

Paweł Kawalec

The John Paul II Catholic University of Lublin

<https://orcid.org/0000-0001-7618-8298>

Jacek Poznański

Ignatianum University in Cracow

<https://orcid.org/0000-0002-8158-564X>

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An outline of the history of science research in Poland

Summary

DEFINITION OF THE TERM: Science of science, broadly understood, refers to a group of research disciplines concerned with science viewed from three perspectives: theoretically, as a system of knowledge; practically, as institutionalized research activity; and culturally, as a formative activity within specific historical, social, economic, political, legal, and cultural contexts. Science of science investigates the products of scientific cognition, the processes of scientific development, methodologies, organisational structures, social functions, and the relationships between science, technology, and culture.

HISTORICAL ANALYSIS OF THE TERM: In the pre-war period, an innovative initiative by S. Michalski to establish a science of science was developed within the milieu associated with the J. Mianowski Fund and its journals “Nauka Polska” and “Organon”. In the post-war era, efforts to revive this tradition were undertaken, most notably through the initiative of T. Kotarbiński at the Polish Academy of Sciences (PAN), and at universities such as Jagiellonian University, the University of Warsaw, Adam Mickiewicz University in Poznań, and the Catholic University of Lublin.

DISCUSSION OF THE TERM: Multiple conceptions of science of science have developed in Poland, ranging from the idea of an integral science of science, through praxeological and federative models, to interdisciplinary research shaped by social challenges. These conceptual frameworks

have influenced the delineation of the subdisciplines of science of science, which are briefly described here, as well as the relationships between them.

SYSTEMATIC REFLECTION WITH CONCLUSIONS AND RECOMMENDATIONS: Despite its current strong orientation toward quantitative approaches, science of science should not abandon its anthropological perspective, particularly in response to challenges such as disinformation, science denialism, and unethical behaviour. Critical challenges (climate change, social inequalities, etc.) call for increased openness, interdisciplinarity, and improved communication between the scientific community and society.

Keywords: conceptions of science of science, subdisciplines of science of science, science of science journals, science of science institutions

Definition of the term

'Science of science', broadly understood, refers to a group of research disciplines concerned with science viewed from three perspectives: theoretically, as a system of knowledge; practically, as institutionalized research activity; and culturally, as a formative activity within specific historical, social, economic, political, legal, and cultural contexts. Science of science investigates the products of scientific cognition, the processes of scientific development, methodologies, organisational structures, social functions, and the relationships between science, technology, and culture. The emergence of science of science reflected a drive to develop synthetic conceptions of science that would account for the complexity of scientific activity and the interconnections among its various aspects – traditionally studied in isolation – with the aim of improving the organisation of this activity.

In the Polish context, science of science addresses not only the natural and exact sciences, but also the humanities and applied sciences, such as engineering and technology. The field considers science as both a type of knowledge, examined from multiple angles, and a form of activity – particularly research and teaching – conducted within organised institutional structures.

Over time, different terms have been used to describe science of science, including *nauka o wiedzy* ('science of knowledge'), *nauki o nauce* ('sciences of science'), and *scientologia* ('scienciology'). The Polish term *naukoznawstwo* ('science of science') gained widespread acceptance in the 1960s, largely due to the influence of Tadeusz Kotarbiński. In English-speaking countries, the term 'science of science' was initially adopted as an equivalent, whereas 'science studies' came to be associated more closely with the sociology of scientific knowledge. More recently, 'science of science' has been used more narrowly to denote quantitative scientometric research, while 'science studies' are considered broader in scope. Equivalent terms in other languages include *scientologie* in French, *Wissenschaftsforschung* and *Wissenschaftslehre* in German, and *naukoviedenie* in Russian.

In his definition of science of science, Kotarbiński emphasised its practical objectives, particularly the development of optimal institutional support for scientific research, especially by public administration.

