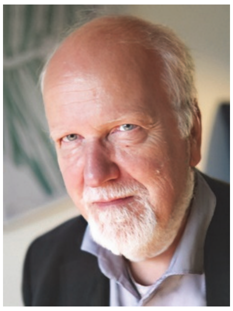
Science, Part III:
Further Developments in the Concept of Science

Birger Hjørland

University of Copenhagen, Faculty of Humanities, Department of Communication, South Campus, building 14, 3rd. Floor, Karen Blixens Plads 8, 2300 Copenhagen S, Denmark, <birger.hjorland@hum.ku.dk>



Birger Hjørland holds an MA in psychology and PhD in library and information science. Since March 2020, he has been Professor Emeritus at the Department of Communication, University of Copenhagen and formerly professor in knowledge organization at the Royal School of Library and Information Science/Department of Information Studies (2001-2020) and at the University College in Borås (2000-2001). He is a member of the editorial boards of Knowledge Organization, Journal of the Association for Information Science and Technology and Journal of Documentation. His h-index on 2023-07-02 is 51 in Google Scholar and 35 in Web of Science.

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Abstract: In this third part of the trilogy about "science," Section 6 presents further developments in conceptualizing science. It has been claimed that science has recently changed in profound ways, and the concept of "epochal breaks" has been used about these developments. The article presents and discusses many of these new concepts, including "triple helix," "post-academic science," "mode 2 research", "technoscience," "postmodern science," "citizen science," and the little older "big science." It is hard to form a clear conclusion about these developments, but most of these conceptions seem based on the increasing commercialization of science. In a way, this is connected to the pragmatic philosophy of science but seems to have failed to address how science can continue to penetrate ever deeper to understand the world and not just reflect the more immediate social and commercial interests. Section 7 is the general conclusion of the trilogy. It states that the many pieces of fragmented knowledge about science from many different fields and perspectives must work together in a much more integrated way. Concerning information science, knowledge organization, and related fields, these fields need to understand themselves as a member of the science studies in its broad meaning. All activities concerning science must realize the socio-cultural and paradigmatic conflicts involved in such activities, from producing over mediating (retrieving, publishing, digitalizing, curating, translating, organizing, teaching, etc.) to use.

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6. Further developments in the concept of science

6.1 Introduction

The last decades have witnessed a bewildering of new concepts relating to science and its changing nature. There are many claims that science has changed profoundly and the concept of "epochal breaks" was suggested by Nordmann, Radder and Schiemann (2011).[152] The editors wrote in the introduction (1): "the idea that there has been a transformation in the relation of science, technology, and society so profound that our received notions of 'science' have been superseded by something else." [153]

However, there is much use of "catchwords" about recent developments in the conception of science.[154] Nordmann, Radder and Schiemann, in their introduction, suggested that three major transformations or breaks are: "entrepreneurial science" and "triple helix" (Section 6.2), "mode 2 research" (Section 6.3) and "technoscience", "postmodern science" and "postnormal science" (Section 6.4); finally, "citizen science" and "big science" (not presented by Nordmann, Radder and Schiemann 2011) are introduced in respectively section 6.5 and 6.6.

6.2 "Entrepreneurial science" and "triple helix"

The concepts "entrepreneurial science" (Etzkowitz 1998) and "triple helix" (Etzkowitz and Leydesdorff 1998) were used by the authors to show how academia, industry, and government became intertwined in the pursuit of research agendas.

Ziman (1996a, 1996b, 1998, 2000, among other publications) debated this further, framing the discussion in terms of "postacademic science" and the norms that guide it. He found (1996a, 751) that "basic" or "pure" science can only be defined sociologically and that "the social institution that has customarily fostered undirected research, without regard for its practical use, is academia. In effect, what we call basic research is almost synonymous with the type of research traditionally carried out by universities".[155] Ziman (1998, 167) argues that a new mode must replace academic research:

> Once upon a time, universities set the pattern. 'Science' - pure, basic, or even to some extent applied - was equated with academic research, which diffused outwards as a bundle of social practices into other sectors of society. Now a new mode of knowledge production has emerged outside academia, and is percolating back into the 'science base'. This process seems irresistible. If universities are to continue as major sites for research, they too will have to adopt the new mode, systematically and wholeheartedly.

