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Problem of Social Responsibility of Laboratory Sciences

Introduction

The philosophical aspects of science have been explored in a vast array of studies. The great majority of them are dominated by the classic approach to science as a form of cognitive activity that aims at a true (or more specifically bringing us to the truth) description of phenomena and processes occurring in the world.[1] Science is also frequently attributed with high explanatory power – with attention being drawn to the deductive-nomological model of explanation which is used in the science domain. Knowledge accumulated in this way is expressed in the form of theories. Even though there is an ongoing dispute between scientific realists and antirealists about the cognitive status of theories, regardless of the outcome of the debate, it is theories that are recognised by many researchers as the basic structural unit of science conceived as a special kind of knowledge. In other words, in the classic approach to science, theory is recognised as a fundamental component of the research tradition that leads to the discovery of the laws of nature. The community of scholars

1 The term "science" is known to be notoriously ambiguous. In this paper, following the Anglo-Saxon tradition, "science" is to be understood as referring to natural sciences.

that cultivates and contributes to this tradition has no social responsibility for products arising within this framework. Imre Lakatos states outright that "*science, as such, has no social responsibility.* […] it is society that has a responsibility – that of maintaining the apolitical, detached scientific tradition and allowing science to search for truth in the way determined purely by its inner life".[2]

Advocates of new experimentalism and science and technology studies (STS), who can be regarded as representatives of the non-classic approach to science, argue that analysing contemporary science calls for greater focus to be put on research practice – or more specifically on various research practices – rather than theoretical tradition. These practices are turning into the main area of interest of laboratory sciences. These sciences – as one of the initiators of new experimentalism Ian Hacking notes – are distinguished chiefly by the fact that they can create phenomena that do not occur in nature in its "pure state before people".

In this paper, the issue of responsibility of science for products achieved throughout its development is approached in relation to science both in its classic and non-classic dimensions. It is argued that while in the former case the issue under study does not provoke serious controversy, in the latter case controversies do exist and, furthermore, they are justified. The concept of social responsibility is discussed in reference to the thesis formulated by Hans Jonas on the growing gap between the human ability to foresee the consequences of their actions and the power inherent in these actions due to technology, which is directly related to the laboratory sciences.[3]

1. Social responsibility of science as knowledge

The classic approach to science is closely related to the position of theoreticism which claims that theories are the basic structural units of research processes. While experimentation is also mentioned, it is generally assigned a supporting role to theory. Experiments are carried out in order to confirm or refute theories, or to determine a certain detail so that an already existing theory can (potentially) be expanded. An example of this approach can be found in medieval optical experiments in which the ex-

2 Imre Lakatos, "The Social Responsibility of Science", in: *Mathematics, Science and Epistemology: Philosophical Papers*, vol. 2, eds. John Worrall, Gregory Currie (Cambridge: Cambridge University Press, 1978), 258; italics as in the original.

3 Hans Jonas, *The Imperative of Responsibility: In Search of an Ethics for the Technological Age* (Chicago: University of Chicago Press, 1984), 32.

perimenters observed the splitting of sunlight passing through water-filled spheres. When Descartes and Newton observed colours through a prism, they also alluded to this outlook on experimentation. The approach may also take the form of 'thought experiments' resting on the foundation of knowledge assumed during their design.[4]

Proponents of theoreticism argue that the main goal of mathematised natural sciences is to formulate theories in the form of conceptually and methodologically consistent sets of theorems.[5] To know is to think, and especially to think in terms that can be expressed through sentences.[6] Knowledge thus conceived is meant to provide abstract statements which, in line with the formula 'first theory, then practice', create a basis for formulating rules of effective practical action. A limitation of this approach is that it overlooks procedural knowledge.

Narrowing the scope of knowledge of natural sciences down to propositional knowledge leads to the adoption of the application-based model of theoretical knowledge (one in which theoretical sciences are clearly distinguished from technology) by representatives of theoreticism. In line with this approach, products of technology are viewed as a one-sided process of applying knowledge gained within the domains of exact and natural sciences. The starting point is basic research in these sciences, which generates theoretical knowledge expressed in the form of general theories. The next step involves finding applications for the knowledge thus acquired. To this end, the place of science is taken over by technology, leading to the creation of various types of artefacts. The subsequent stage is research and development, oriented towards increasing the efficiency of the artefact.