He grounded the discipline in a theory of science based on a philosophical and logical foundation (the latter encompassing semiotics, formal logic, and general methodology).

Within science of science, the following groups of subdisciplines are distinguished: 1. philosophical (philosophy of science, which includes metaphysics, epistemology, and axiology of science); 2. formal (semiotics of scientific language, formal logic of scientific reasoning, and general methodology of science); 3. humanistic (history of science, psychology of scientific creativity, sociology of science, economics of science, and science policy); 4. applied (bibliometrics, scientometrics, scientific information and communication, science management and organisation, ethics of science, praxeology, and forecasting the development of science). Some scholars have also included theology of science as a distinct subdiscipline which addresses the coherence and complementarity of Christian and naturalistic worldviews.

Science of science can be divided into theoretical and practical branches. The theoretical branch is descriptive and analytical and seeks to understand the nature, dynamics, and functions of science in culture and society. It includes philosophy (theory) of science, epistemology, logic of science, methodology of science, history of science, psychology of science, and sociology of science. The practical branch is normative and synthetic and focuses on the organisation of science, the organisation of research and development, and science policy, which includes praxeology, organisational and management sciences, scientific information and communication, and the economics and politics of science. Sometimes the term 'science of science' is used narrowly to refer only to the practical, broadly humanistic disciplines of science of science. In such cases, as a form of pragmatic epistemology (Kotarbiński) it is contrasted with theoretical epistemology, which focuses on scientific cognition as a set of products. Practical science of science, particularly in its praxeological formulation, aims to enhance science's potential, improve its organisation and efficiency, and support the coordination and planning of research activities. A further distinction is occasionally made between general science of science – including philosophy of science, general methodology of sciences, and the history of scientific ideas – and specialised science of science.

In Anglo-Saxon contexts, science of science is often viewed as the theoretical foundation of science policy, which is itself considered part

of broader economic policy. Practical science of science has concentrated on rational resource allocation, the effectiveness of scientific research, the need for planning and coordination, the prioritisation of large-scale research programmes, the avoidance of duplication and inefficiencies, and the development of scientific and technical information systems. These information systems have become vital engines for scientific advancement, innovation, and broader socio-economic transformations.

The notions of practical science of science, the economics of science, and science policy were consolidated after 1967 and, from 1970 onwards, were adopted by organisations such as UNESCO and the International Council of Scientific Unions. These institutions are involved in the coordination and funding of scientific research and have inspired many national governments to establish decision-making bodies at the highest levels, basing their science policy recommendations on empirical research and scientific principles. The demand for research to support science policy led to the creation of national and international institutions, including the International Council of Science Policy Studies, established in 1974. Since the mid-1970s, research in practical science of science – pragmatic epistemology – has become a dynamically developing branch of science of science, complementing metascientific research in the philosophy (theory) of science, supported by the history of science and the sociology of science.

Differences in the conceptualisations of science of science include debates over the interrelations among its subdisciplines, their autonomy in relation to other academic fields, the methodologies appropriate to science of science, and their connections to other meta-theoretical inquiries.

Historically, the development of science of science has proceeded through several distinct phases: 1) a theoretical-philosophical phase (before and shortly after World War II); 2) a political-ideological phase (in the 1950s and 1960s); 3) a socio-economic phase (from the late 1960s); 4) a bibliometric-computational phase (since the early 21st century). These phases mark periods of increased activity in particular approaches but do not exclude the coexistence of different research orientations within each period.

Historical analysis of the term

In antiquity, the origins of the science of science can be traced to the philosophical reflections of the Greeks – particularly Aristotle – on knowledge. Systematic reflection on science of science was further developed by modern scientists and philosophers, notably in Poland by scholars affiliated with the Commission of National Education. The actual emergence of science of science as a research field occurred at the end of the 19th century. P. Hübner (2023) identifies a range of sources of knowledge about science: academic and propaedeutic approaches aimed at orienting students within their fields of study; encyclopaedic presentations of the current state of scientific achievement; the recognition of science as institutionalised knowledge; interest in the biographies of eminent scholars and in the determinants and methods of scientific development; historical treatments of individual disciplines or of science as a whole.