Ziman (2000) reconsidered the Mertonian CUDOS norms (see Section 4.3.1 in Science: Part II) in light of recently changed conditions for science. He opined, for example, that people cannot be communalistic if they are urged to turn their investigations into patents and intellectual property and that the norm of disinterestedness means that scientists should accurately evaluate the contributions of their contemporaries. However, in post-academic science, government agencies and industry are playing an increasing role in deciding what research should be conducted and how to evaluate it. On that basis, Ziman suggested an alternative set of norms using the acronym PLACE:

- Proprietary, and therefore not necessarily communal;
- Local, with researchers concentrating on technical problems that may not contribute to general understanding;
- Authority vested in a managerial hierarchy, not in the individual researcher;
- Commissioned to solve specific problems, not as a contribution to knowledge as a whole;
- Expert, with the scientist valued as an expert rather than a source of creativity.

6.3 "Mode 2 research"

The second break, involving "new production of knowledge", emphasizes that there is a new social contract between science and society. Gibbons et al. (1994) introduced the now-famous distinction between the old "mode 1" and the new "mode 2". Mode 1 is described as traditional research, which is academic, investigator-initiated, and discipline-based knowledge production. This kind of research still exists, but it is being displaced by "mode-2 research", which is described as context-driven, problem-focused, and interdisciplinary. It involved multidisciplinary teams working together for short periods on specific problems in the real world. Nordmann, Radder and Schiemann (2011, 7) found, however, that the term "mode 2" – like "technoscience" - despite their widespread use, lacks proper definitions.

Nowotny, Scott and Gibbons (2001) is a later book written by three of the same authors as Gibbons et al. (1994). The authors base their view on the relations between science and society on four pillars:

- The nature of Mode-2 society. Cause-effect relationships and the search for control and predictability no longer dominate science. This seems to be related to post-modernist accounts, but the authors stress that they believe in rational discourse in contrast to post-modernist protagonists.
- The contextualization of knowledge in a new public sphere called "*agora*". The boundaries between science and society are eroded and new actors, whom we do not traditionally connect with research, are coming to the fore.
- The concept of social robust knowledge takes over (from the concept of knowledge as reliable). This concept is claimed to be relational (but not relativist or absolute) and process-oriented.
- The emergence of socially distributed experts. It is not possible to act as an expert relying on scientific reputation, but (225): "It rests on its ability to orchestrate the many heterogeneous and context-specific knowledge dimensions that are involved".

Many have found that this book provides important thoughts about the development of science, and the concept *agora* has been emphasized. The book has also, however, been reviewed as being very unclear [156].

6.4 "Technoscience", "postmodern science" and "postnormal science"

The third break, discussed by Nordmann, Radder and Schiemann (2011) refers to the term "technoscience", which Bruno Latour (1987, 1993) and Donna Haraway (1997) popularized. This approach does not claim that today's technoscience radically differs from previous versions but advocates a different way of looking at science.

Some researchers use the concept "postmodernism" to characterize developments in (the conception of) science. Forman (2007) argues that a perspective in technoscience, in which heterogeneous actors draw on conceptual and material resources to forge new kinds of entities, including technical artifacts, coincides with postmodernity. However, various thinkers use the term "technoscience" differently. Latour (1987, 1993) and Haraway (1997) emphasize primarily that this concept enables new ways of acting and interacting, while Forman laments that science has become subservient to the realization of desired ends by any means necessary. Channell (2017) described the view that by the second half of the twentieth century, the long-held distinctions between science and technology were beginning to disappear and, in the place of two individual disciplines, there emerged a new concept that some have labeled technoscience (with reference to Latour 1987).

Nordmann, Radder and Schiemann (2011, 6) wrote:

> Forman does not introduce specific labels for the different ways of conceiving the relationship between science and technology. Though he attributes the current way of thinking to postmodernity, he does not speak of 'postmodern science.' That label has been used by others without catching on as of yet. For some, like Stephen Toulmin (1992), postmodern science is a program more than a reality. It is a kind of disunified science that recognizes a multiplicity of standpoints and respects local conditions. Others, like Jan C. Schmidt (2007), use postmodern science, or *nachmoderne Physik*, to designate research that draws on theories of complexity and self-organization rather than privilege isolable cause-effect relations. The identification, characterization, simulation, and 'domestication' of particular highly complex phenomena resembles a 'new natural history', as Arie Rip (2002) has pointed out.