The application-based model of theoretical knowledge adopted in the theoretist framework can be interpreted in at least two ways: contemplatively or performatively.[7] The line of division is the cognitive status

4 Thomas Kuhn, "Mathematical versus Experimental Traditions in the Development of Physical Science", in: Thomas Kuhn, *The Essential Tension. Selected Studies in Scientific Tradition and Change* (Chicago: Chicago University Press, 1977), 41–43.

5 Paweł Zeidler, *Models and Metaphors as Research Tools in Science. Philosophical, Methodological and Semiotic Study of Science* (Berlin–Münster–Wien–Zürich–London: LIT Verlag, 2013), 13.

6 Davis Baird, *Thing Knowledge: Philosophy of Scientific Instruments* (Berkeley: University of California Press, 2004), 1.

7 By highlighting the two ways of interpreting the application-based model of knowledge, I refer to the study by Kazimierz Jodkowski who identified the contemplative and performative models among the various models of knowledge. See Kazimierz Jodkowski, "Kontemplacyjny versus performacyjny model wiedzy a Feyerabendowska krytyka nauki (miejsce nauki w hierarchii wartości różnych

of scientific theory, which remains the main subject of dispute between scientific realists and antirealists. Realists argue that the central purpose of scientific inquiry can be distilled down to the formulation of scientific theories that are true or at least close to the truth. The possibility of fulfilling this purpose justifies the belief in the existence of objects postulated by these theories. Antirealists, on the other hand, claim that scientific theories are tools devoid of logical value that enable the derivation of propositions about what is observable.[8]

The application-based model of theoretical knowledge in its contemplative variant is embraced by scientific realists. In their view, the primary task of science is to contemplate the world, that is to describe it on the basis of the classic definition of truth. In this paradigm, knowledge refers to collecting an ever-greater pool of information about the world. On the other pole, the application-based model of scientific knowledge in the performative variant is represented by scientific antirealists, who equate the primary goal of science with the effectiveness of actions based on a scientific theory.[9] If someone applying a scientific theory is able to adapt to changing circumstances in a malleable and innovative manner, then such a theory can be said to properly fulfil its purpose. In this case, scientific knowledge serves as a fundamental component of the dynamic process by which people adapt to the environment around them.[10] When knowledge is understood classically, in line with Plato's philosophy, i.e. as a true and justified belief, what is meant is – manifestly – the contemplative approach.[11]

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tradycji i form życia)" ["Contemplative versus Performative Model of Knowledge and Feyerabend's Critique of Science (Status of Science in the Hierarchy of Values in Various Traditions and Forms of Life"], *Studia Filozoficzne* 287 (1989): 99–113.

8 Jarret Leplin (ed.), *Scientific Realism* (Berkeley–Los Angeles–London, 1984).

9 Sergio Sismondo, *Science without Myth. On Constructions, Reality, and Social Knowledge* (New York: State University of New York, 1996), 62–63.

10 Konrad Lorenz, "Kant's Doctrine of the A Priori in the Light of Contemporary Biology", in: *Philosophy After Darwin: Classic and Contemporary Readings*, ed. Michael Ruse (Princeton: Princeton University Press, 2009), 231–347.

11 When Jodkowski discusses the contemplative and performative models of knowledge, he does not set them side by side with the dispute between scientific realists and antirealists. The author links the contemplative model directly to the pursuit of a true (or near-true) description of the world. With respect to the performative model, he underlines that it is "part of a specific variety of evolutionary epistemology. Evolutionary epistemology is a theory of cognition that is at least compatible with the stature of man as a product of biological and social evolution. Evolution – even in its biological aspects – also entails the acquisition of knowledge. It is prevailingly recognised that the mechanisms of variation, selection and transmission apply not only to biology but also to epistemology".

