopy
Physics	Life Sciences & Biomedicine - Other Topics	Geology	Ophthalmology
Science & Technology - Other Topics	Physics	Toxicology	Substance Abuse
Life Sciences & Biomedicine - Other Topics	Science & Technology - Other Topics	Zoology	Infectious Diseases
Biotechnology & Applied Microbiology	Environmental Sciences & Ecology	Computer Science	Astronomy & Astrophysics
Engineering	Mathematical & Computational Biology	Remote Sensing	Obstetrics & Gynecology
Materials Science	Research & Experimental Medicine	Biochemistry & Molecular Biology	Fisheries
Mathematical & Computational Biology	Computer Science	Mathematical & Computational Biology	Entomology
Computer Science	Biotechnology & Applied Microbiology	Veterinary Sciences	Pathology
Environmental Sciences & Ecology	Engineering	Instruments & Instrumentation	Psychiatry
Research & Experimental Medicine	Genetics & Heredity	Geography	Nutrition & Dietetics
Genetics & Heredity	Geology	Automation & Control Systems	Psychology
Biophysics	Materials Science	Science & Technology - Other Topics	Food Science & Technology
Developmental Biology	Evolutionary Biology	Radiology, Nuclear Medicine & Medical Imaging	Sociology
Evolutionary Biology	Developmental Biology	Imaging Science & Photographic Technology	Oceanography
Science & Technology - Other Topics	Immunology	Meteorology & Atmospheric Sciences	Mathematical Methods in Social Sciences
Geology	Agriculture	Biotechnology & Applied Microbiology	Business & Economics
Physiology	Marine & Freshwater Biology	Evolutionary Biology	Reproductive Biology
Immunology	Reproductive Biology	General & Internal Medicine	Agriculture
Oncology	Science & Technology - Other Topics	Engineering	Neurosciences & Neurology
Instruments & Instrumentation	Psychology	Life Sciences & Biomedicine - Other Topics	Paleontology
Marine & Freshwater Biology	Physiology	Pharmacology & Pharmacy	Biodiversity & Conservation

Discussion

The results presented in this study and the analysis of interdisciplinary connections among various scientific areas highlight the immense value of fostering collaborations between different fields. These interdisciplinary connections are incredibly valuable for advancing our understanding of complex and multifaceted topics, especially within the intersection of basic sciences and basic medical sciences (Council et al., 2010). Such connections foster a collaborative environment where experts from different fields can combine their knowledge, methodologies, and insights to address challenging problems (Boon et al., 2019; Saez-Rodriguez et al., 2016). These collaborations often lead to groundbreaking discoveries, innovative solutions, and a more holistic perspective on the subject matter. For instance, the close association between biochemistry and molecular biology with health sciences indicates significant collaboration opportunities that can impact many healthcare fields, from cancer research to neurological and genetic disease studies. The integration of mathematical and computational biology with biotechnology and applied microbiology further exemplifies how interdisciplinary approaches can enhance the analysis of big data and the mathematical modeling of biological systems, thereby supporting the development of systems biology and personalized medicine. In particular, the study of mesenchymal stem cells, as highlighted in Cluster 0, illustrates the potential implications for regenerative medicine and tissue engineering. Such interdisciplinary research can lead to new treatments for various medical conditions, showcasing the practical applications of basic scientific principles in the medical field. Moreover, interdisciplinary connections promote the cross-pollination of ideas, leading to the development of new research paradigms and the emergence of entirely new fields of study (Council et al., 2010; Madni, 2007; Richards, 2022; Saez-Rodriguez et al., 2016). This cross-disciplinary fertilization is crucial in the current age of rapidly advancing scientific knowledge, where tackling complex global challenges—such as healthcare, sustainability, and technological innovation—requires a collaborative and integrative approach. These insights underscore the critical need for ongoing interdisciplinary collaboration, highlighting how integrating basic sciences with health sciences is essential for advancing medical research and improving healthcare outcomes. The identified collaboration not only facilitates the transformation of scientific discoveries into health applications but also contributes to the development of more effective diagnosis, treatment, and disease prevention strategies (Cummings & Kiesler, 2005; Giansanti, 2024).