Post-modern science is also a concept that has been applied to the field of social informatics. Smutny and Vehovar (2020, 537) wrote:

> Despite certain tendencies towards convergence, the current article argues that SI [Social Informatics Research] should be understood as a post-modern science. Whereas modern science is built on a homology of experts and universalism, postmodern science builds on a paralogy of researchers and pluralism [...] instead of preferring a single viewpoint, as in modern science, where certain fields can be further constituted as formal disciplines, in SI it is more suitable to follow the approach of postmodern science and observe only a broad common discourse that includes a number of viewpoints. Doing so eliminates the modern science challenge of constantly (re)defining some fixed thematic and methodological boundaries to separate different areas. Indeed, the postmodern perspective concurs that, by its nature, SI is forced into constant reformation of its practices and aims.

"Postnormal science" is a related concept associated with Silvio Funtowicz and Jerome Ravetz (1993, 2001). It deals with scientific inquiry in high stakes situations where the disciplinary knowledge of normal science needs to be extended. Nordmann, Radder and Schiemann (2011, 6-7) further wrote that the production of new forms of ignorance in the course of scientific and technological development has been said by Ulrich Beck, Anthony Giddens, and Scott Lash (1994) to give rise to a "second modernity" or "reflexive modernization," which mobilizes novel approaches to both governance and the production of scientific knowledge in order to deal with the often unintended and unpredictable effects of modernization.

Nordmann, Radder and Schiemann (2011, 7) continued the list [157]. It seems important, however, to consider that many of the described characteristics of these "epochal breaks" are on the margin of science. As Ravetz and Funtowicz (2015, 254) concluded their article about new forms of science:

> We must keep a sense of perspective. All these developments in digital-age science, especially those on the populist fringe, are very much on the margin. The vast majority of scientific work is done just as it has been, in large labs with traditional structures of quality control. The immediate problems facing the scientific communities, such as deceleration of growth, shifting of activity to the East, disentangling the publications system, and shoring up the quality assurance system, continue to require attention from all concerned. Creativity flourishes, in a spate of new inventions as well as in debates on the scientific problems bordering philosophy and theology. But this article is devoted to 'new forms of science,' and so long as they are new they will by definition be on the margins, uncertain, indeed speculative in their future course. We might adopt the title of a recent prophetic book, Science 3.0 (Miedema, 2012), as the motto for our journey into this unknown and challenging future.

The above presented new conceptions of science were based on Nordmann, Radder and Schiemann (2011), which focused on the "epochal break hypothesis". In addition, in the former Section 5.2 [158] we presented some new conceptions influenced by developments in information technology (IT), and in Section 6.5 we shall now consider "citizen science", followed by "Big science" in Section 6.6.

6.5 Citizen science ("science 2.0")

Among the recent changes in science is the growth of "citizen science", which was defined in the mid-nineteen-nineties by Irwin (1995, 11) as a "form of science developed and enacted by citizens themselves". Socientize Consortium (2013, 6) defined it as "public engagement in the scientific research process in which citizens participate actively in different ways, with their intellectual effort or knowledge, tools, or resources". The main aim is to "co-create a scientific culture" and exchange understanding. Cohn (2008, 193) defined: "The term 'citizen scientists' refers to volunteers who participate as field assistants in scientific studies." Cohn also termed it "science 2.0" although he emphasized that the phenomena is not new (3):

> Working with citizen scientists is hardly new. The practice goes back at least to the National Audubon Society's annual Christmas bird count, which began in 1900. About 60,000 to 80,000 volunteers now participate in that survey. What is new is the number of studies that use citizen scientists, the number of volunteers enlisted in the studies, and the scope of data they are asked to collect.

Silvertown (2009, 467) wrote:

> Two centuries ago, almost all scientists made their living in some other profession. [...]
> The rise of science as a paid profession is a relatively recent phenomenon, dating from the later part of the 19th century. However, citizen scientists have never disappeared, particularly in sciences such as archaeology, astronomy and natural history, where skill in observation can be more important than expensive equipment. Today, most citizen scientists work with professional counterparts on projects that have been specifically designed or adapted to give amateurs a role, either for the educational benefit of the volunteers themselves or for the benefit of the project. The best examples benefit both.