In Poland, the theoretical foundations of science of science were established before World War II by a group of contributors to *Poradnik dla samouków* [*Guidance for the self-taught*], edited by S. Michalski and A. Heflich. These contributors included members of the Lwów-Warsaw School and associates of the Scientific Department of the J. Mianowski Fund, under Michalski's leadership. The demand for knowledge about science stemmed from practical challenges, especially those associated with building a scientific infrastructure from the ground up in the newly reconstituted Polish state, formed from the territories of the three former partitions. Michalski envisioned the establishment of a centre for systematic research in science of science, and toward this end he founded the journal "Organon" in 1936.

In 1927, the term 'science of science' (*nauka o nauce*) was used by Tadeusz Kotarbiński, and the term 'science of science' (*naukoznawstwo*) appeared in the name of the Circle of the Science of Science (*Koło Naukoznawcze*), established in 1928 at the J. Mianowski Fund. Within this group, M. and S. Ossowskis delivered a presentation titled *Problematyka naukoznawcza* [*The subject matter of the science of science*]. In 1935, the Ossowskis published an article *Nauka o nauce* [*The Science of Science*], outlining a draft concept for a new academic discipline. An alternative conception of the field had earlier been proposed in 1925

by Florian Znaniecki in his article *Przedmiot i zadania nauki o wiedzy* [*The Subject Matter and Tasks of the Science of Knowledge*].

Before World War II, research within science of science in Poland was conducted by non-academic institutions such as the J. Mianowski Fund – Institute for the Advancement of Science – as well as state bodies involved in science policy, including the Ministry of Religious Denominations and Public Education and the National Culture Fund. The J. Mianowski Fund published two journals, “Nauka Polska” (“Polish Science”) and “Organon”, which featured expanded versions of presentations from the Science of Science Circle, reports on the state and needs of various disciplines, proceedings from Polish Science Congresses, biographies of scientists, and information about scientific institutions and organisations.

After the war, Poland’s communist authorities shut down the “Nauka Polska” (“Polish Science”) yearbook (1947) and launched the monthly journal “Życie Nauki” (“Life of Science”) under the supervision of the Science of Science Seminar (*Konwersatorium Naukoznawcze*), affiliated with Jagiellonian University. Similar initiatives emerged in 1946 in Poznań (the Science of Science Circle) and in Warsaw (the Science of Science Section at the University of Warsaw). In 1946 in “Życie Nauki”, Ludwik Fleck published the article *Problems of the Science of Science (Problemy naukoznawstwa)*, in which he defined science of science as a distinct science “based on observation and experiment, as well as on historical and sociological research”. In communist Poland, science of science was oriented toward examining the social impact of science. In 1948, the journal was relocated to Warsaw and designated as the official publication of the First Congress of Polish Science, while simultaneously being subjected to ideological pressure. The authorities blocked various initiatives from the science of science community, focusing solely on shaping science policy in line with the prevailing political doctrine.

Following the establishment of the Polish Academy of Sciences (*Polska Akademia Nauk*, PAN) in 1951/1952, the conduct of science of science research was discontinued, and “Życie Nauki” ceased publication. The emphasis shifted to promoting ideological or chronicle-style writings. PAN continued to publish the quarterly “Nauka Polska” and established institutions separate from science of science, including the

Commission on the History of Science (1952) and the Institute for the History of Science (1953). Beginning in 1956, the Commission published “Kwartalnik Historii Nauki i Techniki” (“Quarterly Journal of the History of Science and Technology”). In 1958, the Presidium of PAN established the History of Science and Technology Department. In 1960, the Commission on the History of Science was transformed into the Section for the History of Science and Technology of the Commission on Historical Sciences of PAN, and in 1963 into the Commission for the History of Science and Technology of PAN. In these institutional developments, science came to be ideologically and organisationally subordinated to technology.