When evaluating the collaboration models between basic sciences and basic medical sciences, considering metrics such as All Degree, Betweenness Centrality, and Aggregate Constraints, it is evident that these two scientific research fields form an inseparable unity. These metrics help us understand the potential and limitations of collaboration between disciplines (Bright et al., 2017; Madni, 2007; Richards, 2022). For instance, the high All Degree values of "Biochemistry & Molecular Biology" and "Mathematics" indicate that these disciplines are likely to collaborate frequently. Mathematics plays a critical role in modeling and analyzing biochemical processes. Similarly, the high All Degree value for the "Physics" discipline suggests that it can establish strong collaborations with medical sciences; for example, physics knowledge is fundamental in fields such as medical imaging techniques. In our study, Betweenness Centrality was used to determine the potential for disciplines to act as bridges between each other (Bright et al., 2017; Jones et al., 2021; Ni et al., 2011). A high Betweenness Centrality value is significant for "Physics" and "Ophthalmology" as it indicates their potential to bridge the gap between health sciences and physics. The application of physical principles in the development of ophthalmologic imaging and optical devices is an example of how these two disciplines can effectively collaborate. Similarly, other disciplines with high Betweenness Centrality values can form critical bridges between health sciences and basic sciences, promoting multidisciplinary research projects and innovation. Aggregate Constraints are used to identify factors that either limit or encourage collaboration potential between disciplines. For example, the high aggregate constraints between "Biochemistry & Molecular Biology" and "Acoustics" suggest limited collaboration potential between these two disciplines. This may be due to methodological and theoretical differences between them. On the other hand, the low aggregate constraints between "Neurosciences & Neurology" and "Psychiatry" indicate a high potential for collaboration between these disciplines. Neurosciences and neurology play a critical role in understanding the biological foundations of psychiatric disorders, and research in these disciplines can provide significant theoretical and practical benefits.

In conclusion, the collaboration models between basic sciences and basic medical sciences vary according to their potential to act as bridges and their collaboration potential. Disciplines with high All Degree values and low aggregate constraints generally have higher collaboration potential. Additionally, disciplines with high Betweenness Centrality values play a crucial role in facilitating inter-disciplinary communication and collaboration. Such analyses play an important role in guiding research strategies and policy-making processes. The inseparable unity of basic sciences and basic medical sciences will continue to promote scientific progress and innovation.

Starr's detailed examination of advances in basic science in Central Asia from the 8th to the 14th centuries reveals how the convergence of different cultures and the establishment of major scientific centers fostered an environment conducive to scientific collaboration and innovation. This historical perspective highlights several important points that are highly relevant to the results of our current study of collaboration between basic sciences and basic medical sciences. It is possible to collect them under several headings

Cultural and Disciplinary Rapprochement:

Starr underlines how the blending of Islamic, Persian, Turkish and Indian cultures accelerated the spread and development of scientific knowledge. This convergence of different cultures has enabled the formation of a melting pot of ideas and methodologies, like how interdisciplinary collaborations in modern times combine knowledge from various scientific fields. Our study similarly demonstrates that interdisciplinary connections between basic sciences and health sciences can be used as a crucial lever to advance medical research and healthcare. Just as historical collaborations led to groundbreaking advances in fields such as algebra, medicine, and astronomy, contemporary interdisciplinary efforts have the potential to lead to innovations in medical diagnosis, treatment, and disease prevention.

Impact of Key Figures and Collaborative Efforts:

As Starr notes, the contributions of key scholars such as Al-Khwarizmi, Ibn Sina, and Biruni demonstrate the importance of key individuals in driving scientific progress through collaborative efforts. These figures worked at the intersection of multiple disciplines and laid the foundations of modern scientific methods. The high potential for collaboration between fields such as biochemistry, molecular biology, and health sciences in our study reflects the ongoing need for influential researchers to bridge gaps between disciplines. This collaboration is also vital for translating basic scientific discoveries into practical medical applications.

Methodological Developments:

While Starr emphasizes the methodological innovations developed in Central Asia, especially the adoption of observational and experimental approaches, he points out that this methodology contributed significantly to the practical application of theoretical knowledge, inspiring subsequent scientific revolutions in Europe. Our work similarly highlights how interdisciplinary collaborations between biotechnology, applied microbiology, mathematics, and computational biology are essential to advancing fields such as systems biology and personalized medicine. These collaborations are important in facilitating the development and application of complex models and large-scale data analysis in medical research.

