# THE TRANSFORMATION OF THE SCIENCE IN THE AGE OF AI


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# THE TRANSFORMATION OF THE SCIENCE IN THE AGE OF AI

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**Abstract**

This chapter adopts a holistic perspective to examine the transformation of science in the age of artificial intelligence (AI). The increasing integration of AI technologies into scientific research is shown to reshape not only methodological tools, but also the epistemological assumptions, institutional structures, and societal roles of science. AI is approached not merely as a technological advancement, but as a historical threshold that reconfigures scientific practice from within. While AI encompasses a broad spectrum ranging from traditional symbolic logic to contemporary autonomous systems, this chapter focuses on how machine learning (ML) and generative models transform science. By analyzing these data-driven paradigms, it evaluates the key drivers of today's research shifts.The chapter analyzes how data-centered epistemologies, algorithmic modeling, and human–machine collaboration transforms the production of scientific knowledge, the role of the researcher, and the norms of transparency, reproducibility, and scientific authority. It further explores how digital platforms and algorithmic intermediaries restructure the dissemination of science and redefine the relationship between scientific credibility, public visibility, and societal trust.In addition to these global dynamics, the chapter situates the transformation of science within the context of national science policy and governance, with particular attention to the case of Türkiye. Through examples drawn from higher education reform, public-sector AI institutions, and international policy engagement, the study illustrates how national frameworks shape the direction, responsibilities, and societal implications of AI-driven scientific development.The chapter argues that science in the age of AI is undergoing a process of reorganization rather than a crisis. It concludes that the long-term future of science will be determined less by technical capacity than by epistemological choices, ethical principles, and policy frameworks that mediate the relationship between knowledge, power, and society.

***Keywords***

*Artificial Intelligence, Nature of Science, Knowledge Production, Scientific Processes, Knowledge Dissemination*

## Introduction

Science occupies a central position in modern societies as a primary mode of producing knowledge, making sense of the world, and generating predictions. According to Yıldırım (1985), science is defined as a method that seeks to formulate and verify hypotheses with explanatory power by means of controlled observation and logical reasoning grounded in observational results, and it is characterized by being empirical, logical, objective, critical, generalizing, and selective. However, the production and circulation of scientific knowledge have never been shaped solely by these attributes. In every historical period, the tools in use, institutional structures, and societal priorities, together with individual contributions made by human actors to varying degrees, have profoundly influenced and directed how science is updated and how it is understood. From this perspective, the increasingly intensive integration of AI into scientific research processes should be regarded as a historical turning point that generates fundamental transformations not only in the technical methods of science, but also in its nature, functioning, and societal role.

AI systems are now employed across multiple stages of scientific research. Processes such as the analysis of large data sets, pattern discovery, prediction and modeling, literature review, and even hypothesis generation and writing support are increasingly carried out through these systems (Krenn et al., 2022). While these developments expand the speed and scale of scientific production, they also bring the epistemological assumptions of science back into question. In particular, foundational principles of modern science such as human centered knowledge production, causality-based explanation, explainability, and scientific control have become concepts that must be reconsidered in the age of AI (Kitchin, 2014; Messeri & Crockett, 2024; Xu et al., 2021).

The central premise of this chapter is that AI is not merely a tool that accelerates or automates scientific activity (Krenn et al., 2022). Rather, AI should be understood as a socio technical turning point that transforms science at epistemological, institutional, and societal levels. This transformation reopens fundamental questions concerning what scientific knowledge is, how it is produced, by whom it is produced, and in which forms it is legitimized. Accordingly, reflecting on science in the age of AI is not only a debate about technology policy, but also requires a holistic analysis situated at the intersection of epistemology, the sociology of science, and science policy. Indeed, the findings of the World Economic Forum's Future of Jobs Report 2025 indicate that AI is one of the primary driving forces reshaping the global workforce architecture. Eighty six percent of businesses anticipate that AI and information technologies will be the main determinants of their operations by 2030 (World Economic Forum, 2025). While AI and big data skills have become the fastest growing areas of competence, a substantial proportion of companies are redesigning their work processes and transforming employee profiles accordingly. Moreover, it is estimated that approximately thirty nine percent of existing skills will become obsolete by 2030, demonstrating that AI is creating a new cognitive and institutional infrastructure on a global scale, extending well beyond productivity gains alone (World Economic Forum, 2025).

This transformation runs parallel to the changes observed in the production of scientific knowledge. The capacity of AI to reshape labor, expertise, and institutional structures reinforces the rise of computational models that are ranging from pattern recognition to predictive analytics, grounded in data centered accumulation within science. At the same time, the redefinition of the researcher's role around the management of algorithmic systems aligns with an epistemic orientation that prioritizes prediction over explanation. In this way, AI becomes an integral component of a broader paradigm shift, reshaping not only scientific methods but also the institutional and economic environments within which science operates through its modes of recommendation and evaluation (Seker, 2020).