The tradition of science of science was continued by S. Kamiński, who from 1957 headed the Department of Methodology of Sciences at the Faculty of Christian Philosophy of the Catholic University of Lublin. In his book *Pojęcie nauki i klasyfikacja nauk* (*The Concept of Science and the Classification of Sciences*) (1961), he developed the Ossowski’s conception of the ‘science of science’. At the University of Łódź, J. Szczepański carried forward the tradition of research in the sociology of science, heading the Research Unit on Higher Education, which was transferred to Warsaw in 1962 as the Inter-University Institute for Higher Education Studies, where a significant role was played by J. Goćkowski, head of the Sociology of Science Section of the Polish Sociological Association.

In 1963, on the initiative of Kotarbiński, the Commission for Science of Science was established under the Presidium of PAN, and in 1969 it was reorganised into the Committee for Science of Science of PAN. In 1965, the Science of Science Colloquium began operating within PAN, supported institutionally by the Department for the History of Science and Technology and the Department of Praxeology. Also in 1965, the quarterly “Zagadnienia Naukoznawstwa” (“The Science of Science Quarterly”) began publication.

From 1974, the Institute for Science Policy and Higher Education began analysing practical issues concerning the organisation of science. Research shifted toward new themes in the economics of science, moving away from traditional academic value systems. The Department of Praxeology was reintegrated into PAN in 1974 as part of the Institute of Organisation and Management, and in 1976 became part of the

Institute of Philosophy and Sociology. The unit's name was expanded to the Department of Praxeology and Science of Science. As a result of martial law, the separate community experienced significant fragmentation. Since the dissolution of other research units and publishing outlets, the Commission for Science of Science and the quarterly "Zagadnienia Naukoznawstwa" have remained the principal centres of activity in the field.

Discussion of the term

Original perspectives on the subject matter of science of science were articulated during pre-war debates. In his 1925 article and subsequent works from the 1940s and 1950s, Florian Znaniecki situated science of science within the broader domain of knowledge, which, beyond scientific knowledge, also encompassed pragmatic, moral, theological, and philosophical knowledge – each regarded as a coherent system of ideas governed by its own criteria of truth. In contrast, the Ossowskis confined the scope of science of science to science as it had developed since the scientific revolution. They distinguished two fundamental branches of science of science: the epistemological, which considers science as a distinct mode of cognising the world, and the anthropological, which views science as a specific sphere within broadly defined culture. They identified the following principal subdisciplines of science of science: philosophy of science (concerned with the clarification of scientific concepts, the classification of scientific fields and disciplines, and issues related to the general methodology of science); psychology of science (focused on the study of scientific creativity and the conditions that support it, as well as the analysis of scientists' research activities); sociology of science (exploring the relationship between science and economic, social, and cultural life, along with other areas of social activity); practical-organisational issues (including the establishment and organisation of scientific institutions, the application of science in practice, legal regulations, and the relationship between science and technology); and the history of science (examining the development of scientific ideas and the evolution of science and its institutions). In later works – particularly in international contexts – the subject matter, scope, and

structure of science of science were generally narrowed, often omitting their theoretical foundations. This trend began with J.D. Bernal's 1939 monograph *The Social Function of Science*, in which the field of the science of science was limited primarily to practical matters such as the organisation of science and research activity, the financing of science, the efficiency of scientific research, the assessment of science's social functions, and its interrelations with social processes. The use of the term 'science' contributed to this narrowing, often implying a focus on the natural and exact sciences or granting them a privileged status in science of science analyses, due in part to their stronger associations with innovation and the economy.