Citizen science is a way to do research that would not be possible if the costs of professional scientists were the alternative. But it is more than that. It is also part of "the open science movement," and according to Bautista-Puig et al. (2019, 1) it "aims primarily to create a new scientific culture able to improve upon the triple interaction between science, society, and policy in the dual pursuit of more democratic research and decision-making informed by sound evidence". The same publication analyses scientific output on citizen science using bibliometric techniques and *Web of Science* (WoS) data and shows that output in the area has grown since 2010, with a larger proportion of papers (66%) mentioned in social media than reported in other studies.

6.6 Big science

The term "big science" refers to developments in (parts of) science since WW2. (Not to be confused with the term "big data", which developed in the 1990s, presented in Section 5.2). "Big science" was coined by Weinberg (1961), who wrote about the increase in funding for science and the high costs of research fields such as manned space flight and high-energy physics. His main emphasis was to address two questions: (1) Is Big Science Ruining Science? (2) Is Big Science Ruining Us Financially? In the context of the present article, question 1 is important as it addresses qualitative changes in science influenced by its quantitative developments. He quotes [without providing a bibliographical reference] the English astronomer Fred Hoyle's misgivings including the sentence "wherever science is fed by too *much* money, it becomes fat and lazy". Hoyle claims to see evidence that the tight intellectual discipline necessary for science is, especially in America, being loosened, and Weinberg wrote that he shared Hoyle's misgivings. Weinberg (1961, 161) wrote:

> [S]ince Big Science needs great public support it thrives on publicity. The inevitable result is the injection of a journalistic flavor into Big Science which is fundamentally in conflict with the scientific method. If the serious writings about Big Science were carefully separated from the journalistic writings, little harm would be done. But they are not so separated. [...] When these trends are added to the enormous proliferation of scientific writing, which largely remains unread in its original form and therefore must be predigested, one cannot escape the conclusion that the line between journalism and science has become blurred.

Although this specific claim about the development of big science was questioned by Panofsky (1992), Weinberg's interest in the importance of big science for the healthy development of research seems important.

Derek John de Solla Price (1963) contributed to making the term "big science" popular (and well-known in science studies, bibliometrics, and information science) by the title of his book *Little Science, Big Science*. The book is especially known for his empirically based claim that the growth of science has been exponential since the seventeenth century (measured, for example, in terms of scientific workers, scientific publications and dollars spent on scientific work). Price used the term "science of science" in his research field. Regarding the concept "big science" he contrasted science in the seventeenth century ("little science") with science as it looked when he wrote the book ("big science"). Price claimed that "big science" is not just defined by its size, but also and perhaps primarily in terms of certain significant differences in quality, including, for example, its declining growth rate, its dominance by invisible colleges and its potential for driving far-reaching social change. Price's book, its background and influences have been studied by, among others, Cole and Meyer (1985), Furner (2003a, 2003b) and Garfield (1985).

Price's observations contributed to popularizing the term "the information explosion" [159]. This, again, gave rise to increasing interest in "information storage and retrieval" and the establishment of "information science" as a discipline. The term has, however, been seriously criticized. Spang-Hanssen (2001), for example, wrote that the explosion in the number of published documents should not be confused with an explosion in the degree people are being informed. There is, therefore, no indication that demonstrates that Price's growth patterns show a growth in information.

One of the issues associated with big science is the increasing tendency to evaluate research by outsiders rather than by inside scholarly experts. This aspect is addressed by Chubin (1987), who focuses on bibliometrics and quantitative "science indicators". He rightly pointed out that Garfield's (1979) sounding "yes" to his own question, "Is citation analysis a legitimate evaluation tool?" smacks as much of self-interest as does scientists' *a priori* resistance to that tool because the outsiders are neither trained nor practitioners of X, therefore lack understanding of research in X and the ability to produce valid assessments of X. Chubin does not, however, follow-up on the consequences of such self-interests. It is not just Garfield but the whole field of bibliometrics which has such a self-interest. Correspondingly, in many other fields: Psychologists may have a self-interest that psychological testing is valid and reliable, psychiatrists in the reliability of diagnoses of mental diseases, etc. Therefore, scientists' self-interests may always affect science, and this issue should be at the forefront in the management of big science and research evaluation, but it seems to be neglected. The possible negative implications of big science for the internal soundness and quality of scientific inquiry were also addressed by Remington (1988).