The history of science provides multiple examples of the application-based model of scientific knowledge. From the end of the 17th century, progress within scientific knowledge was achieved through the expansion of theoretical knowledge and its applications. As Wojciech Sady notes: "each new successful application is a theoretical discovery: sometimes the discovery of a new law, and far more commonly the discovery of yet another condition".[12] Sady argues that scientific research in the field of physics which he analyses is characterised by a high degree of systematicity. Under the approach, research undertaken in any field should always begin with the simplest phenomena. In addition – he asserts – "multiple experiments should always be carried out to study the same objects or object types in various configurations. Based on the findings, the objects can be assigned appropriate theoretical properties, which gives credibility to study results. As the pool of knowledge in a particular area grows, one moves – in a stepwise manner – to the study of more complex phenomena. […] Any values already measured are specified in greater detail, and further corrections are made to the calculations as the research progresses. After certain objects or processes have been successfully examined, similar investigations of objects or processes resembling them are undertaken".[13] A particularly important function of systematicity – Sady highlights – is to eliminate the category of fortunate chance (serendipity) from the process of knowledge development. For instance, it is sometimes claimed that X-rays or penicillin represent unplanned fortunate discoveries. Such opinions are misleading, though, for they fail to recognise that a prerequisite for making such discoveries is the presence of suitably prepared scientific mind, capable of observing that it deals with something that goes beyond the existing world picture. Furthermore, the systematic nature of research means that – in specific situations – failure to make a discovery should be described as an (unfortunate) chance.[14]

The claim made by Lakatos that science as such does not have social responsibility for the products it generates, is appealing when it is applied in relation to highly mathematised natural sciences, particularly such specific disciplines as theoretical physics, astrophysics or geology which, according to the proponents of theoreticism, are developed as the

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See Jodkowski, "Kontemplacyjny versus performacyjny model wiedzy a Feyerabendowska krytyka nauki": 107.

12 Wojciech Sady, *Struktura rewolucji relatywistycznej i kwantowej w fizyce* [*Structure of the Relativistic and Quantum Revolution in Physics*] (Kraków: Universitas, 2020), 212.

13 Ibidem, 26.

14 Ibidem.

knowledge of abstract systems of theoretical statements. Regardless of the different approaches to theoreticism, its proponents adopt a kind of *consensus omnium* that theories – or rather theoretical complexes – provide a basis to view science as an intersubjectively communicable and controllable system of relatively universal statements about the world. Such statements, despite being occasionally subject to change, as strongly underlined by advocates of the historical current in the study of science,[15] remain part of the theoretical research tradition that leads to learning about the surrounding world and making predictions about it that do not surprise us.[16] Such predictions may be of great usefulness to engineers or technicians building bridges, cars and airplanes, but they are not useful in themselves.

2. Social responsibility of laboratory sciences

Since the 1980s, within the domain of philosophical reflection on science, there has been a gradual emergence of critical responses towards the vision of science defined solely as knowledge. One of them is the position of 'new experimentalism', which was developed in the most systematic and coherent manner by Ian Hacking. In his famous study *Representing and Intervening*, the Canadian philosopher, referring to the manner of doing science initiated by Francis Bacon and later continued by, among others, Robert Boyle and Robert Hooke, recognised that the starting point for scientific research should be experimental research practice rather than theory. Hacking regards experimentation as the key procedure within the sphere of research activity of contemporary empirical sciences. New experimentalists claim that by focusing a spotlight on theoretical activity the classic approach to science presents an excessively one-sided picture of research activity. According to Hacking, theories are concerned with

15 Even though in his early studies Thomas Kuhn argued that a discussion on science should not entail questions about research in a community of scholars within a context broader than that strictly defined by the paradigm, his later works allow for the possibility of progress through revolutions, after which – in a new paradigm – the previous achievements contributing to the development of scientific knowledge are preserved. See Thomas Kuhn, "The Structure of Scientific Revolutions", second edition, in: *Foundations of the Unity of Science*. *Toward an International Encyclopedia of Unified Science*, eds. Otto Neurath, Rudolf Carnap, Charles Morris, vol. 2 (Chicago–London: The University of Chicago Press, 1970), 54–262.

16 Mary Hesse, "Theory and Values in the Social Sciences", in: Mary Hesse, *Revolutions and Reconstructions in the Philosophy of Science* (Brighton: The Harvester University Press, 1980), 190.

making multiple attempts to produce representations of the world, while experimentation involves intervening in the world.[17]

The goal of experimentation is to find an answer to the question of how nature operates in a previously unstudied situation. Experiments manipulate the constituents of the world in order to unravel its mysteries. As Hacking claims: "to experiment is to create, produce, refine and stabilize phenomena".[18] Experimenters generate phenomena through their ingenuity and by designing a variety of devices. Such phenomena represent "the touchstones of physics, the keys to nature".[19]

Processes involved in the creation of new objects and phenomena are studied by laboratory sciences. Such sciences – Hacking highlights – seek to design and use special apparatus for intervening in the untainted state of nature ("a pure state before people") in order to isolate and purify the existing phenomena and create new ones. Such interventions result in the drive to bring about changes in the world, and to increasingly control the phenomena arising from these changes.[20]

