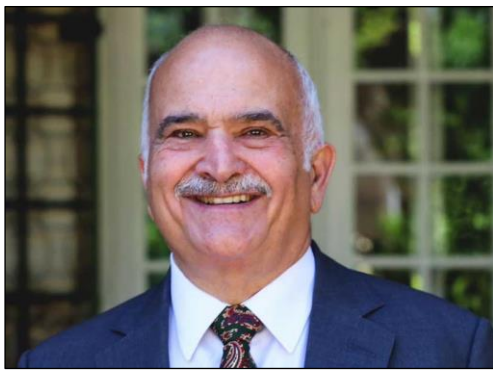


**A CALL TO ACTION:
UPHOLDING HUMAN DIGNITY IN A CHANGING WORLD***

HIS ROYAL HIGHNESS PRINCE EL HASSAN BIN TALAL
FOUNDING PATRON OF THE ISLAMIC WORLD ACADEMY OF SCIENCES (IAS)



In an era of rapid technological, social, and geopolitical change, the fundamental principle of human dignity has never been more vital.

In an era of rapid technological, social, and geopolitical change, the fundamental principle of human dignity has never been more vital. As the world confronts new challenges, from widening inequality to the erosion of democratic norms, compromised implementation of international law, the inherent worth and rights of every individual must remain at the forefront.

For decades, UN-affiliated NGOs such as the United Nations Relief and Works Agency for Palestine Refugees (UNRWA) and the United Nations High Commissioner for Refugees (UNHCR), alongside international bodies like the U.S. Agency for International Development (USAID) and non-

governmental organisations such as Mercy Corps, have played an unequivocally crucial role in delivering essential services - including education, healthcare, and emergency relief assistance. UNRWA alone is responsible for the delivery of essential humanitarian services to 6.7 million Palestinian refugees in its five fields of operation across the region. Other international donors – each in their own capacity – provided much needed assistance and critical services to their targeted populations too, thus playing a stabilizing role in the host communities that they operate in.

Today, these organisations are finding themselves at the crossroads of increasing political scrutiny, misinformation/disinformation campaigns, funding cuts, and mounting regional instability. The recent decision to freeze aid and funding of some of these organisations is deeply alarming, leaving the future of humanitarian efforts uncertain.

A recent UN survey highlighted the far-reaching consequences of these funding reductions, warning of significant disruptions to major UN agencies such as the World Food Programme (WFP), the World Health Organization (WHO), and UNICEF. The

* Source: *Modern Diplomacy*, 11 February 2025

<https://moderndiplomacy.eu/2025/02/11/a-call-to-action-upholding-human-dignity-in-a-changing-world/>

results of this survey are indeed alarming, whether ethically or from a humanitarian and developmental perspective. The world through its members states at the UN General Assembly has committed to the 2030 Agenda and the full implementations of the 17 Sustainable Development Goals – above all, Goal 17, which emphasises partnership.

The United States, traditionally the largest single donor of aid globally, provided more than 40% of the UN’s humanitarian aid budget last year. For instance, USAID has provided over \$600 million in economic assistance to Palestinians in Gaza and the Occupied West Bank since 2021. The erosion of financial support for these vital institutions threatens to deepen the suffering of vulnerable populations worldwide. However, USAID itself has also come under growing scrutiny. As former USAID Administrator Samatha Powers recently emphasised, the politicization of aid poses a serious threat to long-standing diplomatic and humanitarian efforts, undermining the stability and effectiveness of global assistance programs.

In a similar case, UNRWA’s mandate to provide education, healthcare, and emergency assistance to over 6.7 million Palestinian refugees today, underscore the vital importance of the Agency’s mission. A funding shortfall could leave over 700,000 Palestinian children without access to education and disrupt essential healthcare services for more than 3 million refugees who rely on UNRWA for primary care. The international community must recognize that UNRWA’s mandate is a lifeline, not a political tool, and its continued operation is a testament to the world’s dedication to upholding human dignity of the most vulnerable. Preserving the Agency’s ability to operate is an investment in regional and global stability, in peace, and in the future. What these vital institutions face today undermines their ability to fulfill their core

missions. The “weaponization of aid” and the erosion of international cooperation threaten to exacerbate the suffering of vulnerable populations, rather than resolving underlying political disputes. This is a new era where the ethics of war and peace are being revised.

In the 1980s, Jordan led the call for the implementation of a New International Humanitarian Order (N.I.H.O). 28 members, including the five permanent members of the Security Council joined the call, where they prioritised the safeguarding of dignity and right to life of every person and of the future generations.

The responsibility to defend human dignity does not rest solely with policymakers and international bodies. Educators, religious and community leaders, and engaged citizens all have a role to play. By fostering values of empathy and justice in future generations, leveraging moral authority, and mobilizing collective action, we can work toward a world where humanitarian principles prevail over political divisions, and where core humanity is preserved at all times.

Safeguarding these vital institutions and the principles they embody is not just a moral imperative—it is a necessity for navigating the complexities of the 21st century with compassion, cooperation and a steadfast commitment to international law and human dignity.



COMPARATIVE ANALYSIS OF AI DEVELOPMENT IN SOME COUNTRIES OF THE ISLAMIC WORLD

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Abstract

Artificial Intelligence (AI) is transforming economies and industries worldwide, and emerging economies like Malaysia, Indonesia, Pakistan, Iran, and Turkey are striving to establish their AI ecosystems. This research paper provides a comprehensive comparative analysis of AI development in these five countries, focusing on government policies, research output, industry growth, challenges, and future prospects. The study utilizes data from official government reports, academic publications, and industry analyses to evaluate AI progress and propose recommendations for strengthening AI adoption.

1. Introduction

Artificial Intelligence (AI) has become a key driver of economic transformation, impacting sectors such as healthcare, finance,

education, manufacturing, and defense. While Western and East Asian countries lead in AI research and applications, emerging economies are also investing heavily in AI to boost their competitiveness. This paper explores the AI landscape in Malaysia, Indonesia, Pakistan, Iran, and Turkey, highlighting their progress, challenges, and opportunities. The study also examines how geopolitical, economic, and infrastructural factors shape the AI ecosystem in these nations.

2. Government AI Strategies and Policies

2.1 Malaysia

Malaysia launched its **National AI Roadmap (2021-2025)** to integrate AI into its digital economy. The **Malaysia Digital Economy Corporation (MDEC)** is responsible for AI policy implementation, focusing on AI governance, industry collaboration, and talent development. The government has also established the **Malaysia AI Consortium (MAIC)** to promote collaboration between academia, industry, and policymakers ([MDEC, 2023](#)).

Key policy initiatives:

- **AI for Public Sector:** AI integration in government services.
- **AI in Education:** AI-driven curriculum in higher education.
- **Startup Grants:** Financial support for AI-driven enterprises.

2.2 Indonesia

Indonesia's **National AI Strategy (2020-2045)**, developed by **Badan Riset dan Inovasi Nasional (BRIN)**, focuses on AI applications in healthcare, education, and smart governance. AI is being used to optimize the **Smart City Initiatives** in Jakarta and other major urban centers ([BRIN, 2022](#)).

Key policy initiatives:

- **AI in Healthcare:** AI-based diagnostics and telemedicine solutions.
- **Industry 4.0 Framework:** AI adoption in manufacturing and logistics.
- **AI Research Grants:** Government-funded AI research programs.

2.3 Pakistan

Pakistan lacks a dedicated AI policy but incorporates AI under the **Digital Pakistan Initiative**. The **National Center for AI (NCAI)** was established to promote AI research and development, but AI integration in industries remains limited ([NCAI, 2022](#)).

¹ *Biologist, Professor and Chancellor of University of Petra, Jordan.*

Key policy initiatives:

- **AI in Agriculture:** AI-driven solutions for precision farming.
- **AI in Security:** AI-enabled surveillance and cybersecurity.
- **Higher Education AI Courses:** Expansion of AI-focused university programs.

2.4 Iran

Iran integrates AI within its **National ICT Agenda**, emphasizing AI in defense, healthcare, and smart infrastructure. Despite economic sanctions, Iran has a growing AI research base and is investing in AI-driven automation ([Iran Ministry of ICT, 2023](#)).

Key policy initiatives:

- **AI in Defense:** Development of autonomous drones and surveillance.
- **AI in Energy:** AI-based optimization of power grids and oil production.
- **AI-Driven Robotics:** Advances in industrial automation.

2.5 Turkey

Turkey's **National AI Strategy (2021-2025)** aligns with its **Vision 2023** plan. The government promotes AI research through **TÜBİTAK** and private sector collaborations. AI has been integrated into defense projects like **Bayraktar drones** ([TÜBİTAK, 2023](#)).

Key policy initiatives:

- **AI in Defense and Security:** AI-powered military applications.
- **AI in Smart Transportation:** AI-driven traffic management systems.

- **Tech Startup Ecosystem:** AI startup funding and incubators.

3. AI Research and Academic Contributions

3.1 Research Institutions and AI Programs

AI research in these countries is driven by top universities and government-funded research institutes.

Country	Leading AI Research Institutions
Malaysia	University of Malaya, UTM, UKM, MIMOS Berhad
Indonesia	Bandung Institute of Technology (ITB), University of Indonesia
Pakistan	NUST, LUMS, COMSATS University, NCAI
Iran	Sharif University of Technology, Amirkabir University
Turkey	Middle East Technical University, Bilkent University

3.2 Research Publications and Collaboration

According to **Scopus AI Research Index (2023)**, Turkey and Malaysia have the highest AI research output among the five countries, followed by Iran, Indonesia, and Pakistan. International collaborations with Western and Chinese universities have strengthened AI research in Turkey and Malaysia.

4. Industry Growth and AI Startups

The AI startup landscape varies significantly among the five countries.

Country	AI Industry Strengths and Key Companies
Malaysia	Fintech and healthcare AI – Neurobotics, Favoriot
Indonesia	AI in e-commerce and fintech – Gojek, Tokopedia
Pakistan	Cybersecurity and agri-tech AI – VisionRD, Jazz AI
Iran	AI in automation and healthcare – AI Lab Tehran, Sana AI
Turkey	AI in defense and robotics – Baykar, Aselsan

5. Challenges in AI Development

Despite progress, each country faces significant challenges in AI adoption.

Country	Key Challenges
Malaysia	Talent retention & competition from Singapore
Indonesia	Infrastructure & skilled workforce shortages
Pakistan	Limited funding & weak AI policy framework
Iran	Economic sanctions restricting AI tech access
Turkey	Brain drain & geopolitical challenges

6. Future Prospects and Recommendations

- **Policy Expansion:** Strengthening AI policies in Pakistan and Iran.
- **Investment in AI Education:** Expanding AI training programs in Indonesia.