Crease and Westfall (2016) made a distinction between "old big science" and "new big science". In the first, a chief problem was the narrow focus to justify the existence and cost of their tools. "In the new big science, a chief problem is diffuse focus. Machines are more diverse, and because they are used by an amorphous, ever-changing collection of users, research agendas are open-ended. As a result, managers and funders have had to develop new methods for handling, promoting, and evaluating research". Westfall (2003) criticized the use of "big" and suggested alternatively the following set of terms: "Modest-", "Mezzo-" and "Grand Science".

6.7 Conclusion of Section 6

This section provided a selected overview of many new conceptions suggested for understanding recent developments in the concept of "science." It is hard to form a clear conclusion about these developments, but the interpretation here is that most of these conceptions are based on the increasing commercialization of science, which many evaluate as a positive trend. In that way, these conceptions are connected to the pragmatic philosophy of science. However, as already described, pragmatic philosophy has an internal conflict between a long-term, objectivist understanding and a short-term subjectivist understanding. The ideas reported here in Section 6 seem to have failed to address the important question of how science can continue to penetrate ever deeper to understand the world, and not just reflect the more immediate social and commercial interests.

7. Overall conclusion

This article has brought together a lot of fragmented knowledge about science from many different fields and perspectives. The main conclusion is that these different pieces need to work together in a much more integrated way. It is also important to avoid a narrow conception of science, and we may state with Stephen Toulmin (1963, 15):

> A nutshell definition of science – as of anything else – inevitably floats around on the surface. An investigation of any depth forces us to recognize that the truth is much more complex. To understand the ways in which [. . .] scientific ideas differ, in any age [. . .] calls for a painstaking and laborious study: only in this way shall we bring to light the manifold functions that science has performed, performs now, and *might* perform in the future within our whole intellectual economy.

The most important lesson is that inductive, deductive, and abductive methodologies, bottom-up and top-down inquiry strategies, should be considered iterative processes taking place in socio-historical and political contexts and "paradigms," which cannot be ignored. In addition, it must be emphasized that each tradition and each contribution is always dominated by certain philosophical assumptions, which need to be interpreted in light of other philosophies because we are dealing with what, at the deepest level, counts as relevant knowledge and information: All activities concerning science, from producing over mediating (retrieving, publishing, digitalizing, curating, translating, organizing, teaching, etc.) to use must realize the socio-cultural and paradigmatic conflicts, which are necessarily involved in such activities.

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Endnotes

0. The first two parts of this trilogy are Hjorland, Birger. 2021. "Science, Part I: Basic Conceptions of Science and the Scientific Method." *Knowledge Organization* 48, nos.7/8: 473-98 and Hjørland, B. (2022). "Science, Part II: The Study of Science in Knowledge Organization". *Knowledge Organization* 49, no. 4: 273-300.

152. Nordmann, Radder and Schiemann (2011) discuss the epochal break thesis, but in the epilogue (201), Radder found that there is a diversity of views on this thesis and to draw a single, straightforward conclusion for or against the epochal thesis would obviously be premature. Concerning the problem of defining the concept "epochal break" the editors also back away from suggesting one. They propose six "models" (8):
    - The epochal break between the medieval "dark" age and the Renaissance with its light of reason
    - The Kuhnian scientific revolution or paradigm shift
    - "The so-called Hacking revolutions [...] [which] refer to a conceptual or technical innovation that can mark a point of no return" [the book provides no references to further information about this concept]
    - Forman (2007) "modeling the epochal break on the transition from modernity to postmodernity, by which he does not mean a break on the level of practice but on the level of ideology, interpretation, or cultural prestige".
    - "Media theorists refer to the epochal transition from analog to digital imaging, which severs the traditional causal chain from the original to its representation and allows any kind of data to be rendered in any number of visual forms."
    - "Michel Foucault's notion of "epistéme" and a shift in the order of discourse—that is, in the presuppositions that accord power and efficacy to certain kinds of knowledge."