Legacy and Global Impact:

Starr states that the scientific knowledge produced in Central Asia had a profound impact not only in the Islamic world, but also in Europe and Asia. This exchange of historical knowledge occurs in parallel with the global impact of contemporary scientific collaborations. Our study shows that interdisciplinary connections between basic sciences and health sciences can lead to significant advances in healthcare worldwide, reinforcing the idea that scientific progress is a collective, global effort. In the context of scholarly communication, the historical advancements in Central Asia, as highlighted by Starr, demonstrate the critical importance of effective information exchange and collaboration across diverse cultures and disciplines. The scientific achievements of this era were facilitated by vibrant scholarly networks that transcended geographical and cultural boundaries, promoting the free flow of knowledge and ideas. Similarly, our study underscores the necessity of robust interdisciplinary communication in the modern scientific landscape. Effective scholarly communication enables researchers from basic sciences and health sciences to share methodologies, data, and insights, fostering an environment where collaborative efforts can thrive and lead to significant medical and scientific breakthroughs. This exchange is essential for driving innovation and ensuring that scientific discoveries are translated into practical applications that benefit society.

Today, the important contributions of this convergence include digital health services, data security, fast and qualified service delivery, and archiving methods. Here are some current contributions on this subject. They have made a significant contribution to the digitalization of healthcare services. Electronic health records (EHR) and digital patient files increase the efficiency and accuracy of healthcare services and facilitate data sharing in the digital storage, processing and analysis of patient data B These digital systems provide quick access to patients' past health information and enable better management of treatment processes (Adler-Milstein & Jha, 2017). Storing health data digitally raises data security and privacy issues. Advanced encryption methods and security protocols are used to protect health information and prevent unauthorized access (Kruse et al., 2017). Blockchain technology is also used to securely store and share health data (Agbo et al., 2019). Technological advances provided by basic sciences contribute to accelerating diagnosis and treatment processes. Artificial intelligence and machine learning algorithms are used in early diagnosis of diseases and creation of treatment plans by analyzing large data sets (Topol, 2019). For example, artificial intelligence-supported analyzes in imaging techniques help radiologists make faster and more accurate diagnoses. (Litjens et al., 2017). Telemedicine increases access to healthcare by enabling patients to receive healthcare services remotely. These applications make it possible to treat patients in their homes through video conferences, mobile health applications and remote monitoring devices. (Dorsey & Topol, 2020). Telemedicine provides great convenience and benefit, especially for patients living in rural and remote areas. Long-term storage and management of health data is provided by digital archiving systems. These systems ensure that patient data is stored securely and accessed quickly when needed (Borycki & Kushniruk, 2022). Cloud-based solutions offer flexible and scalable platforms for storing and processing large data sets (Fernández-Alemán et al., 2013) (Fernández-Alemán et al., 2013).

The convergence between basic sciences and medical basic sciences has spurred digital transformation processes in recent years. To better understand the impact of these developments on the field, we examined digital technologies and digital transformation across various academic disciplines in Web of Science. The dataset presents a rich collection of 62,040 scientific documents compiled from 11,269 different sources spanning from 1900 to 2024. These documents examine the digitization between fundamental sciences (such as physics, chemistry, biology, mathematics, computer science, astronomy, geology, engineering, statistics, ecology) and medical basic sciences (like anatomy, physiology, biochemistry, molecular biology, genetics, pharmacology, microbiology, pathology, immunology, neuroscience). The dataset exhibits a continuous expansion with an annual growth rate of 6.58%, and on average, each document is 9.24 years old. There are on average 49.47 citations per document and a total of 2,219,409 references. The content includes 76,877 unique Keywords Plus (ID) and 119,228 unique Author's Keywords (DE). In this dataset encompassing 210,805 different authors, 6,086 documents are authored by a single author.

On average, each document is authored by 5.23 co-authors, with 25.21% of these collaborations being international. This dataset can be regarded as a rich academic resource covering extensive collaboration and diverse topics.

Table 3.