Laboratory research practice comprises an array of factors which enter into a variety of interactions with one another, and are classified into three groups: ideas, things, and marks. Each of the groups comprises five components. The group of ideas accommodates a host of questions and theories which make up the intellectual content of activities performed in laboratories. The group of things consists both of material substances which are examined or used for scientific investigation, and devices, apparatus, and theoretical objects used in studies. Furthermore, it includes experimenters who are involved in research. The third group consists of results obtained in laboratory research along with their interpretations.[21]

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17 See Ian Hacking, *Representing and Intervening. Topics in the Philosophy of Natural Science* (Cambridge: Cambridge University Press, 1983), 146.

18 Ibidem, 230.

19 Ian Hacking, "Experimentation and Scientific Realism", in: *The Philosophy of Science*, eds. Richard Boyd et al. (Cambridge: The MIT Press, 1991), 247.

20 Ian Hacking, "The Self-Vindication of Laboratory Sciences", in: *Science as Practice and Culture*, ed. Andrew Pickering (Chicago–London: The University of Chicago Press, 1992), 33. Hacking does not classify palaeontology or astrophysics as laboratory sciences, even though the two disciplines rely on laboratory-generated findings. Such fields as economics, sociology and psychology are also considered to be outside the realm of laboratory sciences. In addition, the sciences whose main focus is observation, classification or historical analyses, are entirely outside Hacking's area of interest.

21 Ibidem, 44–50.

All the constituent elements of laboratory research practice are closely intertwined, and they influence one another. In addition, they may change their nature throughout the course of experimentation. The above statement applies also to theoretical assumptions which are so strongly linked to technological factors in all the three groups of Hacking's proposed taxonomy that the distinct division into theoretical and applied sciences cannot be upheld. The situation is clearly manifest in the approach to phenomenological topical hypotheses used in experiments. The hypotheses are meant to combine general laws of systematic theory with empirical phenomena. The combination is only made possible by employing a set of procedures for the modelling and formulation of approximations.

Another essential element implicated in combining the theoretical and technological dimensions is related to the modelling of the research apparatus applied in the laboratory. The modelling process has two main aspects. Based on the theoretical assumptions adopted, the manner of operation of the apparatus is established, and its interactions with objects studied by experimenters and serving as study aids are determined.

One of the consequences of the possibility for modification and mutual adjustment of all elements involved in experimental works is the stability of laboratory sciences. Researchers pursuing their studies within these sciences, Hacking writes, aim to generate a self-vindication structure that maintains its stability.[22] In advanced laboratory sciences, theoretical premises and research apparatus are mutually self-vindicating in the process of data interpretation. Constituent elements of laboratory practice create a symbiotic relationship between people, scientific organisation, and nature.[23] In doing so, they constitute what Hacking refers to as the "laboratory science style".[24] Within this style, science is interpreted as "science-as-practice", as opposed to "science-as-knowledge".

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22 Ibidem, 29–30.

23 Ibidem, 56.

24 See Ian Hacking, "The Disunities of the Sciences", in: *The Disunity of Science. Boundaries, Contexts, and Power*, eds. Peter Galison, David Stump (Stanford: Stanford University Press, 1996), 37–74. Exploring the nature of "laboratory science style", Hacking refers primarily to the analysis of research practices in the field of experimental physics. Paweł Zeidler argues, though, that the paradigmatic example of the specificity of this style is not physics, but chemistry. "Hence, the establishment of the laboratory style is closely linked to the advent of modern chemistry. Without doubt, chemistry is a science in which the laboratory style predominates, and its internal characteristics are determined by the mutual relations which bring together the constituents of laboratory research practice. Another argument in favour of recognising chemistry as a paradigmatic example of laboratory science is the fact that considerations within the scope of theoretical chemistry which are

In contemporary times, the primary goal of the sciences is not, Hacking argues, striving to formulate true theories, but resolving problems that arise in the course of experimental research practice. It is this practice, and not theoretical considerations, that sets the course for the development of contemporary sciences. Researchers concentrate their attention on things and actions rather than on the conceptual systems that these things and actions are meant to describe and explain. This approach contributes to an expansion of the knowledge of nature, a more insightful understanding of nature, and an increasingly precise control of nature.