- **International Collaboration:**
Enhancing AI research partnerships.
- **Startup Incubation:**
Encouraging AI-driven startups with government support.

7. Conclusion

AI development in Malaysia, Indonesia, Pakistan, Iran, and Turkey is progressing at different rates. While Malaysia and Turkey lead in policy and industry adoption, Indonesia is catching up in commercial AI applications. Pakistan and Iran face structural and economic barriers but are making steady progress. Increased investment in AI education, policy frameworks, and industry-academia collaboration will be critical for the future of AI in these countries.

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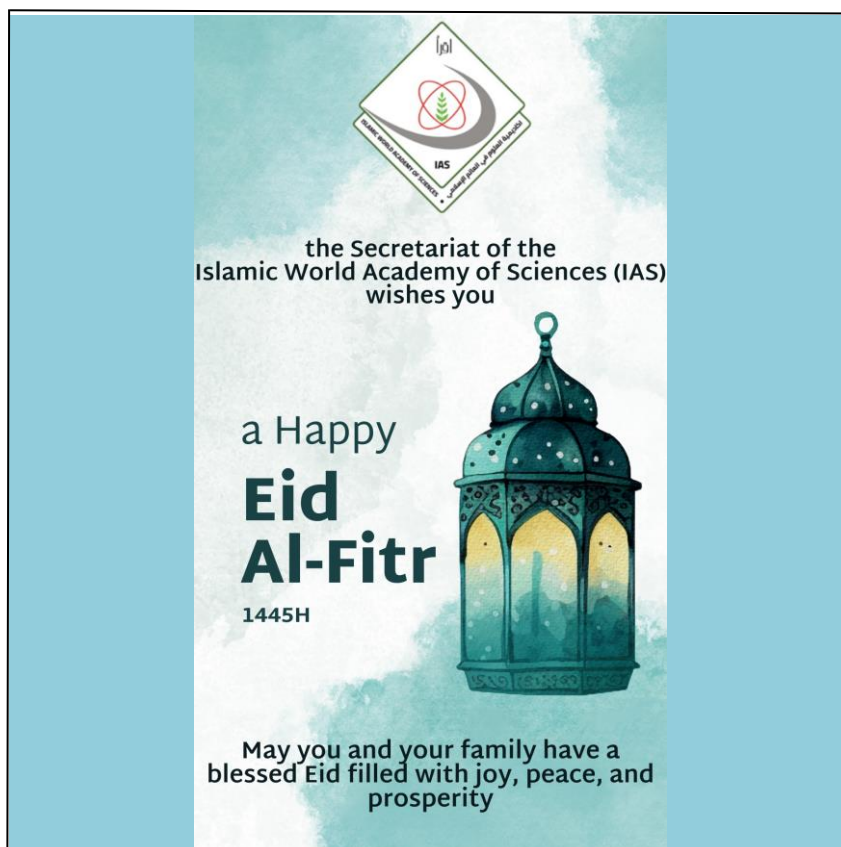
Mahmut Nedim Aytekin

Orthopedic Oncology & Orthopedics and Traumatology Surgeon & Editor, Medical Journal of Islamic World Academy of Sciences



The Medical Journal of the IAS was launched in 1988 with the title of “The Journal of Islamic Academy of Sciences” as an international scientific journal in Turkiye. In 1998 The Journal was re-launched as a specialized “Medical Journal”. This new Journal accepts articles from all Medical Sciences, written by professionals of all nationalities. For around 40 years, the Journal has been published regularly since

then and it is the official peer-reviewed scientific publication of The Islamic World Academy of Sciences. Now it will appear 2 Issues per year. On this occasion we are all thankful to our previous members serving in the editorial advisory and executive boards. We hope to receive your high quality papers for publication in the journal. You can find all issues on the website: <https://medicaljournal-ias.org/>



ATTA-UR-RAHMAN: GREAT ORGANIC CHEMIST AND NATURAL PRODUCTS*

*Adnan Badran FIAS, FAAS
President, Islamic World Academy of Sciences
and President, Arab Academy of Sciences*



Atta-ur-Rahman NI, FRS, FPAS, FIAS

“There is no doubt that Prof. Atta-ur-Rahman is a great scientist. He contributed remarkably to the field of Organic Chemistry and Natural Products. He is also an institution builder of Higher Education and research. Atta is an anchor of Centers of Excellence.

I am thankful to him for accommodating young Jordanian scientists for their post-doc research in his laboratory at the International Center for Chemical and Biological Sciences (ICCBS) in the University of Karachi.”

Atta-ur-Rahman (Urdu: *عطا الرحمان*; born 22 September 1942), NI, FRS, FPAS is a Pakistani organic chemist and is currently serving as professor emeritus at the International Center for Chemical and Biological Sciences at the University of Karachi and as Chairman of PM Task Force on Science and Technology. He has twice served as the President of the Pakistan Academy of Sciences (2003-2006 and 2011-

2014). He was the Federal Minister of Science and Technology (2000–2002), Federal Minister of Education (2002) and Chairman of the Higher Education Commission with status of Federal Minister (2002–2008). He is also the President of the Network of Academies of Sciences in Countries of the Organisation of Islamic Countries (NASIC). After returning to Pakistan from Cambridge after completing his tenure as Fellow of Kings College, Cambridge University, he contributed to the development of the International Center for Chemical and Biological Sciences at the University of Karachi, and transformed the landscape of higher education, science and technology of Pakistan. He is a Fellow of the Royal Society (London), Life Fellow of Kings College, Cambridge University, UK, Academician Chinese Academy of Sciences.

Attending Karachi University in 1960, Rahman graduated with a bachelor's degree (with honors) in chemistry in 1963. He obtained a Master of Science (MSc) in organic chemistry in 1964 with first class and 1st position, and lectured at Karachi University for a year before receiving a Commonwealth Scholarship for doctoral studies in the United Kingdom. He joined King's College at the University of Cambridge and resumed research in natural products under John Harley-Mason. In 1968, Rahman received a Doctor of Philosophy (PhD) in organic chemistry; the subjects of his doctoral thesis were natural products and organic materials. He was elected as a fellow of King's College, University of Cambridge in 1969 and continued his research at Cambridge

* Main source: Wikipedia

[https://en.wikipedia.org/wiki/Atta-ur-Rahman_\(chemist\)](https://en.wikipedia.org/wiki/Atta-ur-Rahman_(chemist))

University until 1973. During that period, he is credited with correcting the earlier work of the Nobel Laureate Sir Robert Robinson on the chemistry of harmaline.

Academic Career

In 1964, Rahman joined the Karachi University as a lecturer in undergraduate chemistry. He remained associated with the Cambridge University between 1969 and 1973. In 1977, he became the co-director of the Hussain Ebrahim Jamal Research Institute of Chemistry at University of Karachi; eventually he was ascended as the Director in 1990. In 1979, Rahman did the post-doctoral research at the University of Tübingen. Upon returning to Pakistan, he joined Karachi University where he lectures and taught chemistry.

He carried out important studies on the synthesis of anti-cancer alkaloids present in the plant *Catharanthus roseus* and analytical studies on organic compounds involving circular dichroism and is generally recognized as bringing a huge positive change in the development of science and technology as well as higher education in Pakistan.

His book entitled "Stereoselective Synthesis in Organic Chemistry" (Springer-Verlag) was termed a monumental contribution in the field by the Nobel Laureate Sir Derek Barton in the foreword of the book written by him. His book entitled "NMR Spectroscopy-Basic Principles" was published by Springer-Verlag and translated into Japanese for use in university courses in Japan. The Nobel Laureate Herbert C. Brown applauded the contributions of Rahman in science and technology.

Prof. Rahman held the following Positions:

- Fellow, King's College, Cambridge University (1969–1973, 2007– for Life)
- Professor at H.E.J. Research Institute of Chemistry at Karachi University
- Professor Emeritus at H.E.J. Research Institute of Chemistry at Karachi University (2012)
- Coordinator General of COMSTECH (1996–2012)

- Federal Minister of Science & Technology (2000–2002)
- Federal Minister of Education (2002)
- Federal Minister/Chairman, Higher Education Commission, Pakistan (resigned due to govt issues) (2002–2008)
- Advisor to the Prime Minister of Pakistan on Science and Technology (2002–2008)

Public Positions held

After securing the fellowship of the Pakistan Academy of Sciences, Rahman had been affiliated with the Pakistan government regarding education and science affairs. From 1996 until 2012, Rahman served in the board of directors of the Committee on Scientific and Technological Cooperation, representing Pakistan's delegation. In 1997, Rahman served as the Coordinator General of the Organisation of Islamic Cooperation's (OIC) Committee on Scientific and Technological Cooperation (COMSTECH) that comprised 57 Ministers of Science and Technology from 57 OIC member countries. In recognition of his scientific transformation of Pakistan and building a large number of Centers of Excellence in the country as well as promoting scientific research, Rahman was conferred the TWAS Prize in Institution Building, in Durban, South Africa in 2009. Atta-ur-Rahman has served as the co-chairman of UN ESCAP.

In 1999, he joined the Ministry of Science and Technology (MoSci) as its minister, assisting in drafting the official science policy of the country. In 2002, he was appointed as minister of the Ministry of Education (MoEd) as well as becoming the chairman of the Higher Education Commission (HEC) until resigning in 2008. Atta-ur-Rahman has also served as Chairman of the Prime Ministers National Task Force on Science and Technology, Co Chairman of Prime Ministers National Task Force on Information Technology and Telecommunications, and Vice Chairman of the Prime Ministers Task Force on Technology Driven Knowledge Economy during the years 2019 to 2022. He is the President of the Network of Science of Organisation of Islamic Countries (NASIC).

Honors and Awards

Atta-ur-Rahman has been selected as one of the 500 most influential personalities of the Islamic World. Institutions have been named after Rahman in China, the Atta-ur-Rahman Institute for Natural Product Discovery (AuRIns) in Malaysia and the Academician Professor Atta-ur-Rahman One Belt and One Road TCM Research Center were named after Rahman, as well as the Atta-ur-Rahman School of Applied Biosciences at the National University of Sciences & Technology (Islamabad, Pakistan) and the Atta-ur-Rahman Laboratories, International Center for Chemical and Biological Sciences (ICCBS) at the University of Karachi, Pakistan. The US Publisher ARKAT USA has published a special issue of the journal *Arkivoc*, Vol 2007, in honour of Atta-ur-Rahman FRS which had contributions from top scientists in the field of natural product chemistry. Similarly, the international journal *Molecules* published by the Swiss publisher MDPI published a special issue of the journal in honour of Atta-ur-Rahman. The World Academy of Sciences, Italy has introduced a special Prize in his honour (IWAS-Atta-ur-Rahman Award in Chemistry) for young scientists which is awarded once every two years. In recognition of his eminent contributions, Prof. Atta-ur-Rahman has received honorary doctorate degrees from many universities including the University of Cambridge (UK), Coventry University (UK), Bradford University (UK), Universiti Teknologi Mara (Malaysia), Asian Institute of Teknologi (Thailand), University of Karachi (Pakistan), Gomal University (Pakistan), and several other universities.