A review of the history of modern science shows that the transformation of scientific practice through technological tools is not a new phenomenon. The spread of the printing press accelerated the circulation of scientific knowledge, the telescope and the microscope expanded the limits of observation, and computer technologies brought simulation and computation to the center of scientific inquiry. What distinguishes AI, however, lies not only in its capacity to transform the instrumental dimension of scientific activity, but in its direct participation in cognitive processes. AI systems are capable of generating data patterns on a scale beyond the capacity of individual researchers to comprehend, and these patterns are increasingly becoming the foundation of scientific knowledge itself (Anderson, 2008).

One of the most striking examples in this regard is the AI based system AlphaFold2, whose developers were awarded the Nobel Prize in 2024. Through this work, protein structure determination tasks that would normally require millions of years under conventional conditions were completed in a very short period of time with a high degree of accuracy. This example demonstrates how a scientific endeavor that would have been impossible to complete even in the pre-AI digital era, when human resources and time costs are taken into account, can now be realized in the present era. At the same time, it provides a compelling case for understanding how research processes are reshaped and how the role of the researcher is reconfigured in the age of AI (AlfaFold2, 2025).

It is increasingly recognized that the new capacities and approaches introduced by AI into scientific research signal a period in which scientific understanding, explanation, and decision-making processes are being fundamentally restructured (UNESCO, 2021). As clearly illustrated by the AlphaFold2 example discussed above, this period is marked by a shifting balance between the explanatory character of scientific knowledge and its predictive capacity. In the traditional understanding of science, theory occupies a central role by making sense of observations and providing causal explanations. By contrast, AI based models are often able to generate highly accurate predictions without clearly demonstrating the causal mechanisms upon which those predictions are based. As a result, scientific inquiry may increasingly move away from the question of why phenomena occur toward an emphasis on how they co-emerge or correlate. This epistemological shift generates both new opportunities and new debates with regard to the reliability of science and its capacity to produce meaningful understanding (Burrell, 2016).

The transformation of science in the age of AI is not limited to the production of scientific knowledge; it also involves a profound reconfiguration of the governance of scientific processes. The growing availability of AI supported solutions across stages such as research design, data collection, analysis, and evaluation is reshaping the nature of data and scientific labor, redefining standards of data reliability, and reconfiguring the functional boundaries of scientific expertise. In this context, the researcher is no longer primarily a subject who directly processes data, but increasingly assumes the role of a coordinator and guide who manages, supervises, and interprets algorithmic systems (Feng et al., 2025). This shift necessitates a redefinition of the skills required for scientific competence, rendering data literacy and algorithmic awareness integral components of scientific expertise. However, the effective exercise of this coordinative role presupposes a strong disciplinary knowledge base and well-developed analytical reasoning capacities. Without these foundations, it becomes difficult to prevent the proliferation of illusory and disinformative manipulations, ethically problematic science like approaches, and misleading quantitative studies that are methodologically weak, conceptually unfounded, and driven by inflated metrics rather than substantive quality. Under such conditions, the scientific community may face chaotic crises marked by significant losses of time and material resources.

These developments related to the transformation of science also render the societal role of science increasingly visible. AI supported scientific knowledge now exerts direct influence across a wide range of domains, from policy making processes to institutional decision-making mechanisms. Algorithmic models developed in areas such as health, security, economics, and the environment produce not only scientific outcomes, but also normative consequences. For this reason, the relationship between science and society in the age of AI must be reconsidered in terms of trust, ethics, and democratic oversight (Jasanoff, 2004; Messeri & Crockett, 2024). In order to avoid the challenges outlined above, consolidated data analyses and comparative scientific outputs will gain greater importance within AI driven research processes.

This transformation is analyzed along five principal dimensions, including the emerging role of AI in autonomous scientific discovery. First, the nature of science in the age of AI is examined, with particular attention to the shifts occurring in the epistemological assumptions of science. This is followed by an analysis of the production of scientific knowledge and the role played by AI in scientific processes, together with an evaluation of the methodological and normative consequences of these developments. The subsequent section addresses the dissemination of science in relation to algorithmic intermediaries and open science, analyzing how the relationship between science and society is being reconfigured in the age of AI. Finally, through discussions of science policy and governance, the institutional and political frameworks within which this transformation is taking shape are assessed.

In conclusion, this study seeks to approach the transformation of science in the age of AI not through a narrative of progress or crisis, but as a process of reconstitution. As emphasized earlier, AI should not be understood as a threat that removes science from human agency, but rather as a historical turning point that compels a rethinking of the boundaries, responsibilities, and societal meaning of science. How this transformation will ultimately be directed, we underline, will be determined less by technical capacity than by epistemological choices, ethical principles, and science policies.

## 1. The Nature of Science and Interaction

The nature of science encompasses the fundamental assumptions concerning what scientific knowledge is, how it is produced, and according to which criteria it is legitimized (Lederman, 1992). The modern understanding of science has largely been grounded in a human centered model of knowledge production. Within this framework, the scientific subject is the scientist themself. Scientific method is conceived as a systematic process operating under the control of human reason, and scientific knowledge is interpreted through causal explanations and theoretical frameworks. The increasingly deep integration of AI systems into scientific research practices directly calls these foundational assumptions into question.