Although Hacking's characterisation of laboratory science is viewed critically by many researchers,[25] it discloses the complexity of the relationship between the theoretical and technological components of laboratory research practice. It is my belief that the close relationship between these two types of components can be recognised as an important premise for the thesis that comparing and contrasting laboratory science and technology in the contemporary age should bring into focus the feedback between the two domains rather than rely on the application-based model of theoretical knowledge. Andrew Pickering goes as far as to claim that the history of science today changes not so much in the wake of scientific revolutions as technological revolutions. In today's world, technological progress is ahead of scientific progress, and practice is ahead of theory.[26]

Although experimentation entails that phenomena are created rather than discovered, Hacking defends the thesis that the phenomena are indifferent to the observer. In his characterisation of laboratory sciences, he focuses predominantly on experiments, ignoring the issue of worldview

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not related – even indirectly – to laboratory practice make up just an insignificant fraction of total research practice in this science". Paweł Zeidler, "Miejsce filozofii chemii w filozofii przyrodoznawstwa" ["Role of Philosophy of Chemistry in the Philosophy of Natural Sciences"], in: Paweł Zeidler, *Chemia w* świetle *filozofii. Studia z filozofii, metodologii i semiotyki chemii* [*Chemistry from the Perspective of Philosophy. Studies in Philosophy, Methodology, and Semiotics of Chemistry*] (Poznań: Wydawnictwo Naukowe IF UAM, 2011), 20.

25 See, for example, Arjan Chakravartty, *A Metaphysics for Scientific Realism. Knowing the Unobservable* (Cambridge: Cambridge University Press, 2007); Stefan Amsterdamski, "Filozofia nauki i socjologia wiedzy" ["Philosophy of Science and Sociology of Knowledge"], in: *Racjonalność współczesności* [*Rationality of Contemporary. Between Philosophy and Sociology*], eds. Helena Kozakiewicz, Edmund Mokrzycki, Marek Siemek (Warszawa: Wydawnictwo Naukowe PWN, 1992), 319–334.

26 Andrew Pickering, "After Representation. Science Studies in the Performative Idiom", *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2 (1994): 13–419.

(*Weltanschanung*) of the experimenters. He highlights that he is interested in the internal, not external elements of the experiment.[27] However, in his later studies, the philosopher draws attention to the need to consider the role of the latter. For example, he highlights the role of military input in the process of laser invention.[28]

The external components of laboratory experiments have become a major area of interest for researchers in the field of science and technology studies as well as for some cognitive science scholars. This is clearly seen in the studies by Karin Knorr Cetina, Bruno Latour or Nancy J. Nersessian, among other scholars. These authors – while not negating the need to study the laboratory experiments themselves – also pay attention to the experimenters. In their proposed vision of science a key role is ascribed to the collective nature of laboratory research practice and the links between experimenters and many different factors in their material environment, occurring both in the laboratory itself and in its surroundings. Unlike Hacking, Knorr Cetina, Latour or Nersessian do not focus solely on analyses related to the field of physics. They extend their area of research interest to a range of other scientific disciplines. Crucially, these scholars do not treat the results obtained in the laboratory as purely social artifacts. Contrary to many claims, they do not move away from exploring the problem of realism in science.

In her characterisation of the laboratory, Knorr-Cetina notes that it is an enhanced environment improving upon the natural order in relation to the social order. The improvement consists mainly in the fact that laboratory research rests upon the tenet of malleability of natural objects. What this means is that they are not treated as 'predetermined' unalterable objects that must be considered as such. As mentioned by Hacking earlier, objects in their "pure state before people" are very rarely subjected to analysis. Instead, they tend to be manipulated, so that only their 'purified' versions are studied. They are 'processed' in order to extract only some of their properties, for example optical, acoustic or electrical.[29] This is how – in the process of scientific research – objects of knowledge arise.[30] The strength

27 Hacking, "The Self-Vindication of Laboratory Sciences", 51.

28 See Ian Hacking, *The Social Construction of What?* (Cambridge: Cambridge Harvard University Press, 1999), 181.

29 Karin Knorr-Cetina, "The Couch, the Cathedral, and Laboratory: On Relationship between Experiment and Laboratory in Science", in: *Science as Practice and Culture*, ed. Andrew Pickering (Chicago–London: The University of Chicago Press, 1992), 116.