National and International Awards

In recognition of his eminent contributions in the field of organic chemistry, he has been conferred with many civil awards, including:

- Nishan-e-Imtiaz (2002) (highest national civil award)
- Hilal-e-Imtiaz (1998)
- Sitara-e-Imtiaz (1991)
- Tamgha-e-Imtiaz (1983)
- UNESCO Science Prize (1999)
- Grosse Goldene Ehrenzeischen am Bande(2007) high civil award by the Austrian government (2007)
- China, International Science and Technology Cooperation Award (2020) bestowed by Chinese President Xi Jinping in Beijing on January 7, 2020
- Academician, Chinese Academy of Sciences (2015)
- Friendship Award of China (2014)
- Vice President, The World Academy of Sciences (IWAS)
- Prescient, Network of Academies of Science of Organising of Islamic Conference (NASIC)
- Member, Korean Academy of Science and Technology
- Einstein Professorship, Chinese Academy of Sciences
- Babai Urdu Award (1994)
- Scientist of the Year Award (for 1985)/Prize Rs. 200,000 (1987)
- FPCCI Prize for Technological Innovation (1985)
- Engro Excellence Award (2010)
- HEC, National Distinguished Professor (2011–present)
- Professor Emeritus, University of Karachi (2011–present)
- Lifetime Achievement Award by University of Management and Technology, Lahore

Fellowships

- Fellow of The World Academy of Sciences (IWAS)
- Fellow of the Islamic World Academy of Sciences (IAS)
- Foreign Fellow of the Korean Academy of Sciences
- Fellow of the Pakistan Academy of Sciences
- Fellow of the Royal Society, London (2006)
- Honorary Life Fellow King's College, Cambridge, UK (2007)
- Fellow of Chinese Chemical Society (1997)
- Foreign Academician of the Chinese Academy of Sciences



Prof. Atta-ur-Rahman with Prof. Adnan Badran, President, IAS at the 24th Islamic World Academy of Sciences (IAS) Conference in Karachi, Pakistan (2023).



Prof. Atta-ur-Rahman receiving an award from the Minister of Higher Education of Austria for revolutionary changes brought about to uplift higher education sector in Pakistan.



Prof. Atta-ur-Rahman receiving UNESCO Science Prize at World Congress on Science in Budapest Hungary (1999).



Prof. Atta-ur-Rahman after receiving the International Science and Technology Collaboration Award, from President Xi Jinping on 10 January 2020.



Atta-ur-Rahman Institute of Natural Product Discovery established in Universiti Teknologi, Mara, near Kuala Lumpur in Malaysia.

MANDRAGORA AUTUMNALIS DISTRIBUTION, PHYTOCHEMICAL CHARACTERISTICS, AND PHARMACOLOGICAL BIOACTIVITIES**

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Abstract:

In the Mediterranean and Himalayan regions, the genus *Mandragora* (family Solanaceae), sometimes called mandrake, is widely utilized in herbal therapy and is well-known for its mythical associations. **Objective:** To compile up-to-date information on *M. autumnalis*'s therapeutic properties. Its pharmacological properties and phytochemical composition are particularly covered in managing several illnesses, including diabetes, cancer, and heart disease. **Methods:** Articles on the review topic were found by searching major scientific literature databases, such as PubMed, Scopus, ScienceDirect, SciFinder, Chemical Abstracts, and Medicinal and Aromatic Plants Abstracts. Additionally, general online searches were conducted using Google Scholar and Google. The time frame for the search included items released from 1986 to 2023.

Results: *Mandragora* has been shown to contain a variety of phytochemicals, including coumarins, with anolides, and alkaloids. The pharmacological characteristics of *M. autumnalis*, such as increasing macrophage anti-inflammatory activity, free radicals inhibition, bacterial and fungal growth inhibition, cytotoxic anticancer activities in vivo and in vitro against cancer cell lines, and enzyme-inhibitory properties, are attributed to these phytochemicals. Furthermore, *M. autumnalis* also inhibits cholinesterase, tyrosinase, α -amylase, α -glucosidase, and free radicals.

On the other hand, metabolic risk factors, including the inhibition of diabetes-causing enzymes and obesity, have been treated using dried ripe berries. **Conclusions:** Investigations into the pharmacological and phytochemical characteristics of *M. autumnalis* have revealed that this plant is a rich reservoir of new bioactive substances. This review aims to provide insight into the botanical and ecological characteristics of *Mandragora autumnalis*, including a summary of its phytochemical components and antioxidant, antimicrobial, antidiabetic, anticancer, enzyme inhibitory properties, as well as toxicological implications, where its low cytotoxic activity against the normal VERO cell line has been shown. More research on this plant is necessary to ensure its efficacy and safety. Still, it is also necessary to understand the molecular mechanism of action behind the observed effects to clarify its therapeutic potential.

Keywords: *Mandragora autumnalis*; phytochemistry; antioxidant activity; antimicrobial activity; anticancer activity; antidiabetic; anti-enzymatic; toxicological activities

Citation: Albahri, G.; Badran, A.; Baki, Z.A.; Alame, M.; Hijazi, A.; Daou, A.; Mesmar, J.E.; Baydoun, E. *Mandragora autumnalis* Distribution, Phytochemical Characteristics, and *Pharmacological* Bioactivities. *Pharmaceuticals* **2025**, *18*, 328. <https://doi.org/10.3390/ph18030328>

** Link to the whole publication: <https://www.mdpi.com/1424-8247/18/3/328>

ETHNOPHARMACOLOGY AND THERAPEUTIC POTENTIAL OF *ANCHUSA STRIGOSA*: A COMPREHENSIVE REVIEW*

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Published: 24 November 2023

Abstract :

Anchusa strigosa Banks and Sol. is a rough flowering plant of the Boraginaceae family native to Eastern Mediterranean region that is widely used in traditional herbal medicine, mainly for the treatment of wounds, abdominal pain, and arthritis, to name a few. This article aims to gather knowledge related to the medicinal properties of *A. strigosa*. Specifically, it summarizes its traditional uses and pharmacological activities in the treatment of various diseases.

Moreover, its botanical, ecological, and phytochemical characteristics are also discussed. Research showed that this plant is rich in pyrrolizidine alkaloids, particularly in the leaves. Other bioactive metabolites identified in this plant includes flavonoids, phenolic acids, triterpenes, organic acids, and volatile organic compounds. These phytochemicals are responsible for the reported pharmacological properties of *A. strigosa*, including antimicrobial, antioxidant, anticancer, anti-inflammatory, antiarthritic, gastric protective, antidiabetic, and pro-wound healing. This warrants further investigation into the molecular mechanism of action behind the observed effects to elucidate its therapeutic potential. Nevertheless, more research on this plant is needed to ensure its efficacy and safety.

Keywords: *Anchusa strigosa*, traditional uses, herbal medicine, phytochemistry, pharmacology

Citation: Chebaro Z, Badran A, Maresca M, Baydoun E and Mesmar JE,(2023), Ethnopharmacology and therapeutic potential of *Anchusa strigosa*: a comprehensive review. *Front. Pharmacol.* 14:1301154. doi: 10.3389/fphar.2023.1301154

* Link to the whole publication : <https://www.frontiersin.org/journals/pharmacology/articles/10.3389/fphar.2023.1301154/full>

NEW DIRECTIONS IN NUCLEAR DATA RESEARCH FOR ACCELERATOR-BASED PRODUCTION OF MEDICAL RADIONUCLIDES*

Syed M. Qaim** FIAS

Research Trends



Professor Dr. Syed M. Qaim, FIAS, of the Forschungszentrum Jülich, Germany, recently analysed new directions in nuclear data research related to accelerator-based production of medical radionuclides. Presently, about 800 cyclotrons/accelerators (small machines) are available to produce radionuclides for use in medical diagnosis and therapy. About 1000 further cyclotrons are being installed in various parts of the world. Thus, on one hand patient care is being assured, and on the other, further research

should be pursued. Professor Qaim, being a leading international expert in the field of medical radionuclides, was invited to deliver a plenary lecture at the International Conference on Nuclear Chemistry held in Budapest, Hungary, in 2023. The talk was published recently in the Springer Nature Group “Journal of Radioanalytical and Nuclear Chemistry” as an open access contribution. It is being reproduced in full below for the benefit of readers of this Newsletter.

Abstract

Extensive nuclear data studies have been carried out over the last 30 years in the context of accelerator-based production of radionuclides, especially at energies below 30 MeV, and the achieved database is fairly good. Yet there are some deficiencies or new needs of data. Those needs are generally associated with new emerging clinical applications of radionuclides, e.g. theranostic approach, bimodal imaging, radioimmuno-therapy, etc. This article gives an overview of on-going nuclear data research utilizing charged-particle accelerators in four directions, namely low-energy region, intermediate energy range, use of the α -particle beam, and utilization of fast neutrons generated at accelerators. Wherever possible, a comparison of experimental data with theoretical estimates is presented and evaluated (standardised) data, if available, are also briefly discussed.

Keywords Nuclear data · Medical radioisotopes · Accelerator · Production

Introduction

Radioactivity finds application in medicine both for diagnosis and radiotherapy, provided suitable radionuclides are used [1]. The decay data of a radionuclide are of paramount importance in its choice for a specific application. The production data, on the other hand, are of crucial importance in obtaining the radionuclide in high purity and in sufficient quantity. Diagnostic studies are generally performed using short-lived γ -ray emitters or positron emitters, utilizing Single Photon Emission Computed Tomography (SPECT) or Positron Emission Tomography (PET), respectively. In contrast, for internal radiotherapy, radionuclides emitting α - or β^- -particles, conversion or/and Auger electrons are needed. In general, the nuclear data of radionuclides commonly used in patient care are well known [2, 3]. In some cases, however, minor discrepancies may exist.

Based on a plenary lecture given at the Third International Conference on Radioanalytical and Nuclear Chemistry, Budapest, Hungary, May 2023.