153. The received notion of science was described by Nordmann, Radder and Schiemann (2011, 1) as the "idea of science that values above all intellectual qualities like curiosity, creativity, and knowledge, and that [it] does so for the sake of the public rather than the corporate good." What seems to replace this idea is mainly market-driven research, which by some makes the distinction between "pure" and "applied" research morally bankrupt.

154. Nordmann, Radder and Schiemann (2011, 7) wrote: "Some of these terms—'technoscience' and 'mode-2 research' in particular—will reappear throughout this book and to the astute reader, they may lack a proper definition. Indeed, more often than not, they are loosely descriptive of a phenomenon that remains to be fully understood. [...] There is another reason why the chapters herein do not enter the thick of labels, adjudicating and comparing them one by one and one against the other. Rather than become entangled by them, it is important to reclaim the critical distance that allows us to ask what is at stake in these various descriptions and redescriptions of research practice."

155. This view was further explored in Ziman (1998), in which the term "fundamental research" was added as a synonym for "basic" science. This article discusses the problem of defining basic science and examines different possibilities: (a) a policy category, (b) a cognitive category, (c) basic science as an individualistic ideology, (d) a sociological category and concludes (166): We set out originally on a hunt for basic research. We thought of it as cognitively fundamental, and vocationally pure. What we have ended up with is academic research - all too often pedantic, sectarian, and corrupted with careerism. These are harsh words, but they reflect the exasperation of decision makers trying to develop a rational policy for the support of science. They insist, again and again, that they value basic research and must rely on the scientific community to conduct it for the common good. And yet the failure of academic research to live up to their expectations impels the policy makers to intervene more and more deeply in the detailed running of the science base ...

156. See, for example, Danermark 2003.

157. Nordmann, Radder and Schiemann (2011, 7) continued: "These catchwords are by no means the only ways by which various authors seek to express what they perceive to be distinctive of much contemporary re-

search. In the 1970s already, Gernot Böhme, Wolfgang Krohn, Wolfgang van den Daele (1973), and Wolf Schäfer (1983) spoke of 'finalized science.' Once the business of internal theory development has been finished, research needs to orient itself explicitly toward specific social or technical ends that are to be achieved. Much more recently, Peter Galison (2006) [published as Galison 2018] began speaking of an 'engineering way of being in science' that is characterized by 'ontological indifference,' while Ann Johnson (2009) employs the notion of 'research in a design mode.' These terms capture the fact that many current research activities are more concerned with building or making than with knowing. Media theorists, art historians, and philosophers of modeling, each from their own disciplinary perspectives, ask whether there has been a major shift in the representational practices of science. And so, the list can be continued."

158. See Hjørland, B. (2022). "Science, Part II: The Study of Science in Knowledge Organization". *Knowledge Organization* 49, no. 4: 273-300. https://doi.org/10.5771/0943-7444-2022-4-273. Also available in *ISKO Encyclopedia of Knowledge Organization*, edited by Birger Hjørland and Claudio Gnoli, https://www.isko.org/cyclo/science.
159. The term "the information explosion" has been traced to Lars Heide 1941, cf., Vahrenkamp (2017, 41)

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Appendix 1: A Marxist Understanding of Science

From Hörnig (1985); translated from German; emphasis in original). [This version is a reprint of the version printed in the 12. edition, 10. Print run (1976); Originally based on an anonymous article in the 1964 edition of *Philosophisches Würterbuch*; a former version authored by Hörnig appeared in the 1972 edition].

"Science": "- complex social appearance and an essential part of the social reproduction process.

The emergence and development of science ultimately depends on the productive confrontation of people with their external nature; it is the result of the growing power of its practical trading. All major innovations in science have their starting point in practice, especially in material production, and find their realization in practice. Science penetrates ever deeper into the laws of nature, social development and thought, enables foresight and transformation of reality in the interests of society. Its knowledge is the basis of human activity and enables the growing mastery of the natural and social environment.

Science is generally characterized by the process of developing knowledge and the historically developed system of scientific knowledge and the individual sciences. Both sides are closely related and mutually dependent. Science is primarily a social process; its development is largely determined by the respective social formation.