30 A fundamentally different approach to the results of laboratory studies was

but also limitation of laboratories is that they approach studied objects as cultural objects.[31] The world recognised through science is an outcome of a research process that is predominantly productive and ontological rather than descriptive and epistemological. Research is always 'concerned' with new procedures for the authentication and recognition of 'something' that becomes an object with identifiable properties and is thus capable of being incorporated into and constituting our future world.[32]

In his analysis of laboratory research practice, Latour applied the actor-network theory. A key means of analysis is the metaphor of creating and breaking relationships between "human and non-human actors" which fully determine the course of actions taken in the laboratory.[33] In order to explicate the nature of these activities and, in their light, show the illusoriness of the asymmetry of the 'inside' of science and its 'outside', Latour cites the example of research conducted by Louis Pasteur. In his *The Pasteurization of France*, he draws attention to the scale of changes that were brought about by Pasteur's laboratory experiments investigating microorganisms. He argues that the transformation encompassed all the actors involved in the experiments. They even changed Pasteur himself – as well as the entire scientific practice in the field of microbiology. However, they also transformed the French society as a whole. Latour points to a very close interdependence between all the factors existing in the laboratory, with a particularly strong emphasis on Pasteur's contribution. He

taken by Roy Bhaskar, who defines the fundamental goal of laboratory sciences as the study and detection of generative mechanisms of nature which govern the course of real phenomena. These mechanisms are referred to by Bhaskar as intransitive objects of knowledge. The philosopher postulates that they are only amenable to exploration in an artificial environment created in the laboratory. The laboratory is a setting that allows the generation of isolated closed systems in which experimental scientists are able to uncover the objective laws of nature. These laws cannot be discovered in open systems in which different laws interfere with one another and, as a result, the operation of some laws is disrupted by the operation of others. For Bhaskar, then, the laboratory remains the place where scientists formulate the objective laws of science applying to diverse areas of human activity. See Roy Bhaskar, *A Realistic Theory of Science* (London–New York: Routledge, 2008), 46–52.

31 Karin Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999), 28.

32 Karin Knorr-Cetina, "The Ethnographic Study of Scientific Work: Towards a Constructivism Interpretation of Science", in: *Science Observed: Perspectives on Social Study of Science*, eds. Karin Knorr-Cetina, Mike Mulkay (London: SAGE Publications, 1983), 115–140.

33 Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge: Harvard University Press, 1987), 63–102.

claims that Pasteur's genius lay not so much in revolutionising biology by identifying the mechanism of microbe attenuation, but rather in being able to perform in the laboratory a successful translation into the language of scientific practice of problems which had carried a great significance for the society for many years preceding Pasteur's seminal discovery.[34] The act of achieving control over microbes discloses, so Latour argues, the nature of relations between the laboratory and its social environment. On the one hand, the outside environment has a marked influence on the laboratory. On the other, results of laboratory studies are given practical applications.

Nersessian claims that the fundamental question posed in the analysis of laboratory research practice is whether it is possible to present the processes by which experimenters solve specific problems. These processes, as emphasised by the Canadian researcher, are difficult to capture accurately, as they extend over time and are dynamic in nature. Contrary to Hacking's concept, they are not only embedded in the objective (i.e. intralaboratory) context, but also depend on the effect of many other factors, sometimes inspired simply by everyday life. Scientific problems that become the focus of laboratory research practice are resolved – Nersessian writes – in complex cognitive-cultural systems.[35] Therefore, the three groups of factors listed by Hacking (ideas, objects and marks) should be expanded by adding another group, comprising sociocultural factors, as argued by representatives of studies in science and technology. Only the full set of factors creates a self-justifying structure of laboratory science. The laboratory, Nersessian argues, is not a place located in the physical space, existing here and now. Instead, it can be described as a dynamic 'lab-as-problem-space' which is characterised by permeable boundaries. For example, engineers' efforts to develop an artificial heart require close cooperation with medical schools.[36]

An analysis of laboratory sciences shows that nowadays they exert an increasing influence on the characteristics of many modern natural and technical sciences. From the second half of the 20th century, classic academic science, which had traditionally focused its efforts on fundamental research, gradually began to evolve, as John Ziman points out, into post-academic science, in which the conventionally sustained distinction

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34 Bruno Latour, *The Pasteurization of France* (Cambridge: Harvard University Press, 1988), 65–67.

35 Nancy J. Nersessian, "The Cognitive-Cultural Systems of the Research Laboratory", *Organization Studies* 27 (2006): 131–132.