In recent years, several new directions in radionuclide applications have been emerging;

* Source: <https://link.springer.com/content/pdf/10.1007/s10967-023-09285-6.pdf>

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for example, theranostic approach, bimodal imaging, immuno PET, radionuclide targeted therapy, radioactive nanoparticles, etc. [4]. They all demand novel radionuclides with somewhat different chemistry than that of the radioisotopes routinely used in diagnosis and therapy. Presently the emphasis is on novel positron emitters (called non-standard positron emitters) for diagnosis, and highly ionizing low-range corpuscular radiation emitters for therapy.

Radionuclides are produced using both nuclear reactors and cyclotrons. However, the trend to use a cyclotron/accelerator is increasing and, over the last 30 years, extensive experimental nuclear data studies have been carried out on accelerator-based production of radionuclides at energies of up to about 30 MeV [5]. Furthermore, standardisation of data has also been going on, mostly under the umbrella of IAEA. The available nuclear database is thus now fairly good [6]. Nevertheless, there are some needs for further nuclear data. This article gives an overview of on-going nuclear data research using charged-particle accelerators in four directions, namely, low-energy region, intermediate energy range, use of the α -particle beam, and utilization of fast neutrons generated at accelerators. Some relevant emerging needs are outlined.

Low-energy charged-particle induced reaction cross sections

As stated above, the cross-section database of nuclear reactions induced by charged-particles of energies up to about 30 MeV is quite good, and theory is fairly successful in describing the low energy reactions. Yet, more detailed studies are needed near thresholds of some reactions, as outlined below.

A large number of low-energy medical cyclotrons ($E_p \leq 20$ MeV; $E_d \leq 10$ MeV) are in operation in many countries and about 1000 more such cyclotrons are being installed in various parts of the world. The major use of those machines is in the production of standard positron emitters for patient care via PET. However, some nonstandard positron emitters could also be produced using those cyclotrons. The main problem, however, is targetry. The medical cyclotrons have, in general, target systems available to irradiate only gases and liquids; thus irradiation of a rather expensive, highly enriched solid material, demands adaptation of the target facility. To this end three concepts exist: (a) development of a solid target

at the medical cyclotron; (b) modification of a liquid target to irradiate a relatively large volume solution; (c) construction of a small solid target for irradiation followed by its immediate dissolution (hybrid target). Due to some uncertainty in the positioning of the low-energy beam on the target and calculation of its energy degradation in the target, it is important to use high-precision nuclear reaction cross sections to calculate the theoretical yield with some reliability. Some of the existing data, however, have low accuracy below 8 MeV. Most of the measurements are done via the stacked-foil technique with primary projectile energies of 20–30 MeV. The energy uncertainties in the last foils of the stack thus become rather large.

In view of above considerations, new measurements were done on novel production routes of several radionuclides near their thresholds. The results for the $^{100}\text{Mo}(p,2n)^{99\text{m}}\text{Tc}$ and $^{124}\text{Te}(p,n)^{124}\text{I}$ reactions were reported quite some time ago [7, 8] and they served as the basis of development of production methodologies of those two radionuclides at a small-sized cyclotron. In recent years we analysed the production reaction cross sections of three non-standard positron emitters, namely ^{64}Cu ($T_{1/2} = 12.7$ h), ^{86}Y ($T_{1/2} = 14.7$ h) and ^{89}Zr ($T_{1/2} = 3.27$ days), via the reactions $^{64}\text{Ni}(p,n)^{64}\text{Cu}$, $^{86}\text{Sr}(p,n)^{86}\text{Y}$ and $^{89}\text{Y}(p,n)^{89}\text{Zr}$, respectively, the first two on highly enriched target materials [cf. [9–11]] but the latter on a natural target.

The data for the $^{64}\text{Ni}(p,n)^{64}\text{Cu}$ reaction were thoroughly evaluated by the IAEA in 2008 [6] and by Aslam et al. [12] in 2009. The agreement in the two curves in the maximum cross section range was good. However, in the low-energy region (shown in Fig. 1) a small discrepancy was observed. A later measurement [13] more or less confirmed the evaluated data by Aslam et al. [12] but some deviation remained. Furthermore, the global theoretical calculation [TENDL 2014] appeared rather far from the evaluated data. A new careful measurement [14] using a low-energy cyclotron at FZJ and a Tandem accelerator at Dhaka was therefore carried out (see Fig. 1). Based on the extended experimental results, a new evaluation was carried out by the IAEA in 2021 [6] and the updated curve is also given in Fig. 1. The discrepancy has now been removed. In the case of the $^{86}\text{Sr}(p,n)^{86}\text{Y}$ reaction, the database was discrepant and weak. The IAEA evaluation proved to be rather erratic because one set of data was rejected and the only other

set of doubtful data was adopted. Zaneb et al. [15], on the other hand, performed a critical evaluation and, on the basis of inconsistencies, recommended a new measurement. This suggestion was followed and, through an international collaboration [16], very precise cross-section data for this reaction were obtained over the whole energy range. The third reaction, namely $^{89}\text{Y}(p,n)^{89}\text{Zr}$, constitutes a typical case where database could be very strong due to the existence and use of a monoisotopic target. Thorough evaluations [6, 17] have established the authenticity of the available data.

The three typical low-energy reactions considered above should emphasize the point that new measurements may be necessary around the threshold of some reactions. They should be performed using projectiles of incident energies around 10 MeV or lower, if possible. Very appropriate for such measurements appear to be Tandem type accelerators which deliver higher quality low-energy beams than the cyclotrons.

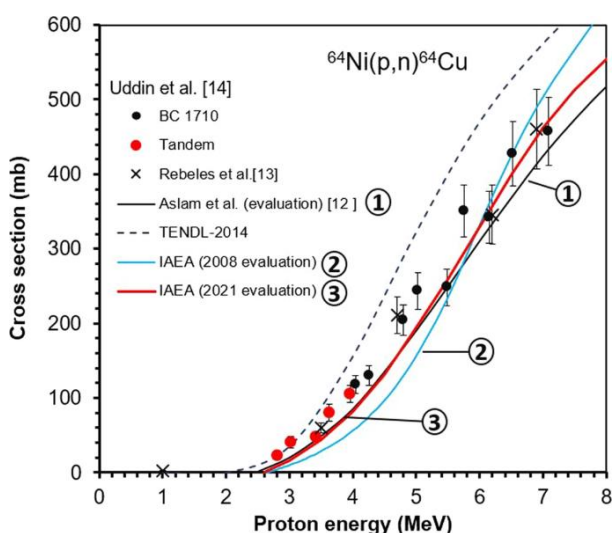


Fig. 1 Low energy region of the excitation function of the $^{64}\text{Ni}(p,n)^{64}\text{Cu}$ reaction important for the production of ^{64}Cu at a small cyclotron: experimental data and evaluations (adapted from Uddin et al. [14] and updated).

Intermediate-energy charged-particle induced reaction cross sections

Protons of energies up to about 70 MeV are frequently utilized for production of a few commonly used radionuclides, e.g. ^{125}I ($T_{1/2} = 13.2$ h) via the $^{127}\text{I}(p,5n)^{123}\text{Xe} \rightarrow ^{123}\text{I}$ route, ^{68}Ga ($T_{1/2} = 1.1$ h) via the $^{nat}\text{Ge}(p,xn)^{68}\text{Ge}(^{68}\text{Ga})$ generator system and ^{82}Rb ($T_{1/2} = 2.3$ min) via the $^{nat}\text{Rb}(p,xn)^{82}\text{Sr}(^{82}\text{Rb})$ generator system (for details cf. [3]).

Interest is now growing in making use of the intermediate-energy protons in the production of many other radionuclides as well. The existing reaction cross-section database is, however, rather weak and nuclear model calculations are only partially successful in describing the data. The list of potentially interesting radionuclides which could be produced by intermediate-energy protons is large. Here we consider only 5 typical radionuclides listed in Table 1, together with the respective promising production routes and relevant energy ranges. Two of them are useful for PET studies and three for internal radiotherapy. We discuss them briefly below.

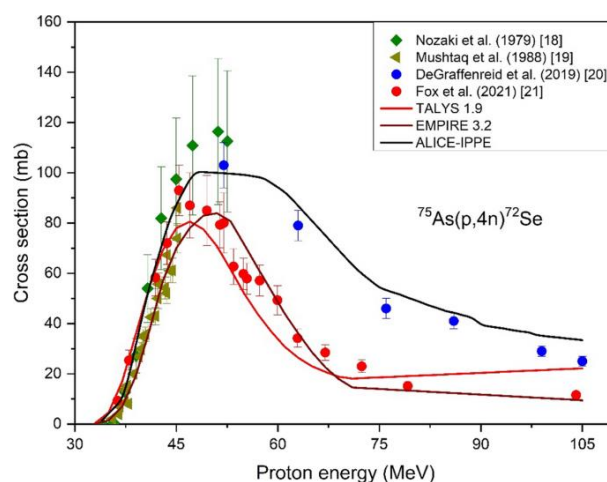


Fig. 2 Excitation function of the $^{75}\text{As}(p,4n)^{72}\text{Se}$ reaction: experimental data and nuclear model calculations (adapted from Amjed et al. [22] and updated).

The radionuclide ^{72}Se is the parent of ^{72}As which is a positron emitter and builds a “matched theranostic pair” with the β^- -emitter ^{77}As . For the production of ^{72}Se the $^{75}\text{As}(p,4n)$ -reaction appears to be promising and several measurements have been reported [18–21], but the database above 50 MeV is weak and discrepant. Nuclear model calculations were done by Amjed et al. [22] using the codes TALYS 1.9, EMPIRE 3.2 and ALICE-IPPE, and the results are shown in Fig. 2 together with the experimental data. Apparently the model calculations describe the data fairly well up to 45 MeV where the experimental database is good. Beyond that energy, the two sets of recent experimental data [20, 21] show large deviations; presumably the cross-section values by DeGraffenreid et al. [20] are too high. The nuclear model calculations differ considerably both among themselves and with the experimental

data, though the ALICE-IPPE values are near to DeGraffenreid et al.[20] and the EMPIRE 3.2 calculation appears to reproduce the data by Fox et al. [21] to a great extent. In general, however,

improvements in both experiment and theory are called for.