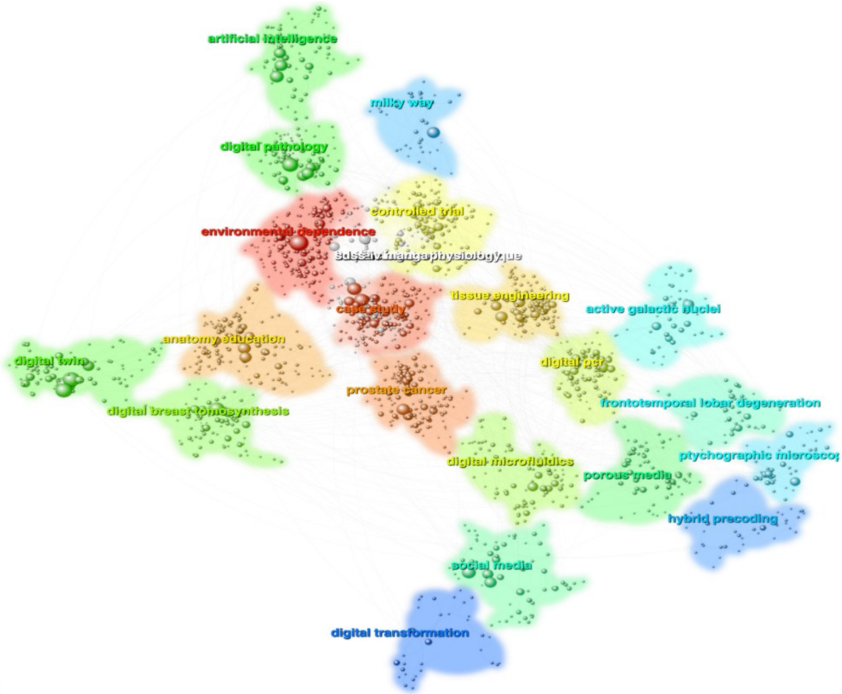
The dynamic interaction between basic sciences and digital transformation

ClusterID	Size	Silhouette	Label (LLR)	Average Year
0	186	0.897	environmental dependence (102440.38, 1.0E-4)	2005
1	159	0.863	case study (181355.56, 1.0E-4)	2004
2	134	0.827	prostate cancer (257985.75, 1.0E-4)	2002
3	127	0.947	anatomy education (34699.92, 1.0E-4)	2014
4	125	0.802	tissue engineering (170427.97, 1.0E-4)	2001
5	115	0.822	controlled trial (87161.27, 1.0E-4)	2008
6	98	0.833	digital pcr (171196.08, 1.0E-4)	2002
7	93	0.812	digital microfluidics (73658.54, 1.0E-4)	2005
8	86	0.804	digital breast tomosynthesis (197325.41, 1.0E-4)	2005
9	83	0.921	digital twin (267330.94, 1.0E-4)	2013
10	79	0.848	digital pathology (157251.06, 1.0E-4)	2007
11	72	0.891	artificial intelligence (174691.12, 1.0E-4)	2013
12	71	0.884	porous media (55969.01, 1.0E-4)	2011
13	68	0.921	social media (75901.56, 1.0E-4)	2011
14	53	0.837	frontotemporal lobar degeneration (23233.86, 1.0E-4)	2005
15	50	0.962	active galactic nuclei (69550.79, 1.0E-4)	2005
16	43	0.885	ptychographic microscopy (35561.96, 1.0E-4)	2005
17	42	0.887	milky way (19561.44, 1.0E-4)	2008
18	39	0.959	hybrid precoding (5020.77, 1.0E-4)	2015
19	33	0.977	digital transformation (28406.66, 1.0E-4)	2018
20	31	0.912	3d printing (32772.88, 1.0E-4)	2010
21	31	0.91	variance reduction technique (10450.86, 1.0E-4)	2005
22	22	0.947	cardiac electrophysiology (3984.99, 1.0E-4)	1996
23	14	0.982	human fetus (6845.69, 1.0E-4)	1995
24	7	0.999	sdss-iv manga (1427.95, 1.0E-4)	2010