In the age of AI, science can no longer be defined solely as an activity based on human cognition. AI algorithms are capable of analyzing data sets at scales beyond the capacity of individual researchers, revealing unexpected patterns and generating models with high predictive power. Moreover, generative AI and agentic AI also has a powerful knowledge processing capacity as well. This development indicates, as also noted by Feng et al. (2025), the emergence of a hybrid epistemic order in which human and machine are jointly involved in the production of scientific knowledge. Accordingly, the scientific subject is transformed from a singular and individual agent into a collective structure operating through human machine interaction (Messeri & Crockett, 2024; Xu et al., 2021). In this context, contemporary debates on human–

machine interaction in scientific knowledge production can be situated within a longer epistemological trajectory. This discussion resonates with the earlier reflections of Cahit Arf, a Honorary Member of the Turkish Academy of Sciences (TÜBA), on whether machines can think, where he approached thinking not as a technical capability, but as an epistemological problem traditionally associated with the human mind (Arf, 1959).

One issue that merits particular attention here concerns the relationship between neuroscience and computer science. This relationship constitutes one of the most vivid examples of how science operates and redefines itself in the age of AI. While neuroscientific research on the human brain’s mechanisms of learning, perception, and decision making has inspired artificial neural networks and ML models, these models in turn offer new ways of thinking about how cognitive processes can be understood computationally (Hassabis et al., 2017). In this sense, AI moves beyond being a purely technical instrument aimed at mimicking the human brain and becomes a research partner that reshapes scientific questions about human cognition itself. This reciprocal interaction provides the foundation for the collective structure discussed above and demonstrates that science is increasingly moving away from an exclusively human centered activity toward a hybrid cognitive order in which humans and machines operate together (Onciul et al., 2025; Ricci et al., 2025).

In this period, science is also reshaping its understanding of objectivity. In the traditional conception of science, objectivity has been understood as the researcher’s elimination of subjective influence and the pursuit of universal truths through methodological control. In AI based scientific practices, however, objectivity becomes largely dependent on data representations, algorithmic choices, and model parameters. How data sets are collected, which samples they include, and under which prior assumptions they are structured directly affect the content and quality of the knowledge produced. For this reason, objectivity in the age of AI must be addressed not primarily as a claim of technical neutrality, but in conjunction with the principles of transparency and accountability (Boyd & Crawford, 2012).

One of the most significant transformations in the nature of science emerges in relation to explanation. Modern science has placed causal explanation at the center of knowledge production. AI based models, however, are often able to generate highly accurate predictions independently of causal reasoning. This development brings the distinction between correlation and causality back into focus and points toward a knowledge regime in which predictive success increasingly replaces explanatory power. The characterization of deep learning (DL) systems as “black boxes” constitutes one of the most striking illustrations of this epistemic shift (Burrell, 2016). However, this trend primarily characterizes modern ML; earlier methodologies like expert systems maintained inherent transparency, and the current rise of Explainable AI (XAI) represents a deliberate effort to restore interpretability to complex models.

In this context, the legitimacy of scientific knowledge in the age of AI depends not only on the accuracy of results, but also on the intelligibility of the pathways through which those results are produced. Explainability is no longer a technical detail, but has become one of the foundational norms of science. As the societal use of scientific knowledge expands, demands for accountability regarding how algorithmic models operate grow correspondingly stronger. In this way, the nature of science is being reconfigured not only as an epistemic domain, but also as an ethical field of concern (Floridi et al., 2018).

Another defining element of the nature of science in the age of AI concerns the process of knowledge discovery. While the traditional understanding of science has been grounded in a hypothesis driven research model, AI supported science places pattern discovery derived from data at its core. This "data centered epistemology" reorients scientific inquiry away from predefined theoretical frameworks toward algorithmic forms of discovery. Anderson's proposition regarding the "end of theory," although containing elements of overgeneralization, nonetheless points to a transformation in the relationship between theory and science in the age of AI (Anderson, 2008).

This epistemic shift produces ambivalent consequences for the critical capacity of science. On the one hand, AI enhances scientific productivity by enabling forms of discovery that exceed the limits of human cognition. On the other hand, the weakening of theoretical orientations carries the risk of diminishing explanatory depth and of reducing scientific knowledge to a form that is functionally effective yet conceptually shallow. Nevertheless, it is argued that AI does not necessarily undermine theoretical foundations; rather, through deep learning, it uncovers previously unrecognized patterns in vast datasets, potentially providing empirical evidence that fosters the development of new, more robust theoretical frameworks. In this context, as noted above, science in the age of AI is compelled to reestablish a balance between theory and data, as well as between explanation and prediction (Kitchin, 2014).