In post-war science of science literature, however, the term 'science' was used more broadly, encompassing not only the natural and exact sciences but also the humanities and various applied sciences (e.g., technical and engineering disciplines). Kotarbiński referred to science of science using the term 'pragmatic epistemology', which he defined as primarily concerned with the study of the organisation of cognition-oriented processes. In his textbook *Elementy [Elements]* (1929), as W. Gasparski noted, Kotarbiński identified design as the defining feature of the applied sciences, whose method involves transforming an object according to a plan by equipping it with features essential to the intended outcome.

Beyond differences in scope, various conceptions of science of science diverged in their treatment of the relationships among subdisciplines and the question of their integration. In the early post-war period, science of science was treated as a distinct, unified discipline. This approach was criticised for granting excessive autonomy to its subdisciplines, which hindered their integration. Moreover, increasing specialisation was seen as progressively narrowing the range of research methods common to the entire field, potentially resulting in a lack of coherence and the risk of dilettantism.

Praxeologists developed a conception of science of science as an integral part of the general theory of efficient action. This approach focused on evaluating the effectiveness of scientific research as goal-directed activity aimed at specific outcomes, such as the discovery of new laws, the formulation of theories, and the resolution of problems. It encompasses three main dimensions: 1) the achievement of significant

cognitive outcomes (through the assessment of research methods and the reliability of results); 2) the efficiency of resource use in generating results useful to the economy (through the optimisation of research and infrastructure resource management); 3) the enhancement of the rationality of social attitudes via the dissemination of research results (through the evaluation of the effectiveness of scientific communication tools and the popularisation of science). The objective of science of science, in this view, is to increase the efficiency of scientific activity through institution-building, resource allocation, workforce training, personnel policy, and practical guidelines for science organisation and resource management. However, this approach has been criticised for marginalising basic research, which often does not yield immediate results; for lacking clear criteria to evaluate research efficiency, particularly in the humanities; and for neglecting the broader social and cultural contexts in which science operates.

An alternative conception of science of science began to gain traction in the early 1960s, presenting the field as a 'federation' of research directions drawn from various disciplines, including sociology, economics, psychology, history, logic, management sciences, and law. This approach was criticised for reinforcing the classical disciplinary structure, for lacking a conception of effective collaboration across disciplines, and for overlooking interdisciplinary issues.

With the emergence of international institutions (such as the OECD Ministers' Conference in Frascati (1967), UNESCO's work on science classification and the founding of the International Council of Science Policy Studies in 1974, affiliated with the International Union of History and Philosophy of Science and Technology), science of science came to be viewed as especially valuable for addressing interdisciplinary problems that fell outside the boundaries of traditional subdisciplines. These included scientometric research on the dissemination of scientific publications and public engagement with them; the development of journal rankings, indicators of scientific productivity, and assessments of the economic impact of research and development; as well as the creation of methods for forecasting scientific development and evaluating the consequences of scientific applications. This approach also encompassed analyses of methodological changes across disciplines driven by the introduction of computer science and information technologies. As a result of the

emergence of specialised subdisciplines addressing such topics (e.g., bibliometrics, scientometrics, scientific information, and ethics of science) and their increasing entanglement with science policy, this model of science of science gradually gave way to the federative conception.

An oft-cited overview of the thematic scope of science of science was prepared by B. Walentynowicz, who, based on an analysis of science of science materials made available by UNESCO, identified the following areas as falling within the field of the science of science: philosophy of science and theory of science; ethics of science; sociology of science; classification of scientific fields and disciplines; questions of creativity and the psychology of scientific personnel; the history of the organisation of science and scientific societies; the organisation, administration, and management of research and development; economics, productivity, efficiency, and the financing of R&D; science and technology statistics; planning of R&D and government science and technology policy; technology forecasting and futurology; comparative science policy; and science and technology legislation.

In his review of theoretical issues in science, Kamiński included the following among the sciences of science: history of science, philosophy of science, logic of science, methodology of science, psychology of science, sociology of science, economics of science, and science policy.