Table 1 Typical examples of production of some medical radionuclides using intermediate-energy charged-particle induced reactions

Radionuclide	$T_{1/2}$	Decay mode (%)	Production reaction	Energy range of interest (MeV)	Status of production data	Application
^{72}Se	8.4 days	EC (100)	$^{75}\text{As}(p,4n)$	40–70	Weak	Generator: parent of ^{72}As ($T_{1/2} = 26.0$ h) (PET)
^{134}Ce	3.2 days	EC (100)	$^{139}\text{La}(p,6n)$	50–100	Fair	In vivo generator: parent of ^{134}La ($T_{1/2} = 6.7$ min) (PET)
$^{67}\text{Cu}^*$	2.6 days	β^- (100)	$^{68}\text{Zn}(p,2p)$	30–80	Good	β^- -Therapy
			$^{70}\text{Zn}(p,x)$	30–80	Weak	
^{149}Tb	4.1 h	α (16.7)	$^{165}\text{Ho}(p,\text{spall})$	1000	Fair	α -Therapy
		β^+ (4.3)	$^{152,154,155}\text{Gd}(p,xn)$	60–100	No data available	
		EC (79)				
$^{225}\text{Ac}^*$	10.0 days	α (100)	$^{226}\text{Ra}(p,2n)$	10–30	Weak	α -Therapy
			$^{232}\text{Th}(p,x)$	60–140	Fair	

* For production, fast-neutron induced and photonuclear reactions are also under intensive investigation (see text).

The radionuclide ^{134}Ce is the parent of in vivo generator $^{134}\text{Ce}/^{134}\text{La}$ which has the potential to serve as a PET surrogate for both α -particle emitting ^{225}Ac and ^{227}Th radionuclides due to the unique Ce(III)/Ce(IV) redox couple [23]. Its production via the $^{139}\text{La}(p,6n)$ -reaction has been demonstrated [23]. The status of the cross-section database is fair [24] but further improvement is desired.

The radionuclide ^{67}Cu is a β^- -emitting therapeutic radionuclide and builds a “matched theranostic pair” with the positron emitter ^{64}Cu or ^{61}Cu . A large number of reactions have been investigated for production of ^{67}Cu (for reviews cf. [25–29]), but the intermediate energy reaction $^{68}\text{Zn}(p,2p)^{67}\text{Cu}$ appears to be the most promising. The database is fairly strong and theory can partially describe the cross section. An evaluation of the data has also been done [6]. Very recently the reaction $^{70}\text{Zn}(p,a)^{67}\text{Cu}$, which is very suitable for the production of ^{67}Cu at a 30 MeV cyclotron [30, 31], was investigated also at energies above 45 MeV.

The cross section increases suddenly [32] due to the onset of the $^{70}\text{Zn}(p,2p2n)^{67}\text{Cu}$ and some other competing processes. This could also become an interesting production route, but the database needs to be strengthened. It is worth mentioning here that GBq amounts of ^{67}Cu are also being produced via the $^{68}\text{Zn}(\gamma,p)^{67}\text{Cu}$ process by a few companies in USA. Furthermore, the use of fast

neutrons appears very promising. This aspect is discussed below separately. The radionuclide ^{149}Tb is an α -emitting rare-earth radionuclide and has been produced to date in small quantity via a heavy-ion induced reaction combined with chemical separation [33], and in larger quantity via spallation combined with on-line mass separation [34]. The intermediate energy reactions $^{152,154,155}\text{Gd}(p,xn)^{149}\text{Tb}$ have so far not been investigated but, from the yield point of view, they appear to be interesting.

The radionuclide ^{225}Ac is an extremely important α -emitting radionuclide and it is presently in great demand for use in α -targeted therapy. Large efforts are being harnessed to produce it in sufficient quantities using 30 MeV protons via the reaction $^{226}\text{Ra}(p,2n)^{225}\text{Ac}$ [35] and fast neutrons via the process $^{226}\text{Ra}(n,2n)^{225}\text{Ra} \xrightarrow{\beta^-} ^{225}\text{Ac}$, or hard photons through the process $^{226}\text{Ra}(\gamma,n)^{225}\text{Ra} \xrightarrow{\beta^-} ^{225}\text{Ac}$. The databases of all processes are rather weak. The (γ,n) route is beyond the scope of this review. But the $(n,2n)$ route is discussed below separately. A further method involves the use of the intermediate energy process $^{232}\text{Th}(p,x)^{225}\text{Ac}$ [36–39]. Its database is fair but more data on the formation of impurities would be beneficial.

In summary, it may be concluded that the needs for intermediate energy reaction cross sections are extensive and they are increasing because of enhancing use of accelerators in production of both diagnostic and therapeutic radionuclides.

Further experimental and theoretical work is needed to improve the databases.

Special use of the α -particle beam in medical radionuclide production

Most of the accelerator-based radionuclides are produced utilizing a proton beam. This is due to generally high reaction cross section and long range of the proton in the target material, leading to high product yield. Deuterons could also be useful but their availability is somewhat limited. As regards α -particles, the cross sections are also generally high but due to their short ranges in the matter, the yields are much lower. Nonetheless, for production of some radionuclides, the α -particle beam could be of special interest (for review cf. [40]).

In Table 2 we list 6 typical radionuclides which are preferentially produced using α -particles. The short-lived ^{30}P is useful for study of phosphorus metabolism via PET, in the form of ^{30}P -labelled phosphate [41, 42] and also as ^{30}P -labelled phosphine gas [42]. The radionuclide ^{38}K is used

in cardiac studies via PET, ^{77}Br finds application in preparing bromoradiopharmaceuticals for metabolic studies via SPECT, and ^{211}At is in great demand for targeted α -therapy. In fact large scale production of ^{211}At is only achieved via the $(\alpha,2n)$ -route. The radionuclides $^{117\text{m}}\text{Sn}$ and $^{193\text{m}}\text{Pt}$ are high-spin isomeric states and decay via internal transition whereby conversion electrons and showers of Auger electrons, respectively, are emitted which could be used for therapy. Both those radionuclides are routinely produced via the $(n,n'\gamma)$ reaction using epithermal neutrons, but the specific activity achieved is rather low. For no-carrier-added production of those two radionuclides, several charged-particle induced reactions can be utilized but the use of the α -particle beam is more advantageous. In both cases, clinical scale production leading to high specific activity products has been demonstrated (for a detailed review of the production methods of those 6 radionuclides, cf. [3]).

Table 2 Typical examples of production of some medical radionuclides using α -particle induced reactions*

Radionuclide	$T_{1/2}$	Decay mode (%)	Production route	Energy range of interest (MeV)	Status of production data	Application
^{30}P	2.5 min	β^+ (99.9)	$^{27}\text{Al}(\alpha,n)$	10–25	Fair	PET
^{38}K	7.6 min	β^+ (99.4)	$^{35}\text{Cl}(\alpha,n)$	7–25	Fair	PET
^{77}Br	57.0 h	EC (99.3) β^+ (0.7)	$^{75}\text{As}(\alpha,2n)$	15–30	Good	SPECT
$^{117\text{m}}\text{Sn}$	13.6 days	IT (100) Conversion electrons	$^{116}\text{Cd}(\alpha,3n)$	30–60	Fair	Low-energy electron therapy
$^{193\text{m}}\text{Pt}$	4.3 days	IT (100) Auger electrons	$^{192}\text{Os}(\alpha,3n)$	30–40	Fair	Auger therapy
^{211}At	7.3 h	EC (58.1) α (41.9)	$^{209}\text{Bi}(\alpha,2n)$	20–28	Good	α -Therapy

* For detailed review cf. Qaim et al. [40].

As far as the status of nuclear data of α -particle induced reactions is concerned, standardised cross section data are available only for the production of ^{211}At which are also well reproduced by model calculations [6]. For other nuclides the database is not strong and theory is only partially successful [40, 43, 44]. Similarly for developing some other potentially useful radionuclides, further cross section measurements and nuclear model calculations are called for.

It may also be mentioned that in recent years the use of the α -particle beam in producing some special radionuclides in the rare-earth region has been finding enhanced attention (e.g. at RIKEN, Moscow, Kolkata, etc.) The product yields are low. However, some accelerator designers/producers in USA have started putting in lot of

effort towards development of machines which may deliver α -particle beams in the mA range. Those machines would lead to much higher yields of the desired products. Obviously this production methodology would demand more nuclear data work on α -particle induced reactions.

Use of accelerator-generated neutrons in medical radionuclide production

Several types of accelerator-generated quasi-monoenergetic as well as spectral neutrons could be made available for medical radionuclide production. A detailed discussion was given earlier [45]. The more important among them are mentioned here only briefly.

White neutron source at a LINAC

A high intensity electron linear accelerator (LINAC) often serves as an intense source of neutrons. The strong low-energy component is suitable for inducing the (n,γ) reaction and the very weak high-energy part of the spectrum could possibly induce the $(n,2n)$ reaction. Thus ^{99}Mo could be produced in a ^{nat}Mo target through $^{98}\text{Mo}(n,\gamma)$ - and $^{100}\text{Mo}(n,2n)$ -reactions. The cross sections of the two processes are fairly well known. The main drawback is the low specific activity of ^{99}Mo produced. But new radiochemical methods and effective absorbing columns for generator production are being developed to cope with the problem.

Spallation neutron source at a high-energy accelerator

The spectrum of such a neutron source extends from very low energies up to the maximum energy of the proton. The hard component is rather strong so that in the irradiated material several neutron threshold reactions could be induced. However, not much attempt has been made to produce radionuclides at the few existing spallation neutron sources. Only at Los Alamos some preliminary studies on the $^{47}\text{Ti}(n,p)^{47}\text{Sc}$ reaction have been performed [46]. Production of some therapeutic radionuclides in no-carrier-added form using a spallation neutron source appears to be quite feasible but extensive neutron data work and technological developments are necessary to achieve the goal.

d/Be breakup neutron source at a cyclotron

The neutron spectrum generated in the breakup of high-energy deuterons on a Be-target has quite a different shape than the neutron spectrum encountered in a fission reactor, at a LINAC or in a spallation source. The neutron spectrum generated in 30 MeV deuterons on Be was quantitatively characterized in the 0° direction [47]. It is very forward peaked and the shape of the spectrum varies with the energy of the incident deuteron [48, 49]. Besides a strong low-energy component the spectrum shows a peak at about half of the deuteron energy and then drops till the end of the maximum deuteron energy. This energy range is very suitable for (n,p) reactions. Thus several useful therapeutic radionuclides like ^{47}Sc , ^{67}Cu , ^{89}Sr , etc. could be produced with high specific activity using breakup neutrons. The neutron-spectrum averaged cross sections for those radionuclides are much higher than with fission neutrons [50, 51]. Clinical scale

production of ^{67}Cu has been practically demonstrated using a 40 MeV d/C neutron source [52, 53]. The d/Be neutron field is also very suitable for inducing the $(n,2n)$ reaction [cf. [54]]. A big disadvantage in that case, however, is the very low specific activity of the product. On the other hand, if the product of interest is the daughter of the radionuclide produced, then the process could be advantageously used. Thus three radionuclides, namely ^{99m}Tc , ^{123}I and ^{225}Ac , could be produced through the routes $^{100}\text{Mo}(n,2n)^{99}\text{Mo} \xrightarrow{\beta^-} ^{99m}\text{Tc}$, $^{124}\text{Xe}(n,2n)^{123}\text{Xe} \xrightarrow{EC} ^{123}\text{I}$ and $^{226}\text{Ra}(n,2n)^{225}\text{Ra} \xrightarrow{EC} ^{225}\text{Ac}$, respectively. This methodology could compete with the LINAC-based (γ,n) process presently discussed for both ^{99}Mo and ^{225}Ac (see above).