The transformation in the nature of science also revitalizes debates surrounding scientific realism. Outputs generated by AI based models are often evaluated less as representations of the world as it is, and more as instruments that function effectively within specific contexts. This raises once again the question of whether science is an activity that reflects reality or primarily a tool for solving practical problems. The increasing orientation of science toward an instrumental epistemology in the age of AI renders the ontological claims of scientific knowledge more cautious and restrained.

Finally, AI also indirectly affects the concept of the autonomy of science. The development and maintenance of algorithmic systems largely depend on the private sector, large scale data infrastructures, and high-cost computational resources (Jeschke et al., 2019). This dependency calls for a reconsideration of the ideals of independence and free inquiry traditionally associated with the nature of science. Accordingly, the nature of science in the age of AI must be examined not only in terms of how knowledge is produced, but also in relation to the institutional and economic conditions under which that knowledge emerges. In the age of AI, science is evolving away from a human centered, causality based, and explanatory practice of knowledge production toward a hybrid structure in which humans and machines operate together, grounded in data centered, prediction-oriented processes and surrounded by ethical responsibilities. This transformation should not be understood as a rupture that diminishes the value of science, but rather as a historical transition that redefines the boundaries and responsibilities of scientific practice.

## 2. The Production of Scientific Knowledge and Risks

The production of scientific knowledge within the modern scientific tradition has been shaped around specific methodological stages and normative assumptions. Within this framework, scientific research begins with the researcher's formulation of a problem and proceeds through hypothesis construction, data collection, analysis, and interpretation. The integration of AI technologies into scientific research not only accelerates this classical mode of production but also transforms the underlying logic of knowledge production at a structural level. Scientific knowledge is increasingly shaped not by human intuition and theoretical guidance, but by large scale data sets and algorithmic discovery processes and models.

In the age of AI, the production of scientific knowledge is fundamentally grounded in a data centered epistemology. Large volume, heterogeneous, and continuously updated data sets have become a prerequisite for scientific research. ML and DL techniques are capable of identifying meaningful patterns within these data without reliance on predefined hypotheses (Krenn et al., 2022). This development challenges the central position of the hypothesis testing cycle in scientific knowledge production and foregrounds a discovery oriented, bottom-up regime of knowledge generation.

This transformation has significant implications for the nature of scientific knowledge. In the traditional understanding of science, theoretical frameworks have functioned as the primary guides that determine how data are interpreted and which results are considered meaningful. In AI based knowledge production, by contrast, knowledge often emerges independently of prior theoretical expectations, with the process of interpretation following the stage of production. Scientific knowledge thus acquires a predictive rather than an explanatory character. While this enhances the practical usability of knowledge, it also introduces new limitations in terms of conceptual depth and causal understanding (Kitchin, 2014).

One of the critical elements shaping the production of scientific knowledge in the age of AI is algorithmic modeling. Furthermore, AI systems increasingly integrate cognitive capacities to process domain-specific knowledge through heuristic models, moving beyond simple data restructuring. These models do not merely represent data; they actively restructure it through specific assumptions, weightings, and classification schemes. Consequently, the scientific knowledge produced is not simply a reflection of observed reality, but also a product of model design and algorithmic choices. This challenges traditional assumptions about the neutrality of scientific knowledge and renders value laden decision points in knowledge production more visible (Boyd & Crawford, 2012).

This transformation in the production of scientific knowledge also fundamentally redefines the role of the researcher. Rather than directly processing data, the researcher increasingly assumes the position of a coordinator or guide who selects, trains, supervises, and interprets algorithms (Feng et al., 2025). This shift broadens the definition of scientific expertise, making data science, statistics, and algorithmic thinking skills integral components of scientific competence alongside domain specific knowledge. Knowledge production thus takes shape not as an expression of individual cognition, but as a socio technical process of collaboration.

AI supported scientific knowledge production also requires a reconsideration of the concepts of error and uncertainty. Although algorithmic systems may offer high levels of accuracy, the conditions under which this accuracy holds and the specific data contexts to which it applies are often unclear. Biases in training data, incomplete representations, and underlying model assumptions can lead to systematic errors in the knowledge produced (Xu et al., 2021). For this reason, the reliability of scientific knowledge must be assessed not solely in terms of the correctness of outcomes, but also in relation to the transparency of the related data sources and modeling processes.

Another significant consequence of AI use in scientific knowledge production is the acceleration of research processes. Automated analysis, simulation, and modeling tools make it possible to generate scientific results within very short time frames. While this acceleration offers important advantages, particularly in the context of urgent societal challenges, it also carries the risk of shortening the periods required for knowledge maturation and critical evaluation. As scientific knowledge increasingly assumes a provisional and continuously updated character, new questions arise regarding its durability and verifiability.

Even though AI makes our life easier, a further critical issue introduced by AI in the production of scientific knowledge is inequality. Access to large data sets, advanced computational infrastructures, and highly skilled human resources remains unevenly distributed on a global scale (Jeschke et al., 2019). This imbalance enables certain institutions and countries to occupy privileged positions in scientific knowledge production. Decisions regarding which questions are investigated, which data are used, and which forms of knowledge are produced are increasingly shaped by economic and political power relations. Consequently, scientific knowledge production in the age of AI inevitably acquires a political dimension.

