Science, Part I: Basic Conceptions of Science and the Scientific Method†

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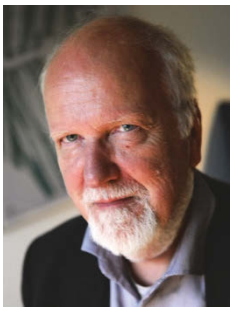

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Abstract: This article is the first in a trilogy about the concept "science". Section 1 considers the historical development of the meaning of the term science and shows its close relation to the terms "knowledge" and "philosophy". Section 2 presents four historic phases in the basic conceptualizations of science (1) science as representing absolute certain of knowledge based on deductive proof; (2) science as representing absolute certain of knowledge based on "the scientific method"; (3) science as representing fallible knowledge based on "the scientific method"; (4) science without a belief in "the scientific method" as constitutive, hence the question about the nature of science becomes dramatic. Section 3 presents four basic understandings of the scientific method: Rationalism, which gives priority to a priori thinking; empiricism, which gives priority to the collection, description, and processing of data in a neutral way; historicism, which gives priority to the interpretation of data in the light of "paradigm" and pragmatism, which emphasizes the analysis of the purposes, consequences, and the interests of knowledge. The second article in the trilogy focus on different fields studying science, while the final article presets further developments in the concept of science and the general conclusion. Overall, the trilogy illuminates the most important tensions in different conceptualizations of science and argues for the role of information science and knowledge organization in the study of science and suggests how "science" should be understood as an object of research in these fields.

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1.0 Etymology and near-synonyms

The English word "science" come, via French, from Latin "scire" (know) and "scientia" (knowledge). *Oxford English Dictionary* [2020] (OED) documents 10 senses (17 including sub-senses), some of which are obsolete, and others are special senses, which can be ignored for the purpose of this article.[1] Based on the resting senses, "science" may thus accordingly to OED mean (4a) a field of study, a discipline, or an activity concerned with theory, or (4b) a "branch of study that deals with a connected body of demonstrated truths or with observed facts systematically classified and more or less comprehended by general laws, and incorporating trustworthy methods." It may also mean (5a) "The kind of organized knowledge or intellectual activity of which the various branches of learning are examples" (e.g., what is taught at universities). It is often implicit understood (5b) to be concerned only with the physical universe (the most

usual sense of "science" since the mid-19th century) and contrasted with religion when regarded as constituting an influence on a person's world view or belief system. It is also used (5c) about the scientific principles or processes which govern or underpin a (specified) phenomenon or technology and (5d) about scientific results obtained from observations, experiments, etc.

We see that etymologically the link between the words "science" and "knowledge" have been very close and that the word science is both used about a kind of knowledge (e.g., as the product of inquiry) and about the kind of social organization that produces that knowledge. We also see that science is associated with methods assumed to provide true knowledge. This means, that the conception of science itself is deeply influenced by epistemological issues on how to obtain knowledge. It is relative difficult in the scholarly literature to find articles discussing different conceptions of science.[2] Below such different conceptions are in the focus and are presented to the extent they have been identified by the author. It is shown how developments in the theory of knowledge have made it increasingly difficult to define the term "science" in epistemological terms.

What today is termed science (and scientist) was formerly mostly termed philosophy (and philosopher). William Whewell (1834) coined the term "scientist" to describe someone who studies the structure and behavior of the physical and natural world through observation and experiment. Formerly "science" as we understand the term today was mostly called "natural philosophy"[3] (and rather clearly distinguished from "natural history"[4] and from chemistry[5]). Persons considered "philosophers" in the history of philosophy were usually also (or even primarily) great scientists, and, retrospectively, we apply the term "scientists" to persons such as Isaac Newton and Charles Darwin, and "science" to the work done by them. A valuable examination of the historical development of the relation between the words "science" and "philosophy" and their changing meanings was done by Ross (1990), who concluded (814):

> Despite the antiquity of the terms 'science' and 'philosophy', they acquired their present meanings only during the nineteenth century. With the benefit of hindsight, we can find much activity which we would call 'scientific' or 'philosophical' in earlier periods; but the respective practitioners did not see themselves as divided into distinct camps, or at least not in a way we would recognise today. Generally, much of what we now call philosophy was tacitly accepted as a proper part of science (or 'philosophy' as it was then called), but contrasted with the useless 'school metaphysics' of the universities. It was only when philosophy more or less as we now know it became a university specialism in the nineteenth century that it became possible for scientists to leave the more philosophical aspects of science to specialist philosophers.[6]