The development and appropriation of knowledge is a creative and social work process. Scientific work, every discovery and invention, is general work. "It is partly due to cooperation with the living, partly through the use of earlier work" (Marx and Engels 25, 114 [1964]). Science is above all scientific activity. Knowledge is a prerequisite and the result of scientific activity. This point of view corresponds to a dialectical-materialistic view and becomes more and more important in the practice of the socialist social order, in the design of scientific and technical progress. Knowledge becomes science, not only from the point of view of registering facts etc., but rather from the point of view of continuing, deepening basic knowledge and also scientific working methods.

From the point of view of its results, science is a historically developed system of knowledge about nature, society and thought, which has objective (relative) truth. This system of knowledge is fixed in concepts, statements (especially scientific laws), theories and hypotheses. Science is the highest generalization of practice and, in an abstract form, conveys correct knowledge of the nature of phenomena, of the laws of nature and society.

The structure of science reflects the real process of understanding, the interrelations between theory and practice. Science includes empirical knowledge of facts that have been developed through experience, observation and experiment. The most essential element of science is theoretical knowledge. It is created by arranging known appearances, connections and understanding, through abstraction and systematization. The emergence of a theory is primarily characterized by the development of a system of fact about the objective Regularities of an object. For example, it was only with the work of Euclid that mathematics was given a systematic and demonstrative character. The elementary knowledge of chemical processes did not reach the level of a science before Boyle et al. provided the necessary knowledge that enabled chemistry gradually to be transformed to a science. It was only with this and with the development of the necessary concepts that many facts could be explained.

Political economy and social sciences could only develop into science with the epoch-making discoveries of Marx and Engels about the economic social formations.

When new facts become known, which cannot be explained with the current state of knowledge, new theories arise, and new areas of knowledge develop.

Hypotheses and scientific predictions (forecasts) must also be included in the area of theoretical knowledge.

All theories are checked and corrected in practice and are incorporated into the theoretical system of science as confirmed scientific knowledge.

Of particular importance to science are its ideological and philosophical foundations and conclusions. All scientific theories are highly related to philosophical questions. This affects all areas of science. Both the individual sciences and the system of sciences as a whole cannot do without ideological and philosophical prerequisites and problems.

Theses on the liberation of science from philosophy and ideology, as represented by bourgeois ideologists, especially those of a positivist nature, only document the dilemma of bourgeois ideology in explaining the nature of science and confirm its unscientific character.

As a scientific worldview and philosophy, *dialectical and historical materialism* represents the ideological, epistemological, and methodological basis of all sciences.

Scientific knowledge is embedded in the overall social work process. Science can only become a productive force in this context. Originally indirectly included in the practical production activity, science has increasingly become a special area of the social division of labor as a result of the division of physical and intellectual work. This area of social work includes a large and growing number of scientific institutions, scientific workers, and scientific organizations.

This process of socializing science has also made it an important institution that requires enormous material resources to support it. A broad industrial-technical basis is required today, especially in the field of natural science.

The ever-evolving division of scientific labor requires scientific management, planning and extensive organizational work. It must be designed in accordance with the objective requirements of scientific and technical progress and the management of science increasingly has the character of scientific work.

The rapid progress of human knowledge has led to a very extensive differentiation of the fields of knowledge and the emergence of numerous new special disciplines. This further specialization of science is a necessary process and expression for the fact that man, with his knowledge, penetrates deeper and deeper into laws and thus acquires an ever-greater ability to master the laws of nature and society. Since the individual sciences are concerned with the exploration of certain sides of objective reality or their reflection in consciousness, their development must at the same time bring the different branches of science closer together. There is also an inner connection between the sciences, there are mutual relationships that have a general meaning. The differentiation also includes the ever-stronger integration of the fields of knowledge. The scientific activities therefore include the interrelations and interactions of different fields of knowledge.

Of great importance for this integration are such sciences as Marxist-Leninist philosophy, mathematics, and cybernetics, which examine relationships and laws that are common to qualitatively different objects.

The differentiation and integration of the sciences are two sides of a real dialectical process of ever deeper knowledge of objective reality and better mastery of the processes in nature and society. The successful application of scientific knowledge in practice depends to a large extent on a correct understanding of the dialectic of scientific and technical progress, the place and the possibilities of a special science as well as its methods and relationships with other sciences.