36 See ibidem.

between science and its practical applications is gradually blurred.[37] This state of affairs is due to very tight links between elements from the sphere of basic and technical sciences within laboratory research practice. The laboratory is thus turning into a place where the material, cognitive and social dimensions are becoming increasingly intertwined. Connecting these three dimensions becomes – to a large extent – the basis for practical successes and achievements of the field referred to as technoscience.[38] The type of knowledge that is in the focus of interest of technoscience is not cognitive knowledge but rather concrete skills manifesting as practical knowledge. Any questions about its specificity, therefore, refer not so much to the criterion of truth and falsehood as to the criterion of stable control of processes produced during laboratory research practice.

Technoscience is a consequence of the development of science and technology which, for the last few decades, has been taking place mainly in the area of nanobio- and infotechnology as well as in physics, chemistry and biology. Explorations into the phenomenon of technoscience reveal a distinctive overlap between different disciplines and fields of science and engineering/technical activity. In his book *Science in the Private Interest*, which analyses the research processes in biomedical science in the USA, Sheldon Krimsky provides a strong case for the growing expansion of technoscience. The author discusses the ever-urgent need to change the concept of 'university'. What he proposes is addressing universities as "university-industry research centres" rather than places for playing a game for the truth.[39] The new approach to the role of the university is an expression of new relationships existing between commercial institutions and research establishments. The analyses presented by Krimsky attest to the increasing commercialisation of multiple technoscience disciplines. A particularly clear example of this trend is biotechnology. Biotechnological experiments are the prime illustration of how closely science is intertwined with industry. A paramount manifestation of this interconnection is the phenomenon of globalisation.

37 John Ziman, *Real Science* (Cambridge: Cambridge University Press, 2000), 116. See also: Joachim Schummer, "W kierunku filozofii chemii" ["Towards a Philosophy of Chemistry"], in: *Chemia w laboratorium myśli i działań* [*Chemistry in the Laboratory of Thoughts and Actions*], eds. Danuta Sobczyńska, Paweł Zeidler (Poznań: Wydawnictwo Naukowe IF UAM, 1999), 197.

38 Ronald N. Giere, Barton Moffatt, "Distributed Cognition: Where the Cognitive and the Social Merge", *Social Studies of Science* 33/2 (2003): 301–310.

39 Sheldon Krimsky, *Science in Private Interest. Has the of Profits Corrupted Biomedical Research?* (Lanham: Rowman & Littlefield, 2003), 31.

When technoscience is considered in the context of its relationship with globalisation, evidence is obtained not only to justify the existence of feedback between science and technology, but also the already mentioned thesis that both fields are becoming more and more dependent on what is beyond their boundaries.[40] Biomedical activity aimed at improving the human being, efforts undertaken within genetic engineering as a biotechnological tool dedicated to the manipulation of genes, growing production of animal and plant food or rapid development of artificial intelligence – these are just a few examples of the operation of technoscience, which is more cultural and social in intent than technical or scientific. On the one hand, technoscience undoubtedly helps in the resolution of a wide range of economic, social and political problems, providing instruments that bring tangible benefits. On the other hand, it also gives rise to an array of problems. Unquestionable successes of technoscience include, for example, its contribution to the fight against the COVID-19 pandemic. Based on the relatively fast identification of the SARS-CoV-2 virus and the development of vaccines, medical services have succeeded in saving the lives of a great number of people. On the other hand, technoscience is also linked to major threats, for example, the emergence of a new generation of weapons of mass destruction (nuclear, laser, chemical, biological) or input towards the development of cutting-edge methods of surveillance that make it possible to subjugate individuals and entire social groups to political or economic power.[41] Technoscience also contributes to a vast extent to the entrenchment of an unjustified belief referred to as 'technological fix' (or 'technological shortcut'), which assumes that as-yet unknown discoveries and future innovations in technology will be able to address all risks facing humanity.[42]

Equipped with the possibilities offered by laboratory sciences, humans now have the power to modify what was previously unalterable. As a result, the distinction between what is natural and what is produced becomes increasingly obscure. In such circumstances, the very concept of 'nature' changes. It ceases to refer to 'natural resources', and acquires

40 For a discussion of the relationship between science and technology in the era of globalisation, see: Marek Sikora, "Nauka i technika w dobie globalizacji" ["Science and Technology in the Age of Globalisation"], *Filozofia Nauki* 105 (2019): 121–138.