As already stated, the main meaning of the English "science" since the mid-19th century is narrowed to natural science (sense 5b in OED), excluding, for example, the humanities. According to Daston (2015, 241) this narrowing was influenced by Auguste Comte's (1830-42) hierarchy of sciences, in which only some fields had reached the stage of "positive knowledge."[7] The corresponding word to science has somewhat different meanings in other languages. The German word "Wissenschaft", for example, includes the humanities and philosophy (and has thus not followed the same influence from Comte). This limited meaning of the English word is, however, often a problem also for English language authors, who then choose to use the English word in the wider sense.[8] An example is Hoyningen-Huene (2013, 8-9), who wrote:

> First, with respect to disciplines covered by the term 'science,' I want to understand the term and thus the question 'What is science?' in their broadest possible sense. Therefore, not only all sciences in the (English) standard sense shall be included, namely the natural sciences, but also mathematics, the social sciences, the humanities, and the theoretical parts of the arts. Unfortunately for my project, there is no appropriate single English term denoting this broad variety of disciplines. We might collectively refer to them as 'research fields' or 'research disciplines.' In German, there is the term "*Wissenschaft*," which covers all research fields that I intend to cover here. However, for lack of a better word, the term 'science' will be subsequently used, although it does not represent well the semantic shift proposed here. Other authors pursuing studies of a similar breadth and being confronted with the same difficulty have also resorted to the very broad usage of the term 'science'.

Likewise, in phrases such as "classification of sciences", "science mapping" and "atlas of science", the work science is often understood in its broad meaning, corresponding to Wissenschaft. The platform "Web of Science" also includes arts and humanities in its coverage, as does the book *The Cambridge History of Science* (Lindberg and Numbers, 2002-2020). This broad meaning will also be used here *in ISKO Encyclopedia of Knowledge Organization* (IEKO) unless otherwise specified. The term *scientific communication* may also be understood in this broad way (e.g., by Ossenblok 2016), although in this case the term *scholarly communication* (or *scientific and scholarly communication*) may be preferred in order explicitly to include the humanities. The term "scholar" includes, according to the OED any "person who is highly edu-

cated and knowledgeable, usually as a result of studying at a university" (this term is, however, also ambiguous in that it sometimes includes natural scientists and sometimes is used only about people in the humanities). The discussion of the issue what is included in the term (e.g., whether the humanities should fall within the label "science") is in philosophy called "the demarcation problem" and we return to this in Section 4.1.2, but it should be said here, that some authors, e.g., Mahner (2007) explicitly consider the humanities to be "non-science" fields.[9]

"Science" is used both as a generic term for all sciences (whether understood in the narrow or in the broad sense), and about a specific science ("scientific discipline" or just "discipline"). This generic use seems connected to the idea of the "unity of science". The use of "science" about different fields of knowledge is often relative to a positivist or non-positivist understanding (e.g., in history[10] and psychology[11]). The most famous attempt to describe the difference between science and humanities was the distinction between explanation (German: erklären) in the (natural) sciences and understanding (German verstehen) in the humanities/human sciences (or the older German term Geisteswissenschaften) suggested by Droysen ([1858], 1937) and later used by Dilthey (1894, 1314). This understanding has, however, been criticized by modern hermeneutics (see, e.g., Caputo 2018). An important trend today is to conceive both sciences and humanities to be about interpretations, to consider positivism a failed idea, and to emphasize the concept "culture" as important for both natural and human sciences (cf., Margolis 2009)[12]. Rather than upholding a sharp dualism between "science" and "humanities", the contemporary tendency is to acknowledge the uniqueness of many forms for studies. Still, however, some researchers do not feel that "science" is a proper label for their field, but prefer other labels, e.g., "studies". "Science" and "studies" may be considered synonyms in some fields (or at least hard to distinguish as in "information science" versus "information studies"), but in *Web of Science,* for example, there are two different categories "environmental sciences" and "environmental studies"[13], indicating an operational criterion of differentiation between the two concepts. Thus, the application of the term "science" to a field of study seems not to be a closed, but an open issue.

"Research" as a noun has, according to the *Oxford English Dictionary* (OED), four meanings of which 2a is synonymous with science in the broad sense:

> Systematic investigation or inquiry aimed at contributing to knowledge of a theory, topic, etc., by careful consideration, observation, or study of a subject. In later use also: original critical or scientific investigation carried out under the auspices of an academic or other institution.

However, "research" is often used in a yet broader sense, including, for example, journalist research.
Another near synonym is "inquiry", which is defined by the OED (meaning 1.a): "The action of seeking, esp. (now always) for truth, knowledge, or information concerning something; search, research, investigation, examination". The term inquiry is, as described in Section 3.4, a preferred term by many pragmatic philosophers.