In recent years, the following areas of science of science have developed rapidly: the transfer of knowledge and innovation from science to the economy; the strategic management of higher education institutions (particularly in relation to the outcomes of foresight studies); the development of qualification frameworks within the Bologna Process; the parametrisation of scientific research; the protection of intellectual property; and the enhancement of human capital in research and development (R&D) activities.

Subdisciplines of science of science

Currently, science of science research is primarily conducted within its various subdisciplines.

Metascience, in its broadest sense, is the science of science. Typically narrowed to a formal approach to the structure of science as

an abstract system, it encompasses the semiotics of scientific language, the formal logic of scientific reasoning, and the general methodology of science.

The philosophy of science addresses fundamental questions concerning the nature of scientific knowledge, its sources, boundaries, and methods of justification. It analyses the language of science – its structure and functions – as well as the relationship between science and systems of values. From a praxeological perspective, the formation and operation of the sciences are regarded as historically and socially shaped wholes, influenced by socio-organisational instruments and, at times, by reciprocal dependencies between scientific research and the economy.

The methodology of science focuses on the study of scientific methods, including their assumptions, principles, and procedures. It describes and analyses the rules of scientific procedures and codifies standards of conduct. Following K. Ajdukiewicz, two types of methodologies of science are distinguished: apragmatic methodology (the logic of knowledge, applied logic, or formal theory of science), which uses tools from formal logic and mathematics to formally analyse the products of science, such as reasoning and the structure of scientific language; pragmatic methodology (practical or pragmatic logic, the theory of rational scientific procedure), which examines science as a process of action, drawing on the humanities, empirical and applied disciplines, and praxeology. The methodology of science may be descriptive (analytical or historical) when it reconstructs methods used in scientific practice, or normative when it critically evaluates the assumptions and reasoning involved. In Ajdukiewicz's view, methodology constitutes a reconstruction and codification of scientific procedures and their justification in relation to the goals science is expected to serve. The diversity of methodological approaches supports the recognition of the methodology of science as a complex discipline focused on the study of the types and structures of scientific activity and on the construction and functions of scientific theories developed within paradigms shaped by specific social and historical contexts.

The history of science examines the development of science over time, analysing both the progression of scientific knowledge (internal history) and the social determinants that shape it (external history). It studies the evolution of scientific ideas, organisational forms of science,

research methods, and the impact of science on society. In Kotarbiński's pragmatic epistemology, the history of science includes not only the development of ideas, but also the operational dimension, such as scientific toolkits, the creative struggle with problems, errors, and the reciprocal relationship between science, the economy, and technology. The goal of such research is to identify patterns of dependence between circumstances and outcomes, as well as between the results of different disciplines, such as between purely cognitive achievements and their practical applications, or the influence of results in one field on outcomes in others. The history of science also reveals challenges related to the growth of science, such as the increasing difficulty in mastering the knowledge required for competent practice in a field; increasing specialisation, narrowing intellectual horizons of experts; the growing need for synthesis and information management; deepening interdependence between science, technology, and the economy; and the expanding administrative burdens on scientists. Among the sciences of science, the history of science is the most institutionally established, with its organisational forms having emerged as early as in the 19th century.

The psychology of science investigates the cognitive processes involved in scientific activity, including the creation, acquisition, and processing of knowledge; the role of thinking, abilities, and intuition in discovery; personality traits; cognitive styles; problem-solving strategies; and the motivations conducive to scientific creativity. It also examines the creative process and its subjective and situational determinants, the criteria for creative solutions, methods of fostering creativity, the social determinants of creativity, and psychological challenges related to institutional contexts. At the intersection of psychology, philosophy of science, and cognitive science, this field addresses scientific discovery, the nature of scientific problems, mechanisms of idea generation, and the formulation and resolution of hypotheses. Both formalised modes of discourse and less structured strategies – such as analogy, heuristics, insight, and intuition – are analysed. In terms of institutional development, the psychology of science is one of the youngest subfields within science of science.