41 Shoshana Zuboff, *The Age of Surveillance Capitalism* (London: Profile Books Ltd., 2019), 19–24.

42 See Lech Zacher, *Transformacje społeczeństw. Od informacji do wiedzy* [*Transforming Societies: From Information to Knowledge*] (Warszawa: Wydawnictwo C.H. Beck, 2007), 171.

a normative and problematic dimension.[43] In view of growing human agency, the problem of social responsibility of laboratory sciences for their products ('responsibility for') is gaining relevance. In this context, Hans Jonas argues that the traditional principle of responsibility needs to be revised, mainly in the aspect related to the gap between the human capacity for prediction and the power of action achieved through laboratory sciences. In view of the prominent superiority of the latter, recognising what is yet unknown becomes the other side of the obligation to know, and thus part of ethics that must guide the increasingly urgent need for self-control curbing excessive human power.[44] The need for self-control stems from an awareness of the scale of risks both to ourselves and future generations ('responsibility before').[45]

The problem of social responsibility of laboratory sciences is directly linked to the concept of human freedom. As stated by Hannah Arendt, freedom also refers to a collective ability to coordinate efforts and act together in the pursuit of a specific social goal. One of such goals today is definitely a critical analysis of research activity of laboratory sciences. It shows that the main interest should lie not only in examining the practical successes of the experiments carried out in the laboratory, but also in reflecting on the social effects of their operation and investigating the associated risks. Roald Hoffmann, a Nobel Prize winner in chemistry, asks outright: do chemists take an interest in the subjects of their research for purely cognitive reasons, or are there other motivations behind their choices? Does chemistry produce socially desirable or undesirable effects? Is evaluation of these effects subjective or objective?[46] Hoffmann's questions acquire special relevance in the context of the ambiguous achievements of another Nobel Prize winner, also an eminent chemist, Fritz Haber, who once said that during peace a scientist belongs to the World, but during war he belongs to his country.

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43 Ewa Bińczyk, *Epoka człowieka. Retoryka i marazm antropocentryzmu* [*The Age of Man. The Rhetoric and Lethargy of the Anthropocene*] (Warszawa: Wydawnictwo Naukowe PWN, 2018), 15.

44 Jonas, *The Imperative*, 32.

45 Dieter Birnbacher, *Odpowiedzialność za przyszłe pokolenia* [*Responsibility for Future Generations*] (Warszawa: Oficyna Wydawnicza, 1999), 6–8.

46 Roald Hoffmann, *The Same and Not the Same* (New York: Columbia University Press, 1995), 139–140.

Concluding remarks

The process of creating and disseminating science has always involved endeavours to put its applications into practice. However, the difference between the classic and non-classic approaches to practising science need to be clearly delineated. The main line of division is the fundamental purpose of research carried out in science. It is reduced either to discovering, describing and explaining processes and phenomena occurring in the world (as postulated in the classic view of science represented by mathematised natural sciences), or to intervening with these processes and phenomena in a manner that changes them or allows adaptation to the changes they induce (non-classic view of science represented by laboratory sciences), using diverse kinds of tools. The contemporary human being, emboldened by the string of successes achieved in exact, natural and technical sciences, today sets out new goals for these scientific disciplines. Unlike mathematised natural sciences, they are not intended primarily to explore the world, but to change it in the spirit of projected (though not fully predicted) expectations. Examples of how such expectations are fulfilled can be found in the realm of laboratory sciences. Hence, it becomes justified to postulate that the products of laboratory sciences should be evaluated on the basis of criteria which take into account social responsibility of these sciences for the effects they induce.

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Summary

The classic approach to science is dominated by the belief that science is a form of cognitive activity that focuses on constructing theories to describe and explain the phenomena and processes found in the world. Due to the fulfilment of the criteria of intersubjective communicability and controllability, theories are considered to be objective products of research activity that do not bear social responsibility for their applications. In this paper, the issue of social responsibility of science is addressed both from the classic perspective and from the non-classic viewpoint represented by laboratory sciences, i.e. those sciences that are predominantly concerned with creating phenomena rather than discovering them. It is argued that whereas in the former case the problem of social responsibility of science does not provoke serious controversy, in the latter case such controversies do exist and, furthermore, they are justified.

Keywords: social responsibility, laboratory sciences, theory, Ian Hacking, Imre Lakatos