Overall, the production of scientific knowledge in the age of AI signals a transformation that is methodological as well as epistemological and societal. Knowledge is no longer solely the product of human cognition, but rather a hybrid outcome generated through the collaboration of humans and algorithms. While this enhances the productivity of science, it simultaneously introduces new responsibilities concerning the interpretation, reliability, and societal orientation of scientific knowledge.

## 3. Scientific Processes in the Age of AI

Scientific processes encompass the set of methodological and institutional practices that extend from the production of scientific knowledge to its presentation to the public. Within the modern scientific tradition, these processes have been organized around sequential stages such as research design, data collection, analysis, interpretation, evaluation, and replication. The integration of AI technologies into different phases of scientific research is transforming not only the speed of these processes, but also their structure and normative foundations. In the age of AI, scientific processes are becoming increasingly automated, more complex, and less transparent.

Automation (in terms of the self-decision-making capability of AI) plays a central role in AI supported scientific processes. Stages such as literature review, data cleaning, statistical analysis, modeling, and visualization are increasingly carried out by algorithmic systems (De La Torre-López et al., 2023). While this automation significantly enhances scientific productivity and efficiency, it also relatively reduces the researcher’s direct control over methodological procedures. The acceleration of scientific processes introduces new risks, particularly with regard to methodological awareness and critical oversight.

One of the most contested issues in the transformation of scientific processes concerns reproducibility. In the traditional understanding of science, the ability of independent researchers to replicate a study has been regarded as a fundamental indicator of the reliability of scientific knowledge. In AI based research (specifically in ML-based research), however, the data sets, algorithms, and software infrastructures employed are often closed or context specific. This situation makes the replication of experiments and analyses technically and institutionally more difficult, thereby weakening the auditability of scientific processes (Kapoor & Narayanan, 2023).

Another critical issue introduced by AI within the context of scientific processes is algorithmic transparency. Although DL models deliver high levels of accuracy, the intermediate steps through which these results are achieved often remain opaque. This “black box” condition poses a serious challenge to the transparency and methodological explainability of scientific processes. One of the foundational assumptions of the scientific method is that the process by which results are obtained should be understandable, reproducible, and open to critique by others. Algorithmic opacity directly challenges this norm (Burrell, 2016).

Scientific processes in the age of AI are also transforming systems of evaluation and peer review. Automated text analysis tools, citation metrics, and algorithmic pre-evaluation systems are increasingly employed in scientific publishing. While these tools render scientific production more manageable in quantitative terms, they may simultaneously complicate the assessment of qualitative dimensions such as originality, creativity, and critical contribution. Algorithmic evaluation systems risk reinforcing existing paradigms and indirectly constraining scientific diversity (Kousha & Thelwall, 2023).

The transformation of scientific processes also affects conceptions of scientific time. AI supported analytical tools make it possible to generate scientific results at unprecedented speed, while preprint servers and accelerated publication cycles significantly shorten the time required for knowledge to enter circulation (Švab et al., 2023). This acceleration, however, carries the risk of increasing the dissemination of scientific errors by compressing the periods necessary for knowledge maturation and critical evaluation. As scientific processes increasingly take on a continuously updated form, the provisional and temporary character of knowledge becomes more visible.

In the age of AI, scientific processes also redefine the nature of scientific labor. The role of researchers is shifting away from that of actors who directly process data toward that of coordinators who manage, validate, and interpret algorithmic systems. This transformation affects laboratory hierarchies, modes of collaboration, and the academic division of labor. Scientific processes thus evolve from activities based on individual performance into collective practices conducted through complex team structures and technical infrastructures. One of the most illustrative examples of this collective and algorithm centered scientific labor is the AlphaFold project mentioned earlier (AlfaFold2, 2025). By predicting protein structures with high accuracy, this AI system has enabled the completion of research that would otherwise require years of work, transforming the researcher’s role from an experimenter into a coordinator who validates model outputs and interprets their biological significance (Jumper et al., 2021). Similarly, in particle physics research at CERN, ML-based analytical systems are used to identify meaningful signals within trillions of collision events, requiring physicists to work primarily in teams that oversee algorithmic selection processes rather than directly filtering data (Radovic et al., 2018). In astronomy, AI supported classification models employed in sky survey projects accelerate the discovery of galaxies and supernovae, replacing research practices based on individual observation with the collaborative efforts of interdisciplinary teams composed of data scientists, domain experts, and software developers (Ivezić et al., 2019). A comparable reconfiguration is evident in clinical disciplines: in psychiatry, natural language processing, machine learning, and deep learning models are increasingly employed to detect depressive symptoms and to predict treatment response from speech, neuroimaging, and genomic data, repositioning the clinician–researcher as an interpreter and validator of algorithmic outputs rather than the sole source of diagnostic judgement (Ricci et al., 2025). Taken together, these examples clearly demonstrate that scientific advancement in the age of AI relies less on the performance of individual scientists and more on collective knowledge arrangements in which humans and algorithms operate together.