As far as the nuclear data for the production of radionuclides with d/Be breakup neutrons are concerned, neutron spectrum averaged cross sections have been reported for a large number of reactions on many target elements using 30 MeV and 50 MeV deuterons on Be [54–56]. However, more data will be needed. Partly evaluated excitation functions of several (n,p) and $(n,2n)$ reactions are also available (cf. ENDF-B-VIII), but the energy range covered is generally limited up to 20 MeV. Thus for obtaining full scale spectrum-averaged cross sections, some reliance will have to be placed on nuclear model calculations.

Concluding remarks

Accurate knowledge of nuclear data is absolutely necessary for production and application of radionuclides in medicine. Whereas well standardised data are available for the production of radionuclides commonly used in patient care, constant nuclear data research is essential to meet changing trends in radionuclide applications in medicine, especially using metallic radionuclides. A large number of small medical cyclotrons are being installed in various parts of the world, mainly for routine production of standard positron emitters. But they are also finding increasing use in production of non-standard positron emitters through development of versatile irradiation targets. The latter demands high-accuracy data near reaction thresholds. The present interest in medical application of radionuclides is directed towards targeted radionuclide therapy, preferably applying the theranostic approach. This is leading to an enhanced use of intermediate energy

accelerators in production of β^- and α -particle emitting therapeutic radionuclides. The available cross-section database in this energy range being rather weak, detailed experimental work and further development of theory are called for. Most of the radionuclides are produced using protons, but in some cases use of the α -particle beam is very advantageous, e.g. in the production of ^{211}At for α -targeted therapy, or the high-spin isomeric states $^{117\text{m}}\text{mSn}$ and $^{193\text{m}}\text{mPt}$ for Auger therapy. More cross section work is needed to develop production of some other potentially useful radionuclides. Furthermore, the deuteron beam from a cyclotron falling on a Be target provides fast neutrons that can be advantageously used for the production of a few therapeutic radionuclides via the (n,p) and $(n,2n)$ reactions. For this purpose, however, more detailed information on the excitation functions of the producing reactions above 20 MeV is needed. In short, with enhancing interest in accelerator-based production of medical radionuclides for emerging novel applications, the need of nuclear data research in new directions will continue.

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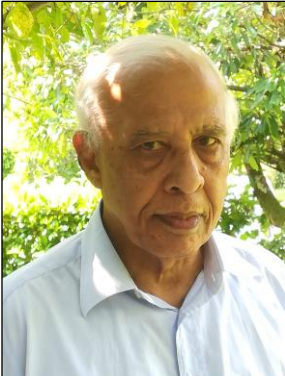
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<https://link.springer.com/content/pdf/10.1007/s10967-023-09285-6.pdf>

LINEAR AND NONLINEAR FUNCTIONS

Mohammed Asghar[^] FLAS



Abstract: This note defines the rule governing linear and nonlinear functions along with examples from the field of physics.

1. Introduction

In mathematics and science, linearity is a property of the differential equations governing many systems, for instance, the Maxwell equations or the diffusion equation. Linearity of a homogenous differential equation means that if two functions f and g are solutions of the equation, then any linear combination $af + bg$ is, too. This principle holds also for any linear algebraic equation.

In mathematics and science, a nonlinear system is a system in which the change of the output is not proportional to the change of the input. The easiest way to know if a function is linear or not is to look at its graph. A linear function A forms a straight line when it is plotted on a graph. A nonlinear function does not form a straight line: it is curved in some way, Figure 1.

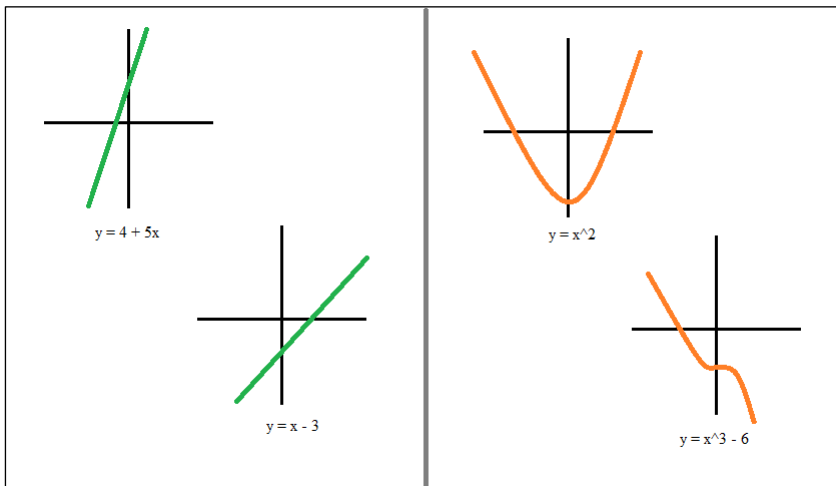


Figure 1. The linear relations: $y = 4 + 5x$ and $y = x - 3$, represent linear functions; and the nonlinear relations: $y = x^2$ and $y = x^3 - 6$, represent nonlinear functions (1).

2. Examples of linear equations.

- Fundamental theorem of calculus: $\mathbf{A}(\mathbf{x} + \mathbf{h}) - \mathbf{A}(\mathbf{x}) \sim \mathbf{f}(\mathbf{x}) \cdot \mathbf{h}$

with A , the area; x , a real number; h , the height; $f(x)$, function of x .

- Schrödinger's time-dependent quantum equation: $i \hbar \delta / \delta t | \psi \rangle = \mathbf{H} | \psi \rangle$

with i , imaginary number $= (-1)^{1/2}$; \hbar , the reduced Planck constant $= h / 2\pi$; ψ , wavefunction of the system; H , Hamiltonian operator.

3. Examples of nonlinear equations.

- Einstein's energy E - mass m equivalence relation: $E = mc^2$,

where c is the velocity of light in vacuum.

- Einstein's general relativity field equations:

$$\mathbf{G}_{\mu\nu} + \Lambda \mathbf{g}_{\mu\nu} = \kappa \mathbf{T}_{\mu\nu},$$

where $G_{\mu\nu}$ is the Einstein tensor; $g_{\mu\nu}$ is the metric tensor; $T_{\mu\nu}$ is the stress-energy tensor; Λ is the cosmological constant; κ is the Einstein gravitational constant $= 8\pi G / c^4$, where G is the Newton's gravitational constant, and c is the velocity of light in vacuum.

- Boltzmann's entropy S relation:

$$\mathbf{S} = k_B \ln \Omega,$$

where k_B is Boltzmann constant, and Ω , the number of microstates of the system.

- Force of gravity F between two masses m_1 and m_2 :

$$\mathbf{F} = \mathbf{G} m_1 m_2 / r^2,$$

where G is the gravitational constant; m_1 and m_2 , masses of objects; r , the distance between the center of gravities of both objects.

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1. Courtesy google.

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PROF. HASSAN'S REPORT ON ISC MUSCAT GLOBAL KNOWLEDGE DIALOGUE (GKD) & THIRD ISC GENERAL ASSEMBLY

*Mohamed Hag Ali Hassan FLAS
Representing IAS*



The meetings were held in Muscat, Oman from 27-30 January 2025 and were generously hosted by the Ministry of Higher Education, Research and Innovation



MUSCAT GLOBAL KNOWLEDGE DIALOGUE

Hosted under the patronage of His Highness Sayyid Asaad bin Tariq Al Said, the Muscat GKD gathered over 415 representatives from ISC Members across 132 countries for two days of discussions on science priorities in advancing sustainability and global development. The meeting addressed a wide range of issues, from artificial intelligence to trust in science, and from just transformations to sustainability, laying the groundwork for meaningful cooperation.

The Muscat Global Knowledge Dialogue has underscored the critical importance of international scientific collaboration in tackling the world's most pressing issues.

At the conclusion of the meetings, the participants adopted the Muscat Declaration, urging scientists and other stakeholders to actively engage in addressing urgent challenges

and enhancing the role of science as a global public good.

The Declaration highlights key priorities:

1. Protect and promote free, responsible scientific practice, ensuring cross-border collaboration, even in crises.
2. Invest in capacity-building for under-resourced regions, promoting equitable scientific knowledge access.
3. Foster international, inter- and transdisciplinary collaborations to address global challenges such as sustainability, inequality, and emerging technologies.
4. Transform science systems to enhance transparency, inclusion, and integrity, equipping future scientists to tackle complex societal issues.

It also calls for science's integration into global policy, emphasising trust in scientific institutions through transparency and ethical practices. These directives will steer the ISC's future efforts, inspiring collective action for peace, sustainability, and the well-being of humanity and the planet.

Third ISC General Assembly

The Assembly addressed key topics, including the ISC Strategic Plan 2025–2028, its budget, expanding regional presence through new antennas, and finalising the ISC Statutes and Rules of Procedure.

Delegates discussed priority areas from the draft strategic plan, such as:

- Freedom, Responsibility, and Inclusivity in Science.
- International Science Agenda Setting.
- Evolution of Science and Science Systems.
- Evidence-Based Policymaking.
- Science Diplomacy.

These discussions helped refine the Council's strategic directions to align with the evolving needs of the global scientific community.

Members emphasised issues related to Freedom and Responsibility in Science, focusing on free scientific circulation, visa challenges, and enhancing diverse scientific community representation.

Each category of ISC Members, including young scientists, ISC Fellows, and thematic groups, contributed to discussions on key strategic priorities. Regional meetings in Latin America and the Caribbean, Africa, and Asia and the Pacific fostered collaboration and reinforced ISC's commitment to regional scientific priorities.

Members shared feedback from their discussions, offering valuable insights for refining the draft strategic plan and proposing modifications to the Council's Statutes. These included aspects of ISC core values, committees, governance, and financial dues. A proposal submitted by ISC management to increase the dues by 2% was rejected by the majority of voting members.