The clusters identified in our study reveal the richness and diversity of interactions between basic sciences and digital transformation. While advances in basic sciences support the development and application of digital transformation technologies, digital transformation also accelerates research in basic sciences and paves the way for new discoveries. For example, in the fields of biochemistry and molecular biology, digital PCR and digital microfluidic technologies add new dimensions to genetic research by enabling sensitive and quantitative analysis of DNA and RNA. Similarly, digital breast tomosynthesis and digital pathology offer more accurate diagnosis and treatment opportunities as part of the digital transformation in medical imaging and radiology. Innovations such as artificial intelligence and digital twins are revolutionizing engineering and manufacturing processes while accelerating the development of systems biology and personalized medicine. Additionally, 3D printing technology supports innovations in bioengineering by providing the ability to produce complex structures quickly and at low cost in manufacturing and design. This interrelationship allows scientific and technological advances to develop synergistically, making it possible to investigate topics such as environmental interdependence, active galactic nuclei and the Milky Way in greater depth and on a larger scale. As a result, this dynamic interaction between basic sciences and digital transformation contributes to the development of more effective strategies by enabling the translation of scientific discoveries into health applications and industrial innovations.

Figure 3.

Major Clusters on the intersection of basic sciences with digital transformations



Throughout history, the development of science and technology has been possible because of the exchange of information and intellectual rapprochement between different cultures and civilizations. The Islamic world made significant contributions to basic sciences and engineering during the Middle Ages, and these contributions laid the foundations of modern science in the West with the Renaissance. While scientific developments in Islamic civilization advanced fields such as mathematics, astronomy, medicine and optics, scientists in this period took ancient Greek, Indian and Persian sciences and developed them further, developing new theories and applications. This information was revived in the West with the Renaissance and paved the way for the scientific revolution in the Western world. The contributions of the Islamic world, especially in mathematics and astronomy, were adopted and expanded by scientists in the West. This process was not limited to the transfer of scientific knowledge, but also led to the evolution of scientific methods. Experimental methods developed in the Islamic world, observational astronomy, mathematical modeling and systematic studies in medicine played a critical role in the formation of the scientific method in the West and became an event that emphasized the importance of convergence between sciences. Scientific developments in the Islamic world have not only been limited to basic sciences but have also manifested themselves in applied sciences and technological innovations. These innovations have demonstrated the superiority of Islamic civilization in practical areas such as navigation, cartography, agricultural techniques and architecture. On the other hand, it is obvious that scientific advances in the modern world have been enriched by social diversity, cooperation and mutual learning processes. Today, science and technology are being carried forward with the contributions of different cultural and ethnic groups, and this diversity nourishes scientific creativity. In this context, the scientific heritage that began in the Islamic world and continues in the West inspires today's interdisciplinary studies. Modern scientific processes are a natural result of the intellectual convergence in the past and the accumulation of different civilizations. The adoption and expansion of scientific developments that began in the Islamic world in the West has ensured the formation of a global scientific heritage. This heritage emphasizes the importance of diversity and cooperation in modern science and reveals the value of sharing knowledge and mutual learning among societies. Therefore, the nourishment of scientific developments by social and cultural convergence has contributed to the increase in humanity's common scientific knowledge. In this context, the scientific rapprochement that took place between the Islamic world and the West throughout history continues to inspire today’s interdisciplinary scientific studies and technological innovations. In this context, the revival of scientific studies that were founded in the Islamic world in the West demonstrates how cooperation between basic and applied sciences enables the development of innovations that will benefit humanity. Findings obtained in basic sciences such as mathematics and astronomy have been transformed into practical applications in fields such as geography, medicine and engineering, which has led to an increase in scientific knowledge. This process demonstrates how basic and applied sciences complement and enrich each other, and how interdisciplinary cooperation is the key to scientific progress and technological innovations.

References

Acedo, F. J., Barroso, C., Casanueva, C., & Galán, J. L. (2006). Co-authorship in management and organizational studies: An empirical and network analysis. *Journal of management studies*, *43*(5), 957-983.

Adler-Milstein, J., & Jha, A. K. (2017). HITECH Act Drove Large Gains In Hospital Electronic Health Record Adoption. *Health Affairs*, *36*(8), 1416-1422. https://doi.org/https://doi.org/10.1377/hlthaff.2016.1651

Agbo, C. C., Mahmoud, Q. H., & Eklund, J. M. (2019). Blockchain Technology in Healthcare: A Systematic Review. *Healthcare*, *7*(2), 56. https://www.mdpi.com/2227-9032/7/2/56

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative science quarterly*, *45*(3), 425-455.

Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular biology of the cell 6th ed (new york, ny: Garland science).

Berg, J., Tymoczko, J., Gatto Jr, G., & Stryer, L. (2015). Protein synthesis. *Biochemistry*, *8*, 893-924.

Boon, M., van Baalen, S., & Groenier, M. (2019). Interdisciplinary expertise in medical practice: Challenges of using and producing knowledge in complex problem-solving. *Medical Teacher*, *41*(6), 668-677.

Borycki, E. M., & Kushniruk, A. W. (2022). Reinventing virtual care: Bridging the healthcare system and citizen silos to create an integrated future. *Healthcare Management Forum*, *35*(3), 135-139. https://doi.org/10.1177/08404704211062575

Bright, C. F., Haynes, E. E., Patterson, D., & Pisu, M. (2017). The value of social network analysis for evaluating academic-community partnerships and collaborations for social determinants of health research. *Ethnicity & disease*, *27*(Suppl 1), 337.

Burt, R. S. (2018). Structural holes. In *Social stratification* (pp. 659-663). Routledge.

Bushberg, J., Seibert, J., Leidholdt, E., & Boone, J. (2011). Modes of CT acquisition. *The Essential Physics of Medical Imaging*, *1*, 341-350.

Council, N. R., Earth, D. o., Studies, L., Engineering, D. o., Sciences, P., Sciences, B. o. C., Sciences, B. o. L., Physics, B. o., Physical, C. o. R. a. t. I. o. t., & Sciences, L. (2010). Research at the intersection of the physical and life sciences.

Cummings, J. N., & Kiesler, S. (2005). Collaborative research across disciplinary and organizational boundaries. *Social studies of science*, *35*(5), 703-722.

Dorsey, E. R., & Topol, E. J. (2020). Telemedicine 2020 and the next decade. *The Lancet*, *395*(10227), 859. https://doi.org/10.1016/S0140-6736(20)30424-4

Fernández-Alemán, J. L., Señor, I. C., Lozoya, P. Á. O., & Toval, A. (2013). Security and privacy in electronic health records: A systematic literature review. *Journal of Biomedical Informatics*, *46*(3), 541-562. https://doi.org/https://doi.org/10.1016/j.jbi.2012.12.003

Feynman, R. (1967). The character of physical law (1965). *Cox and Wyman Ltd., London*.

Fisch, B. J., & Spehlmann, R. (1999). Fisch and Spehlmann's EEG primer: basic principles of digital and analog EEG. *(No Title)*.

Galilei, G., & Drake, S. (1990). Discoveries and opinions of Galileo: including The starry messenger (1610), Letter to the Grand Duchess Christina (1615), and excerpts from Letters on sunspots (1613), The assayer (1623). *New York: Anchor Books*.

Giansanti, D. (2024). Joint Expedition: Exploring the Intersection of Digital Health and AI in Precision Medicine with Team Integration. In (Vol. 14, pp. 388): MDPI.

Goldman, A. W. (2014). Conceptualizing the interdisciplinary diffusion and evolution of emerging fields: The case of systems biology. *Journal of informetrics*, *8*(1), 43-58.

Greg Miller, W., Myers, G. L., Lou Gantzer, M., Kahn, S. E., Schönbrunner, E. R., Thienpont, L. M., Bunk, D. M., Christenson, R. H., Eckfeldt, J. H., & Lo, S. F. (2011). Roadmap for harmonization of clinical laboratory measurement procedures. *Clinical Chemistry*, *57*(8), 1108-1117.

Hager, T., & Hager, T. (2000). *Linus Pauling: And the Chemistry of Life*. Oxford University Press.

Hoffbrand, A. V., Higgs, D. R., Keeling, D. M., & Mehta, A. B. (2016). *Postgraduate haematology*. John Wiley & Sons.

Izzo, J. L., Sica, D. A., & Black, H. R. (2008). *Hypertension primer*. Lippincott Williams & Wilkins.

Jones, P. J., Ma, R., & McNally, R. J. (2021). Bridge centrality: A network approach to understanding comorbidity. *Multivariate behavioral research*, *56*(2), 353-367.