This transformation also differentiates the language and competence levels of the actors involved in scientific processes. For students, AI supported scientific environments provide an interactive space oriented towards learning and discovery, while for researchers, skills related to working with algorithms, model validation, and data interpretation come to the fore. Academics, in turn, are required to develop a meta level discourse that extends beyond technical proficiency to encompass methodological oversight, ethical responsibility, and interdisciplinary coordination. As a result, scientific communication in the age of AI acquires a multilayered structure -comprising automated data processing, algorithmic interpretation, and human expert synthesis etc.- grounded in varying degrees of cognitive and methodological awareness rather than a uniform expert discourse.

The ethical dimension of scientific processes has assumed a more central position in the age of AI. The involvement of algorithmic systems in decision points renders issues such as responsibility for error, data security, and discrimination integral components of scientific practice. Indeed, a recent study focusing on early career researchers shows that while ChatGPT is rapidly becoming an indispensable tool in higher education, healthy integration is not possible without ethical and effective use guidelines. This finding underscores that as AI transforms scientific practice; it simultaneously generates new governance needs in education and research processes (Yılmaz & Yüceol, 2025). Accordingly, scientific processes must be evaluated not only within methodological frameworks, but also within normative ones. Ethical oversight mechanisms and demands for explainable AI constitute key elements in efforts to preserve the legitimacy of scientific processes (Floridi et al., 2018).

In the age of AI, scientific processes are becoming faster, more automated, more autonomous, and more complex. While this transformation enhances the productivity of science, it also compels a reconsideration of fundamental scientific norms such as reproducibility, transparency, and critical scrutiny. Scientific processes should therefore be understood not merely as sequences of technical steps, but as socio technical arrangements in which ethical, epistemological, and institutional choices are concretized.

## 4. The Dissemination of Science, Open Source, and Commercial Concerns

The dissemination of scientific knowledge constitutes one of the fundamental determinants of science's societal function and legitimacy. The modern understanding of science has assumed a system in which knowledge is produced through academic institutions, validated by peer reviewed publication processes, and presented to the public through relatively controlled channels. In the age of AI, however, the circulation of scientific knowledge is not only accelerating, but is also being fundamentally restructured through algorithmic intermediaries, digital platforms, and data infrastructures. This transformation affects not only modes of communication, but also the knowledge regimes that determine the frameworks within which knowledge acquires meaning.

In AI supported dissemination processes, algorithms play a central role in shaping the visibility of scientific knowledge. Search engines, academic indexes, recommendation systems, and social media platforms have become key actors in determining which information is highlighted and which research gains visibility (Drivas, 2024; Ma et al., 2022). As a result, the dissemination of scientific knowledge becomes increasingly dependent on algorithmic rankings and metrics. Knowledge now circulates not solely on the basis of scientific validity or quality, but through interactions shaped by criteria such as accessibility, attractiveness, and measurable impact.

In this context, AI also redefines the notion of scientific publicness. In the traditional model of public science, scientific knowledge is produced by experts and subsequently translated or popularized for the public. Digital platforms and AI supported content generation tools disrupt this one-way transmission model, rendering the circulation of scientific knowledge more participatory yet simultaneously less regulated. The boundaries between expert discourse and popular narratives in scientific communication become increasingly blurred.

This transformation in the dissemination of science also gives rise to issues of credibility and authority. AI supported systems are not always sufficiently effective at distinguishing between scientifically validated content and material that merely adopts the appearance of science. Automated text generation tools enable the rapid circulation of content that resembles scientific articles but has not undergone scientific scrutiny (Messeri & Crockett, 2024). Such developments risk undermining public perceptions of the reliability of scientific knowledge and may create fertile ground for the strengthening of anti-science narratives.

From the perspective of knowledge regimes, the dissemination of science in the age of AI is increasingly shaped by measurement and performance-oriented logics. Citation counts, download rates, impact factors, and alternative metrics have become more visible in determining the value of scientific knowledge (Kavic & Satava, 2021). AI supported analytical tools make it possible to monitor and compare these indicators in real time. However, this quantitative orientation carries the risk of overshadowing the qualitative dimensions of scientific value. The circulation of knowledge is thus increasingly governed by performance indicators that are detached from the substantive content of knowledge itself.

Open science movements constitute a central component of contemporary debates on the dissemination of science in the age of AI. Demands for open access, open data, and open methods aim to democratize scientific knowledge. AI can support these goals by expanding opportunities for data sharing and reuse (Hombana, 2025). At the same time, however, open data infrastructures may be used asymmetrically by large technology companies and powerful institutional actors, deepening the tension between the public accessibility of knowledge and its privatization.

The role played by AI in the dissemination of science also renders geographical and institutional inequalities more visible. Access to digital infrastructures, data sets, and advanced algorithms remains unevenly distributed on a global scale. This imbalance enables certain regions and institutions to gain structural advantages in the circulation of scientific knowledge (Schmallenbach et al., 2024). Which forms of knowledge enter global circulation and which are marginalized are increasingly shaped indirectly by AI supported systems.