During the last session of the General Assembly a memorandum signed between Ministry of Higher Education, Research and Innovation and ISC outlining plans for a regional office of ISC to be established in the Middle East, with Muscat as its headquarters.

A memorandum was signed by H E Dr Rahma bint Ibrahim al Mahrouqi, Minister of Higher Education, Research and Innovation, and President of ISC.

The General Assembly concluded with the inauguration of the new President-Elect, Robbert Dijkgraaf, alongside several new ISC Governing Board members.

Recommendation:

The establishment of an ISC regional office in Muscat, serving the Middle East and North Africa, presents a significant opportunity for the Islamic World Academy of Sciences to enhance its partnership with ISC. Given that all countries in this region, except one, have predominantly Muslim populations and are members of OIC, collaboration is key.

I suggest reaching out to the Oman Minister of Higher Education to offer support and collaboration. Additionally, IAS should connect with accomplished Omani scientists for potential IAS membership, fostering stronger ties between Oman and the IAS.

PROMINENT MUSLIM REFORMERS OF THE TWENTIETH CENTURY

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After several centuries of intellectual decline in the Islamic world and a prolonged period of stagnation for Muslims globally, several 19th-century scholars, such as Syed Ahmed Khan and Mohammed Abduh, took the initiative to remind Muslims of their rich intellectual heritage and the pressing reality of their current backwardness. They emphasized that this decline stemmed from their detachment from science and the modern world. Nevertheless, these reformers laid the foundation for modern Muslim education in India and other parts of the Islamic world.

The groundwork laid by these 19th-century thinkers significantly influenced 20th-century reformers such as Dahlan of Indonesia; Maulana Azad, Sir Muhammad Iqbal, and Shibli Nomani of India; Atatürk of Turkey; Ali Shariati of Iran; Ismail al-Faruqi of the U.S.; and Taha Husain of Egypt. These scholars worked tirelessly to convince the wider Muslim community that Islamic principles are compatible with modern values, including democracy and human rights. Their efforts led to the establishment of various institutions across the Muslim world, which became centers for progressive thought and learning.

It is important to recognize that during this period, numerous Ulema (religious scholars) from various Islamic countries played significant-

sometimes diverse-roles in advancing the cause of Islam. Their contributions left a lasting impact on large sections of the Ummah. Some of the most influential among them include:

Muhammad ibn Abd al-Wahhab (1703-1792), Imam Ahmed Raza Khan Bareilvi (1856-1921), Syed Abul A'la Maududi (1903-1979), Ayatollah Ruhollah Khomeini (1902-1989), Muhammad Ilyas Kandhlawi (1885-1944).

Notable 20th-Century Reformers

Following is a list of influential figures who, directly or indirectly, contributed to the advancement of science, the promotion of scientific temper, rational thought, intellectual inquiry, and interfaith relations within the Islamic world.

Abdul Majid Daryabadi (1892-1977, India)--Renowned Islamic scholar, journalist, and Quran commentator. He was a rare blend of traditional Islamic scholarship and modern intellectual inquiry.

Abdul Malik Karim Amrullah (Hamka) (1908-1981, Indonesia)--Like Muhammad Abduh and Rashid Rida, he advocated for rational Islamic thought and opposed blind traditionalism.

Abul Hasan Ali Hasani Nadvi, Maulana (1914-1999, India)--An internationally known Islamic scholar and prolific writer, he served as Chancellor of Nadwatul Ulema, Lucknow. He played a crucial role in shaping the institution's direction and its influence within the Islamic world. He observed that "after the 16th century, Muslims lost interest in scientific inquiry and focused more on metaphysical sciences, which hindered intellectual progress".

Abul Kalam Azad (1888-1958, India)--India's first Education Minister, he was instrumental in establishing institutes and colleges for higher scientific learning. He noted that after the 16th century, Christians adopted the Muslim approach to progressive thinking and inquiry, while Muslims, in contrast, embraced the medieval Christian mindset of superstition and stagnation.

Ahmad Dahlan (1868-1923, Indonesia)--Founder of the Muhammadiyah movement, one of Indonesia's largest Islamic organizations. He emphasized modern education and the return to the Quran and Sunnah. His movement led to the

establishment of hundreds of schools, universities, and hospitals in Indonesia.

Alexander Russell Webb (1846-1916, USA)--One of the first prominent American converts to Islam, he actively promoted Islam in the West through writings, lectures, and interfaith dialogue.

Ali Shariati Mazinani (1933-1977, Iran)--Blended Islamic thought with socialist and revolutionary ideals, inspiring political and religious reform movements.

Bashir Husain Zaidi, Col. (1898-1982, India)--Vice-Chancellor of Aligarh Muslim University. Played a crucial role in the expansion of the university's academic programs and research initiatives, especially in the sciences.

Burhanuddin al-Helmy (1911-1969, Malaysia)--Advocated for Malaysian independence and the establishment of a modern Islamic-based governance system.

Fazlur Rahman Malik (1919-1988, Pakistan)--A liberal reformer who emphasized the revival of independent reasoning (ijtihad). He argued that science once flourished in the Muslim world because it fulfilled Quranic injunctions.

Gamal Abdel Nasser (1918-1970, Egypt)--A leader in the Non-Aligned Movement alongside Tito and Nehru, he worked for international peace and promoted modernization in Egypt.

Hakim Ajmal Khan (1868-1927, India)--A multifaceted personality-physician, scholar, and nationalist leader. Played a key role in the development of herbal medicine and founded the Ayurvedic and Unani Tibbia College in Delhi. He was also one of the founders of Jamia Millia Islamia, reflecting his progressive vision for education.

Hasan al-Banna (1906-1949, Egypt)--Sought to establish modern governance rooted in Islamic principles and founded the Muslim Brotherhood.

Hasyim Asy'ari (1871-1947, Indonesia)--Founder of Nahdlatul Ulama, Indonesia's largest Islamic organization. Advocated for a balance between traditionalism and modernism.

Husain Ahmad Madani (1879-1957, India)--Played a significant role in India's independence movement and was a strong advocate for Hindu-Muslim unity. His legacy continues to inspire peace and harmony.

Ismail al-Faruqi (1921-1986, Palestine/USA)--A scholar known for his work in Islamic studies and interfaith dialogue. Founded the International Institute of Islamic Thought (IIIT).

Kemal Atatürk (1881-1938, Turkey)--Founder and first President of the Republic of Turkey. Modernized Turkey's educational system, encouraged European ways of life, introduced the Latin alphabet, and promoted women's emancipation.

Malcolm X (el-Hajj Malik el-Shabazz) (1925-1965, USA)--Embraced Islam and promoted racial equality within an Islamic framework. Advocated for unity among Muslims worldwide.

Malek Bennabi (1905-1973, Algeria)--Argued that the decline of Islamic civilization was due to a lack of intellectual creativity and new ideas. Stressed the need for an environment that empowered individuals.

Mehmet Akif Ersoy (1873-1936, Turkey)--Islamic modernist, poet, and author of Turkey's national anthem. Advocated for Islamic revival through education and ethical reform.

Mohammad Natsir (1908–1993, Indonesia)--Islamic thinker and politician. Emphasized democracy, education, and an Islamic-oriented yet pluralistic society.

Muhammad Ali, Maulana (1878–1931, India)--A prominent leader of the Khilafat Movement and a close associate of Mahatma Gandhi. Strongly promoted Hindu-Muslim unity and independence.

Mohammed Hussein Haikal (1888-1956, Egypt)--Influenced by Muhammad Abduh's reforms, he emphasized that Islamic civilization was historically built on science and rationalism--the same foundation on which Western civilization thrives today. Author of *The Life of Muhammad* (Hayat Muhammad).

Muhammad Asad (1900-1992, Austria/Pakistan)--A convert to Islam and author of *The Road to Mecca*. Advocated for the revival of Islamic values in modern governance.

Muhammad Iqbal (1877-1938, India)--Philosopher and poet who envisioned a reformed Muslim identity based on *ijtihad* and education. Believed that education was the key solution to the Ummah's challenges.

Muhammad Rashid Rida (1869-1935, Egypt)--A disciple of Abduh, he led modernization efforts and advocated for greater openness to science.

Musa Bigiev (1870-1949, Tatarstan)--Referred to as the "Luther of Islam," he was a key figure in the Jadid movement for educational and religious reform.

Said Nursî (1877-1960, Turkey)--Opposed Atatürk's policies but promoted a peaceful Islamic revival, emphasizing the compatibility of Islam with modern science. Sheikh Mahmoud Shaltut (1893-1963, Egypt)--A leading scholar of the Abduh school of thought, he rose to become the Grand Imam of Al-Azhar.

Shibli Nomani (1857-1914, India)--Islamic scholar with a modern outlook. Founder of Shibli National College and Darul Mussanifin (House of Writers) in Azamgarh.

Syed Ameer Ali (1849-1928, India)--A jurist and historian who wrote extensively on Islamic history and modern development.

Taha Hussein (1889-1973, Egypt)--One of Egypt's most influential intellectuals. Worked to modernize Egyptian society and sought to reconcile Islamic tradition with Western thought.

Zakir Husain, Dr. (1897–1969, India)--Statesman and educationist. Vice-Chancellor of Aligarh Muslim University and the first Muslim President of India. Strong advocate of modern education.

Ziya Gökalp (1876–1924, Turkey)--Promoted Islamic values while embracing modern nationalism.

Source - Encyclopedia Britannica/Wikipedia



PICKS OF THE CHIEF EDITOR

10 HEALTH TRENDS OF 2025 REVOLUTIONIZING HEALTHCARE*

Revolutionary Health Trends in 2025

2025 is poised to be a pivotal moment of transformative changes in medicine. Groundbreaking technological advancements will reshape healthcare, enhancing efficiency and enabling individuals to access and understand their health information more easily.

1. Precision Medicine



The Royal Society of Thailand (2020) defines Precision Medicine as a medical approach that delivers highly effective and personalized health treatments by targeting specific factors such as genetics, environment, lifestyle, and more. Precision medicine can maximize treatment efficacy while minimizing unwanted side effects. It represents a revolution in modern medicine and healthcare that deserves significant attention.

2. Telehealth

The COVID-19 pandemic has fundamentally transformed how we access medical care. Telehealth allows patients to consult virtually with healthcare professionals, receive follow-up care, and learn about disease prevention without a hospital visit, reducing the risk of respiratory infectious diseases. Technological advancements, such as smartphones, wearable devices, and medical applications, have made it easier for patients to schedule appointments and access diagnostic results with a tap on their devices. Telehealth has also broadened healthcare access to patients in remote areas or those facing mobility challenges.