The sociology of science examines science as a social phenomenon. It investigates interactions among scientists, the impact of social norms on research, the social roles of scholars, science's place

in society, and issues related to the organisation of research. It focuses on processes of scientific education and communication, as well as the social status of scientists. The 'strong programme' of the 1970s gave rise to the emergence of the sociology of scientific knowledge, defined as a social construct and departing from traditional views of science as objective and independent. It highlights specific scientific practices such as laboratory negotiations, research team dynamics, and the role of institutions in producing scientific facts. A key theoretical contribution was B. Latour's actor-network theory. A distinct line of thought developed by Goćkowski focuses on the ethos of science as a normative style of scientific work, characterised by objectivity, rationalism, critical thinking, conceptual clarity, and intellectual independence. He also emphasised the importance of scientific tradition, which ensures continuity in scientific worldviews and sustains scientific authority. This tradition includes the purification of science from non-scientific elements, the reinterpretation and verification of cognitive values, the challenging and formulation of new concepts, and the adaptation and refinement of existing problem situations.

The economics of science explores the economic dimensions of scientific activity, including researcher productivity, the efficiency of scientific work, indicators of scientific development, science funding, scientific potential, and the economic effects of science policy. It also investigates how economic factors influence research directions. Within the framework of economic growth theory, scientific knowledge is treated as an economic resource, with attention given to its production, distribution, and value in a knowledge-based economy, as well as to the processes of commercialisation, innovation, and technology transfer at both local and global levels. The field also considers the effects of public policy, patent systems, and open-access models on the development and dissemination of knowledge across different sectors of the economy.

Science policy focuses on shaping strategies, regulations, and actions that support the development of science and technology. This includes setting research directions and priorities, designing scientific programmes, allocating public and private funding, identifying priority research areas, developing scientific infrastructure, fostering innovation, and promoting international scientific collaboration. Science policy also

examines mechanisms of knowledge transfer from science to the economy, particularly through the commercialisation of research findings and support for early-stage technology firms. Normative in character, it investigates how science ought to be developed in response to social, economic, and cultural needs. Its connection with ethics of science is especially relevant in sensitive areas such as genetic research or artificial intelligence. Compared to scientometrics, science policy places greater emphasis on the practical and strategic implications of research. Its analyses inform the governance of science and technology systems, shaping decisions made by governments, international organisations, and research institutions. Contemporary science policy increasingly engages with global challenges, including climate change, sustainable development, and data security.

The legal sciences today hold a significant place among the disciplines of science of science. They address issues related to the regulation of organisations, the operation and financing of scientific institutions (including PAN, research institutes, and institutions of higher education); the protection of intellectual property resulting from scientific research (particularly patents, copyrights, and industrial property rights); the principles governing access to research findings; the ethical standards applicable to research and teaching, as well as to international scientific collaboration.

The ethics of science involves the systematic analysis of the moral norms and principles that regulate scientific activity. It considers the autonomy of research, the various dimensions of scientists' responsibilities, and the societal and environmental impact of scientific work. It also examines the standards for conducting research involving humans and animals. The ethics of science emphasises the sharing of knowledge (openness, transparency) as an ethical value that stands in opposition to the commercialisation and concealment of research findings. It explores how science can support the common good and how to prevent its misuse for harmful ends. It also addresses the issue of equitable access to research results and technologies. The field defines conflicts of interest and their effects on research impartiality and integrity. It highlights the ethical implications of data falsification, plagiarism, self-plagiarism, and other forms of misconduct in scientific publications. Closely tied to science policy, the ethics of science

establishes the boundaries and standards that policy should observe. At the intersection of the ethics of science and the philosophy of science lies a reflection on the values and goals of scientific cognition, particularly in the context of truth and objectivity.