2.0 Some developments in the conception of science

There is today no consensus of what the term science means. Ziman (2000, 12) holds that: "... science is too diverse, too protean, to be captured in full by a definition." Sadegh-Zadeh (2015, 856) expressed the same opinion:

> It might come as a surprise that there is as yet no agreement on what science is. Although attempts to characterize or even to define it have a long history, going all the way back to Aristotle, it was not until the British empiricism of the seventeenth and eighteenth centuries that definite criteria were suggested for differentiating science from non-science and pseudoscience. [...]. Science is too complex a phenomenon to be characterized by a single, simple demarcation criterion. A multicriterial concept of science will be necessary to capture its degree of complexity. [14]

Achinstein (2011, 346) found that many people consider scientific inquiry as superior to other forms of inquiry and subscribing to three principal theses:

1. Science aims at and can achieve knowledge of the world.
2. Knowledge in science requires proof, the standards for which are universal for all the sciences and can be formulated in a set of rules called the 'scientific method.'
3. Although unproved propositions (sometimes called 'hypotheses') are introduced into science for purposes of investigation, scientists are not justified in believing them until they are proved in accordance with the standards set by the 'scientific method.'

Achinstein's quote, as a to-day's view of science, is partly challenged by Hoyningen-Huene (2013, 1-6), who (with many reservations) distinguished four phases in the history of the conceptions of science:

1. The first phase started around the times of Plato (about 428–348 BC) and Aristotle (384–322 BC) and dominated Western antiquity and the Middle

Ages and ended in the early seventeenth century. Two traits for scientific knowledge are postulated for this period: (1) The epistemic ideal of the absolute certainty of knowledge. Scientific knowledge conceived in this manner, or with the Greek word, episteme, stands in sharp contrast to mere belief, or doxa. Only episteme, by being certain, qualifies as scientific. (2) The methodological idea of deductive proof as the appropriate means to realize this ideal. Euclidean geometry was understood as a model, which could in principle be applied to all areas of science.

2. The second phase in Hoyningen-Huene's schematic history of philosophy of science begins in the early seventeenth century and ends sometime in the second half of the nineteenth century. This phase continues the first phase by equally subscribing to the epistemic ideal of the certainty of scientific knowledge. However, it is discontinuous regarding how this ideal is to be achieved. Whereas in the first phase, only deductive proof is a legitimate means to attain the certainty of knowledge, the second phase liberalizes this requirement to what will eventually be known as the "scientific method." What is meant exactly by that concept is typically left unanswered and could be understood either as one single method or as a set of methods. Deductive proof is still a part of the scientific method, but the most important extension concerns inductive procedures. Hoyningen-Huene mentions Galileo Galilei (1564–1642), Francis Bacon (1561–1626), René Descartes (1596–1650), and (a little later), Isaac Newton (1642–1727) as the most famous protagonists of "the scientific method".
3. The third phase begins in the late nineteenth century and stretches into the last third of the twentieth century. This phase is characterized with the belief that scientific knowledge is not certain and never can be certain, but it is hypothetical and fallible. Both inductivist and deductivist philosophies of science, though relying on strict methodological procedures for confirmation or testing of hypotheses, stress the hypothetical nature of scientific knowledge from the natural sciences. This is true both with respect to the mathematical, the natural, and the human sciences. (4): "For the mathematical sciences, the discovery of non-Euclidean geometries in the course of the nineteenth century is dramatic. It demonstrates that the belief in the uniqueness of Euclidean geometry, and thus the conviction of its unconditional truth, is unfounded. However, the conclusiveness of mathematics is restored if the axioms of any mathematical theory are taken as assumptions whose truth or falsehood is not up for grabs [...] In the natural sciences, the process of erosion of scientific certainty is often only associated with the advent of the special theory of relativity [Einstein 1905] and of quantum mechanics [Born 1924[15] and others]".
4. The fourth phase begins during the last third of the twentieth century and continues until today. In this phase, belief in the existence of scientific methods conceived of as strict rules of procedure has eroded. (4-5): "Historical and philosophical studies have made it highly plausible that scientific methods with the characteristics posited in the second or third phases simply do not exist. Research situations, i.e., specific research problems in their specific contexts, are so immensely different from each other across the whole range of the sciences and across time that it appears utterly impossible to come up with some set of universally valid methodological rules".