In the age of AI, the dissemination of science also transforms the communicative roles of scientists themselves. Beyond academic production, scientists are increasingly expected to present their research in formats accessible to broader audiences and to remain active within digital public spheres. While this trend encourages simplification and visualization of scientific discourse, it simultaneously carries the risk of excessive reduction of scientific complexity. The boundaries between the dissemination of knowledge and the transformation of knowledge thus become increasingly blurred. Moreover, in a manner similar to what Seker (2020) has emphasized, this dynamic contributes to the emergence of an information environment characterized by ambiguity and contestation over the validity and reliability of circulating knowledge.

In the age of AI, the dissemination of science is not merely a matter of communication; it constitutes a knowledge regime issue closely tied to scientific authority, trust, and democratic oversight. Algorithms have become invisible intermediary actors that shape the public visibility of science. This development necessitates moving beyond classical conceptions of scientific dissemination and calls for critical inquiry into who circulates scientific knowledge, according to which criteria, and in whose interests.

From the perspective of individual and societal security, one of the principal areas to which states must devote sustained attention concerns AI and the threats posed by developments related to information security and informational sovereignty. These threats extend across domains such as commerce, politics, and international security, while also directly implicating individual security, which remains the most vulnerable link and one that states are obligated to protect. In order to safeguard individuals' right to reliable information and their privacy, as well as their socio economic and cultural lives, against malicious actors, the need for legal regulation and continuous updating becomes unavoidable (Seker, 2020).

## 5. Science Policies and Governance

In the age of AI, not only the nature, methods, and processes of knowledge production and dissemination, but also the science policies and governance structures that guide these domains, have become fundamental determinants of the social impact and responsibility of knowledge. Decisions regarding which data are used, which variables are incorporated into models, and which outputs are prioritized carry significant societal implications. In this context, science has evolved beyond a purely technical domain of expertise into an activity that requires public accountability (Jasanoff, 2004). For instance, in this period, the need for legal regulation and continuous updates aimed at protecting individuals' access to reliable information, privacy, and socio-economic and cultural life against malicious actors has become unavoidable (Seker, 2020).

Within this AI-driven transformation process, the integration of legal and ethical principles into oversight, management, and auditing mechanisms, alongside a new governance approach in which the human factor is recognized as an integral part of management, has become a critical necessity. This governance imperative has also been reflected in academic platforms, such as the TÜBA International Symposium on Artificial Intelligence Law and Digitalization in Law (TÜBA, 2025), which addressed the normative, constitutional, and regulatory implications of AI systems and underscored the need for an interdisciplinary legal framework capable of responding to algorithmic governance challenges. The scholarly output of this agenda has been consolidated in the TÜBA edited volume Artificial Intelligence Law and Digitalisation in Law (Okur, 2025a), also published in Turkish as Yapay Zekâ Hukuku ve Hukukta Dijitalleşme (Okur, 2025b), which brings together interdisciplinary analyses of AI liability, high-risk AI certification, intellectual property, data protection, and the evolving relationship between AI and judicial decision-making. Moreover, this governance imperative is explicitly emphasized in recently adopted international policy documents. For example, the 2024 Budapest Declaration highlights the urgency of establishing trustworthy and innovative science–policy interfaces. The Declaration particularly recommends the institutionalization of ethical oversight in emerging technologies such as AI, the protection of academic freedoms, and the strengthening of governmental scientific advisory systems. In this framework, the

Declaration positions science in the AI era not only as a driver of technical progress, but also as a fundamental component of inclusive global resilience and sustainable development (Seker & Dogrul, 2025).

The Government AI Readiness Index 2025 report published by Oxford Insights (Iida et al., 2025) indicates that Türkiye possesses a strong digital government infrastructure and governance capacity in the field of AI. According to the report, while Türkiye ranks highly at the regional level, it stands at a critical juncture where sustainable progress in science policy and governance depends on supporting strategic documents with concrete policy instruments and institutional practices. The practical reflections of this holistic approach are becoming increasingly visible in Türkiye across the private sector as well as public and semi-public institutions.

At the international level, Türkiye was admitted as a member of the Global Partnership on Artificial Intelligence (GPAI) in 2022. As part of this partnership, it has committed to promoting the ethical and responsible use of AI in alignment with the values of GPAI (Ministry of Foreign Affairs, 2022). At the national level, the 2025–2027 Values-Based Development Vision Document published by the Independent Industrialists and Businessmen's Association (MÜSİAD) provides significant insights. In this document, MÜSİAD incorporates into its vision both the development of AI-related competencies within its relevant units and the provision of education and guidance services in this field (MÜSİAD, 2025).