Scientometrics focuses on the quantitative analysis of scientific activity, examining the dynamics of scientific development, its structure, and its efficiency. While often associated with bibliometric analysis of publications and citations, the field encompasses broader areas such as the study of scientific collaboration, the impact of science policy, the evaluation of accomplishments of institutions and researchers, the efficiency of research funding, the assessment of innovation in research projects, forecasting future directions of scientific development, inequalities in access to scientific resources, and the dynamics of international collaboration. Scientometrics integrates statistical methods, artificial intelligence algorithms, and data visualisations to uncover hidden patterns and relationships in large datasets. Commonly used scientometric indicators include the Hirsch index (h-index), the Impact Factor (IF), and more recent metrics such as altmetrics, which account for the dissemination of research through social media and digital platforms. The field also examines networks of scientific collaboration, the geographic distribution of research, and knowledge flows between academic centres and industry. Thanks to its interdisciplinary nature, scientometrics contributes to science policy, research management, and the monitoring of global challenges.

Scientific communication studies the processes through which information is exchanged among scientists, and between science and society, as a driver of knowledge development and its social legitimacy. Within the scientific community, it concerns the dissemination of research results through publications, conferences, data repositories, and digital platforms, all of which foster collaboration and enable the verification of findings. Transparency and accessibility of scientific information are crucial, particularly in democracies, where they support informed civic decision-making, for example on health or climate issues. Major challenges for scientific communication include combating misinformation and addressing ethical controversies in research. In democratic societies, scientific communication fosters dialogue between science and the public, highlighting the importance of transparency, accountability, and inclusivity in scientific practice.

Scientific information focuses on the systems used to collect, store, organise, and disseminate scientific knowledge. Ensuring efficient access to reliable sources of knowledge supports both research activities and communication among scientists. Modern tools, such as bibliometric databases and digital repositories, enable rapid searching and sharing of information, thereby accelerating the circulation of scientific knowledge. This field also evaluates the effectiveness of different models of access to knowledge, including open access, which reduces financial barriers and enhances equity in the use of research findings. Scientific information assesses source quality and addresses challenges related to information overload and the rise of pseudoscience in the digital age. In contrast to scientific communication, which centres on human interaction, scientific information focuses on the infrastructure and tools that facilitate these exchanges. Nonetheless, both fields work closely together to support knowledge flows within academia and between science and society.

Among the practically significant issues addressed from an interdisciplinary perspective that integrates various subdisciplines of science of science are, among others, the classification of scientific fields and disciplines, interdisciplinary research, the development of science and its forecasting, the boundaries of science, the evaluation of science, open science, the commercialization of scientific knowledge, and models of the university.

Systematic reflection with conclusions and recommendations

Science of science was originally conceived as a humanistic discipline, empirically and historically grounded in human agency, in which not only research outcomes but also the processes and determinants under which science is produced were considered essential. This anthropological dimension of science of science is now diminishing as the term 'science of science' is gaining prominence in the literature, largely referring to large-scale, data-driven research employing artificial intelligence that is focused on the analysis of scientific outputs. Nevertheless, ongoing ethical violations, scientific misinformation, and various forms

of science rejection point to the continued relevance of the anthropological perspective.

Today, science of science faces major global challenges such as climate change, pandemics, and social inequality, all of which demand greater openness, interdisciplinarity, and social engagement from science. Some of the most pressing concerns are the rise of misinformation, denialist movements, and the erosion of science's authority in society. Potentially effective responses include strengthening science education, popularising scientific knowledge, and enhancing communication between scientists and the public.

Scientometrics and research management play a vital role in optimising research resources, yet care must be taken to avoid overreliance on quantitative indicators as they can distort the aims of science. Ethics of science and technoscience studies emphasise the need to monitor the consequences of new technologies and to develop standards that promote the responsible implementation of research findings.

Recommendations for science of science include promoting interdisciplinary research, open science, the development of knowledge visualisation tools, and the strengthening of public trust in science through transparency. Contemporary theoretical challenges call for a balanced approach that combines philosophical reflection, empirical analysis, and social engagement.

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