3. Mental Health Tech

Mental health technology plays a crucial role in supporting individuals struggling with anxiety, post-traumatic stress disorder (PTSD), and other mental health challenges. AI-powered therapy apps and virtual reality treatments offer accessible, personalized care, allowing individuals to receive therapy from virtually anywhere and encouraging them to seek mental health therapy.

4. Wearable Health Tech



Once a basic step counter or fitness tracker, smartwatches have evolved to monitor various health metrics, including blood pressure, blood sugar levels, and early signs of health conditions. This easy access to personal health information empowers individuals to stay informed about their physical well-being and encourages them to take a more active role in maintaining their health.

5. Gut Health and Microbiome Research



* Source: <https://www.medparkhospital.com/en-US/lifestyles/10-health-trends-of-2025>

The gut microbiome is a critical factor for overall health, influencing digestion to mental well-being. In 2025, microbiome research is expected to grow significantly, with scientists gaining a deeper understanding of how these microbial communities affect human health, helping to develop more sophisticated and effective probiotics and prebiotics.

6. Sustainable and Ethical Health Choices

Consumers are becoming increasingly conscious of the environmental and ethical impacts of their health and wellness practices. These lead to the popularity of plant-based nutrition and eco-conscious fitness equipment. In 2025, we anticipate increased products and services that reflect these values.

7. Artificial Intelligence (AI) and Machine Learning in Disease Diagnosis



With the ability to rapidly analyze vast amounts of data with precision, Artificial Intelligence (AI) and Machine Learning are revolutionizing disease diagnosis. These technologies enable early detection of illnesses and more accurate prediction of personal health trends. In 2025, the integration of AI-driven diagnostics will play an important role. Leveraging AI in analyzing medical data—such as blood tests, medical imaging, and medical history—will lead to faster, more accurate diagnoses, allowing for timely and personalized treatments tailored to each patient's unique health profile.

8. Holistic and Integrative Health Approaches

The holistic health care of the body, mind, and spirit -- combining conventional medicine with alternative therapies, such as acupuncture, yoga,

and herbal treatments -- is becoming more popular. This merging of diverse healthcare practices allows individuals to choose personalized approaches that best suit their needs, promoting a balanced, sustainable quality of life.

9. Health Gamification

The integration of games into health and fitness motivation is becoming an increasingly popular approach. By incorporating elements such as earning points or receiving rewards for engaging in exercise or consuming healthy foods, health gamification encourages individuals to take a greater interest in their well-being. By 2025, transforming health care into an engaging, game-like experience is anticipated to become a pivotal strategy for promoting healthy lifestyles.

10. Advanced Genomic Research

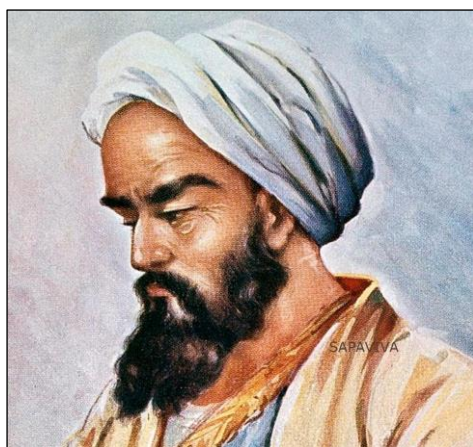


Genomic research is unlocking new avenues of understanding in human biology, providing foundational genetic insights, and enhancing our knowledge of the mechanisms underlying various diseases, particularly genetic disorders and cancers. Genetic data can help healthcare professionals devise appropriate and personalized treatments according to the unique genetic profiles of individuals.

Conclusion

The health trends anticipated for 2025 signal a significant transformation of the healthcare landscape. Treatments will become increasingly precise and personalized, emphasizing holistic care that addresses physical and mental well-being driven by cutting-edge technology. People will have easier and quicker access to health information and medical services. 2025 will revolutionize healthcare, ushering in a new era of precision and accessibility that promotes sustainable and improved well-being.

**MOHAMMAD IBN ZAKARIYA
AL-RAZI***
(864 - 930 AD)



Abu Bakr Mohammad Ibn Zakariya al-Razi (864-930 AD) was born at Ray, Iran. Initially, he was interested in music but later on he learnt medicine, mathematics, astronomy, chemistry and philosophy from a student of Hunayn Ibn Ishaq, who was well versed in the ancient Greek, Persian and Indian systems of medicine and other subjects. He also studied under Ali Ibn Rabban. The practical experience gained at the well-known Muqtadari Hospital helped him in his chosen profession of medicine. At an early age, he gained eminence as an expert in medicine and alchemy, so that patients and students flocked to him from distant parts of Asia.

He was first placed in-charge of the first Royal Hospital at Ray, from where he soon moved to a similar position in Baghdad. There, he remained the head of its famous Muqtadari Hospital for a long time. He moved from time to time to various cities, especially between Ray and Baghdad, but finally returned to Ray, where he died around 930 AD. His name is commemorated at the Razi Research Institute near Tehran.

Razi was a Hakim, an alchemist and a philosopher. In medicine, his contribution was so significant that it can only be compared to that of Ibn Sina. Some of his works in medicine e.g. *Kitab al-Mansoori*, *Al-Hawi*, *Kitab al-Mulooki* and *Kitab al-Judari wa al-Hasabah* earned everlasting fame. *Kitab al-Mansoori*, which was translated into Latin in the fifteenth century AD, comprised ten volumes and dealt exhaustively with Greco-Arab medicine. Some of its volumes were published separately in Europe. His *al-Judari wal Hasabah* was the first treatise of smallpox and chicken pox, and is largely based on Razi's original

contribution. It was translated into various European languages. Through this treatise, he became the first to draw clear comparisons between smallpox and chicken pox. *Al-Hawi* was the largest medical encyclopaedia composed by then. It contained on each medical subject all-important information that was available from Greek and Arab sources, and this was concluded by him by giving his own remarks based on his experience and views. A special feature of his medical system was that he greatly favoured cure through correct and regulated food. This was combined with his emphasis on the influence of psychological factors on health. He also tried proposed remedies first on animals in order to evaluate in their effects and side effects. He was also an expert surgeon and was the first to use opium for anaesthesia.

In addition to being a physician, he compounded medicines and, in his later years, gave himself over to experimental and theoretical sciences. It seems possible that he developed his chemistry independently of Jabir Ibn Haiyan. He has portrayed in great detail several chemical reactions and also given full descriptions of and designs for about twenty instruments used in chemical investigations. His description of chemical knowledge is in plain and plausible language. One of his books called *Kitab-al-Asrar* deals with the preparation of chemical materials and their utilization. Another one was translated into Latin under the name *Liber Experimentorum*. He went beyond his predecessors in dividing substances into plants, animals and minerals, thus in a way opening the way for inorganic and organic chemistry. By and large, this classification of the three kingdoms still holds. As a chemist, he was the first to produce sulphuric acid together with some other acids, and he also prepared alcohol by fermenting sweet products.

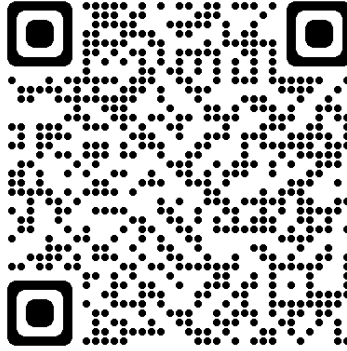
He was a prolific author, who has left monumental treatises on numerous subjects. He has more than 200 outstanding scientific contributions to his credit, out of which about half deal with medicine and 21 concern alchemy. He also wrote on physics, mathematics, astronomy and optics, but these writings could *not* be preserved. A number of his books, including *Jami-fi-al-Tib*, *Mansoori*, *al-Hawi*, *Kitab al-Judari wa al-Hasabah*, *al-Mulooki*, *Maqalah fi al-Hasat fi Kulla wa al-Mathana*, *Kitab al-Qalb*, *Kitab al-Mafasil*, *Kitab-al-'Ilaj al-Ghoraba*, *Bar al-Sa'ah*, and *al-Taqseem wa al-Takhsir*, have been published in various European languages. About 40 of his manuscripts are still extant in the museums and libraries of Iran, Paris, Britain, Rampur, and Bankipur. His contribution has greatly influenced the development of science, in general, and medicine, in particular.

* Source: *Personalities Noble*, 2nd Edition, 2000, Edited by Hakim Mohammed Said, published by LAS with permission of Hamdard Foundation Pakistan.

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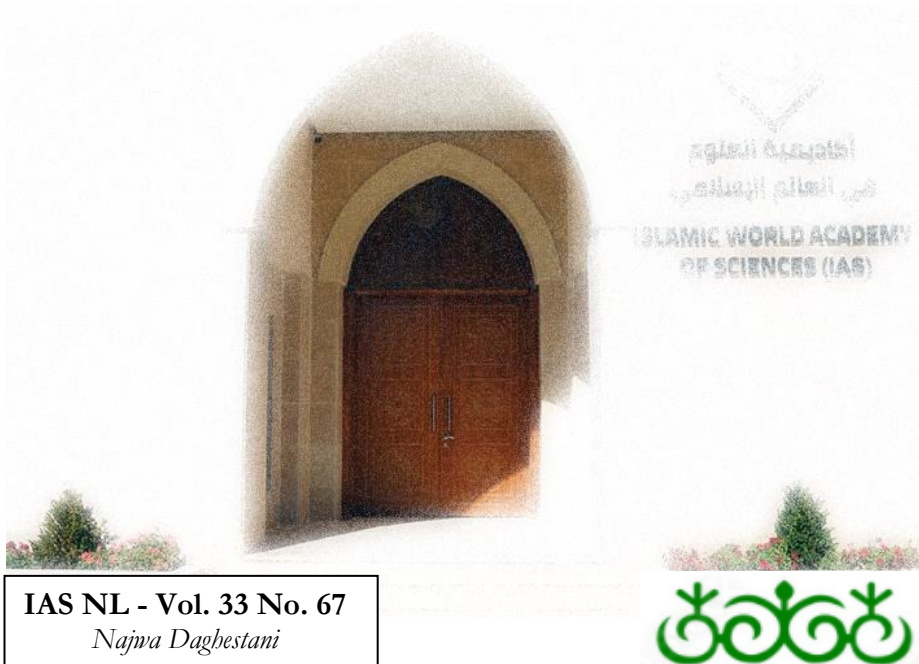
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