Science is particularly important as an educational factor. In this context, it occupies a relatively independent place in the social reproductive process by elaborating and imparting the necessary knowledge bases and the methods of acquiring knowledge for all forms of education. In socialism, science and scientific education are the foundations of the education system of the whole population. The socialist state enables every working person to acquire science through all-round and continuous education.

This development of the all-round and continuous education of the working people is fundamentally conditioned and made possible by the requirements of scientific, technical, and social progress, the increasingly intensive integration of science and production and the development of socialist democracy.

The interrelation between science and production is becoming increasingly important due to the scientific and technical revolution. A closer interaction between science and production is an essential prerequisite for rapid development and for changes in almost all areas of society. The results of science increasingly influence the technical level of production, while production at the scientific and technical progress level increases the possibilities of science.

Despite the constant increase in the role of science for the level of production and the performance of social processes, science remains an inseparable and dependent part of social practice. The progress of science is ultimately determined by social practice, primarily by the development of production.

The management, planning and organization of science is aimed at high growth to solve the main task of socialist society and to increase the effectiveness of scientific and technical work. Science is increasingly becoming an immediate productive force (German: *Produktivkraft*).

Such a direct relationship between science and production does not mean narrowing the tasks, the structure or the different levels of science. It is only possible through a deeper penetration into the laws of nature and society, the development of new production systems and technologies in production preparation, the scientific management of production and a conscious design of social relationships. For this purpose, both extensive basic research and extensive applied research are necessary. The necessary scientific advance for the production of tomorrow, the development of forecasts as well as the possibility of planned scientific and technical progress in socialism increase the importance of the subjective factor of society.

The increasing socialization of science and the acceleration of scientific and technical progress require a new quality of scientific information and documentation, which to a certain extent maintains the character of scientific knowledge.

The importance of science for society also results from its history. It is part of the history of human society, the struggle of the classes for historical progress. Science is essentially human and revolutionary. Scientists' constant struggle for new knowledge, better mastery of the laws of nature and society and improving people's lives. It is incompatible with stagnation and reaction.

Science can only do justice to its revolutionary and human nature if it is based on the most revolutionary class in society. Great insights, which above all initiate a qualitative development in the history of science, were always borne and promoted by the class, which itself was interested in the changes in existing social conditions, while the conservative classes and their ideologists oppose the revolutionary science. The ideological struggle took a dominant place in these debates. The fundamental achievements of Copernicus, Kepler, and Galilei in the field of astronomy, physics and mechanics, the development of the experiment as scientific methodology and practical demonstration of evidence, for example, trembled the foundations of the feudal society and its world view and withdrawn from the representatives of the clergy their claim of the supremacy of divine Authority. That is why the ruling forces went against science and its most revolutionary representatives by all means of political and economic coercion and did not shy away from murder. Until today, reactionary philosophy has been characterized by skepticism in answering science's claim to objective truth, and by replacing the close relationship between science and worldview with an idealistic worldview and subjectivism. This attitude also corresponds to the one-sided and extremely pragmatic relationship of the monopoly bourgeoisie and its state to science. It expresses the limits of capitalist society for the development of science.

The imperialist bourgeoisie tries to use the achievements of science to increase profits and maintain their class rule. Science has today become an important factor in competition between capitalist countries.

The history of science makes it clear that scientific knowledge can only practice its usefulness for mankind if it meets the needs of historical progress and is supported by the most progressive forces. The ruling bourgeois class and its ideologists reject scientific knowledge that justifies social progress as an objective lawfulness and the unity of natural and social science because it makes clear the demise of capitalist society and the communist future. The history of science teaches that it is science's responsibility to fight against reaction and anti-human theories.

In the 20th century, social progress was directed towards communism; it is connected with the scientific and technical revolution, with the all-round development of science and is based on the discoveries of the laws of nature, society and thought and its basis of unity and universality.

Science lives up to its essence and responsibility for humanity if it is based on the most revolutionary class of the 20th century, the working class, and is guided by its scientific worldview, Marxism-Leninism.

The most important driving force for the development of science to the immediate productive force in the present is the socialist relations of production. The degree of mastery of the natural and social environment develops not only quantitatively but also qualitatively in socialism, because science in the politics of the party of the working class also becomes the basis for the development of society. The primary task of science is to strengthen socialism."