Similarly, the "Smart SME" platform established by the Union of Chambers and Commodity Exchanges of Türkiye (TOBB) to facilitate the digitalization of small and medium-sized enterprises (SMEs) offers training programs focused on the practical use of AI for the business community and SMEs (TOBB, n.d.). The restructuring of the National Technology Directorate within the Ministry of Industry and Technology into the National Technology and Artificial Intelligence Directorate (Anadolu Agency, 2025). demonstrates that AI is no longer merely a supporting technology, but has been positioned at the core of development and industrial policies. Likewise, the establishment of an "Artificial Intelligence and Innovative Technologies Department" under the General Directorate of Health Information Systems within the Ministry of Health (Ministry of Health, 2026). represents an important indicator that transformations in the AI era are being closely monitored and that high-level policies are being pursued in a synchronized manner. In parallel with these institutional transformations, TÜBA has also contributed to the national policy discourse through its report The Role of Artificial Intelligence in Energy, which systematically analyzes the strategic, economic, and sustainability dimensions of AI integration in the energy sector and emphasizes the necessity of data-driven governance frameworks in critical infrastructures (Dinçer et al., 2022).

In this context, adopting a more proactive policy approach in the field of AI is of critical importance for Türkiye to move beyond a consumer position and transform into a producer and technology-developing actor. In this regard, increasing the production of science-based, national, and original high-technology products and systems is directly dependent on the cultivation of a qualified workforce. The coordinated structuring of education, research, and innovation ecosystems has become a strategic necessity for transforming scientific knowledge into economic and social value (Seker, 2022).

With respect to the qualified human resources dimension, the Council of Higher Education (YÖK) has moved swiftly to address this need by launching new academic programs. Accordingly, in 2024, 17 AI-based programs were initiated at 20 universities, with the aim of increasing the number of universities offering such programs to more than 80 in the short term (YÖK, 2025). These indicators demonstrate that Türkiye is rapidly adapting to the transformation taking place in the higher education sector. Moreover, a policy trajectory parallel to higher education is being pursued at the primary and secondary education levels. In this regard, the “Artificial Intelligence in Education Policy Document and Action Plan (2025–2029)” published by the Ministry of National Education constitutes one of the most concrete examples of this transformation in the educational domain (MEB, 2025).

In the AI era, science ceased to be an isolated domain of knowledge production and has become a public activity shaped by societal expectations, ethical responsibilities, and political preferences. Science policies are not merely instruments that seek to manage this transformation; rather, they constitute normative frameworks that define how science relates to social values. When the impacts of AI on science are addressed through the lenses of democratic governance, adherence to ethical principles, and a long-term public interest perspective, the social legitimacy of science can be strengthened.

Although Türkiye’s science policy and governance indicators are above average, there remains a need for more rapid and decisive action in this area. In this way, Türkiye can swiftly transition from a consumer position to a producer position in the field of AI. It should not be overlooked that, alongside investments in human capital, the budgetary costs of existing and future investments have the potential to amortize rapidly through their contribution to national value creation and to represent a major gain in establishing a permanent and sustainable AI infrastructure with a high potential to reduce the current account deficit.

## Conclusion

This chapter examined the transformation of science in the age of artificial intelligence as a process of structural reorganization rather than a simple narrative of progress or disruption. By situating AI within the epistemological, methodological, institutional, and societal dimensions of scientific practice, the analysis has demonstrated that AI functions not merely as a technical instrument, but as a constitutive element that reshapes how knowledge is produced, validated, and circulated.

The findings highlight a fundamental shift toward hybrid forms of scientific agency, in which human judgment and algorithmic systems operate in increasingly interdependent ways. This shift reconfigures the balance between explanation and prediction, theory and data, and autonomy and institutional dependence. While AI enhances the capacity of science to address complex and large-scale problems, it simultaneously introduces challenges related to transparency, reproducibility, ethical accountability, and inequalities in access to data, infrastructure, and expertise.

Within this broader global transformation, the case of Türkiye illustrates how national science policy and institutional restructuring actively shape the trajectory of AI-driven science. As discussed in this chapter, Türkiye's participation in international governance frameworks such as the Global Partnership on Artificial Intelligence, the establishment of dedicated public-sector AI units, and the integration of AI into health, industry, and education policies signal an effort to move beyond a consumer role toward becoming a producer of scientific knowledge and technology. Initiatives in higher education, including the rapid expansion of AI-based academic programs, further demonstrate how the cultivation of human capital is positioned as a central pillar of national scientific capacity in the AI era.

These developments underscore that the transformation of science is not only a technological or epistemological process, but also a political and institutional one. The increasing societal reach of AI-supported scientific knowledge intensifies the need for governance mechanisms that ensure democratic oversight, ethical standards, and public trust. In this respect, Türkiye's evolving policy framework exemplifies how national contexts mediate the global dynamics of scientific change, shaping both opportunities for innovation and responsibilities for accountability.

In summary, the chapter argues that the long-term future of science in the age of AI will be determined less by the expansion of computational power than by the epistemological, ethical, and policy choices made by scientific communities and governing institutions. Sustaining a critical, reflexive, and socially grounded scientific culture remains essential to ensuring that the reorganization of science contributes not only to technical advancement, but also to broader human, societal, and democratic values.

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