Kong, X., Shi, Y., Yu, S., Liu, J., & Xia, F. (2019). Academic social networks: Modeling, analysis, mining and applications. *Journal of Network and Computer Applications*, *132*, 86-103.

Kruse, C. S., Smith, B., Vanderlinden, H., & Nealand, A. (2017). Security Techniques for the Electronic Health Records. *Journal of Medical Systems*, *41*(8), 127. https://doi.org/10.1007/s10916-017-0778-4

Kwoh, Y. S., Hou, J., Jonckheere, E. A., & Hayati, S. (1988). A robot with improved absolute positioning accuracy for CT guided stereotactic brain surgery. *IEEE transactions on biomedical engineering*, *35*(2), 153-160.

Lin, Z., Zhang, Y., Gong, Q., Chen, Y., Oksanen, A., & Ding, A. Y. (2021). Structural hole theory in social network analysis: a review. *IEEE transactions on computational social systems*, *9*(3), 724-739.

Litjens, G., Kooi, T., Bejnordi, B. E., Setio, A. A. A., Ciompi, F., Ghafoorian, M., van der Laak, J. A. W. M., van Ginneken, B., & Sánchez, C. I. (2017). A survey on deep learning in medical image analysis. *Medical Image Analysis*, *42*, 60-88. https://doi.org/https://doi.org/10.1016/j.media.2017.07.005

Madni, A. M. (2007). Transdisciplinarity: Reaching beyond disciplines to find connections. *Journal of Integrated Design and Process Science*, *11*(1), 1-11.

Ni, C., Sugimoto, C., & Jiang, J. (2011). Degree, Closeness, and Betweenness: Application of group centrality measurements to explore macro-disciplinary evolution diachronically. Proceedings of ISSI,

Odum, E. P., & Barrett, G. W. (1971). *Fundamentals of ecology* (Vol. 3). Saunders Philadelphia.

Pescatello, L. S., Franklin, B. A., Fagard, R., Farquhar, W. B., Kelley, G. A., & Ray, C. A. (2004). Exercise and hypertension. *Medicine & science in sports & exercise*, *36*(3), 533-553.

Richards, M. (2022). Interdisciplinary Research: Bridging Gaps for Comprehensive Scientific Understanding. *International Journal of Open Publication and Exploration, ISSN: 3006-2853*, *10*(1), 19-25.

Rifai, N. (2017). *Tietz Textbook of Clinical Chemistry and Molecular Diagnostics: Tietz Textbook of Clinical Chemistry and Molecular Diagnostics-E-Book*. Elsevier Health Sciences.

Saez-Rodriguez, J., Costello, J. C., Friend, S. H., Kellen, M. R., Mangravite, L., Meyer, P., Norman, T., & Stolovitzky, G. (2016). Crowdsourcing biomedical research: leveraging communities as innovation engines. *Nature Reviews Genetics*, *17*(8), 470-486.

Savanur, K., & Srikanth, R. (2010). Modified collaborative coefficient: A new measure for quantifying the degree of research collaboration. *Scientometrics*, *84*(2), 365-371.

Sezgin, F. (2018). *İslam'da Bilim ve Teknik*. Türkiye Bilimler Akademisi.

Skundberg, P. A. (1998). Radiologic Science for Technologists: Physics, Biology, and Protection. *Radiology*, *207*(2), 310-310.

Starr, S. F. (2013). *Lost enlightenment: Central Asia's golden age from the Arab conquest to Tamerlane*. Princeton University Press.

Stillman, D. (1957). *Discoveries and opinions of Galileo* (Vol. 94). Anchor.

Teplan, M. (2002). Fundamentals of EEG measurement. *Measurement science review*, *2*(2), 1-11.

Topol, E. J. (2019). High-performance medicine: the convergence of human and artificial intelligence. *Nature Medicine*, *25*(1), 44-56. https://doi.org/10.1038/s41591-018-0300-7

Tortora, G. J., Funke, B. R., & Case, C. L. (1989). *Microbiology*. Benjamin-Cummings Publishing Company.

Wang, C., Rodan, S., Fruin, M., & Xu, X. (2014). Knowledge networks, collaboration networks, and exploratory innovation. *Academy of management journal*, *57*(2), 484-514.

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