Hoyningen-Huene (2013, 6) further wrote:

> Thus, the first two phases are connected by the ideal of certainty for scientific knowledge, but deductive proof is replaced by scientific method(s) in the second phase. The second and third phases are connected by the idea of scientific method(s), but the ideal of certainty is replaced by fallibility in the third phase. The third and fourth phases are connected by the idea of the fallibility of scientific knowledge, but in the fourth phase, the belief in scientific method(s) as constitutive for science ceases. Note that only in the present fourth phase, the question about the nature of science becomes dramatic, because the only feature left for science, namely fallibility, is by no means a sign for its uniqueness. Therefore, it is no exaggeration to state that although we are familiar today with the phenomenon of science to a historically unparalleled degree, we do not really know what science is.

These quotes by Achinstein and Hoyningen-Huene made it clear that the conceptions of science have been intricately connected to ideas about the scientific method, to which we now turn.

3.0 Scientific method

Some philosophers and scientists defend the view that there exist basic methods common to all sciences.[16] Kincaid (1998) argued that one of the basic characteristics of positivism is the idea that there is a universal and a priori scien-

tific method. However, as presented in Section 2.0, the tendency today is, with Hoyningen-Huene (2013), that former times belief in the existence of scientific methods conceived of as strict rules of procedure has eroded. Bauer (1992, vii) agreed, writing against using "sweeping generalizations" about science.[17]

Achinstein (2011, 346-50) found that the three principal theses of scientific inquiry have been defended by three prominent but very different historical views: (1) Cartesian rationalism (2) Newton's and Mill's inductivism and (3) William Whewell's inference to the best explanation,[18] after which he presented some contemporary positions that contradict one or more of these three ideas, but does not come up with a view of positive characteristics of science or alternatives to the contradicted positions. In the following some of Achinstein's arguments will be inscribed in the presentation of the following positions: (a) Rationalism with deductionism (b) Empiricism with inductivism (c) Historicism with Kuhn's philosophy of science and (d) Pragmatism with feminist epistemology, Marxism and critical theory. These four positions represent a classification of positions suggested by Hjørland (1998), but it is related to commonly used labels and positions in epistemology. Rationalism and empiricism are mostly considered the basic theories of knowledge during the enlightenment that were combined by the logical positivists in the beginning of the 20st century but were criticized by Kuhn's (1962) historicism. Pragmatism, which was founded by Peirce (1878), is related to critical theory and to feminist standpoint epistemology and seems to have growing influence today. The positions are further described in independent sections below, but a preliminary characteristic of them is:

- Rationalism gives priority to a priori thinking. Research in this tradition (e.g., logical division in classification) is characterized by its lack of a described empirical methodology (although empirical knowledge may be implicitly given). In this view, our knowledge, for example, that 2+2=4, is considered based on a form of intuition or the direct, rational apprehension of its truth (cf., Barnes, Bloor and Henry 1996, 173).
- Empiricism gives priority to the collection, description, and processing of data in a neutral way (i.e., not data selected by theoretical criteria). With enough data, a hypothesis may be considered verified, and empiricism may be understood as the ideal of letting data speak for themselves.
- Historicism gives priority to the interpretation of data in the light of research tradition and "paradigm" (realizing that the collection, description, and processing of data is influences by research contexts).
- Pragmatism emphasizes the analysis of the purposes, consequences, and the interests, which the knowledge / research is supporting, and it shares many characteristics with historicism. In this view, our knowledge that 2+2=4 can never be finally proven by any rationalist or empiricist method but is based on its broad utility for organizing practical affairs (see further about the sociological analysis of the 2+2=4 example in Barnes, Bloor and Henry 1996, chapter 7).

A classification such as the one provided here is not true or false but may be more or less fruitful for certain purposes, for example, for considering positions in the conceptions of science (the formerly mentioned use of deductive and inductive methods in the characterization of two phases of the conception of science by Hoyningen-Huene 2013 seems partly to confirm its fruitfulness for this purpose). The classification may also be fruitful to classify contemporary positions (e.g., Hjørland's 2013b classification of positions in knowledge organization). An obvious drawback is that it hides the complexities and mutual dependencies of theories of knowledge and that it simplifies them in a way that philosophers and scientists may have difficulties to recognize as their own standpoints. It is also important to realize that each of these labels (e.g., empiricism) is highly ambiguous, and that the classification itself implies an interpretation of them.[19]

There is another issue with the suggested classification that needs to be considered. One of the anonymous reviewers of this paper wrote: "Rationalism and empiricism are described as extreme positions that no sane person would support them in modern time." Yes, these positions (and their combination in logical positivism) are often declared dead, but as Bentz and Shapiro (1998, 26-35) wrote in the section "The Mysterious Death and Afterlife of Positivism", in spite of its official death (and its replacement with other labels such as "post-positivism"), positivism, explicitly or implicitly, is at the core of the modern worldview of scientific, technological, bureaucratic, commercial civilization. The authors support their view (30-31) on Habermas' (1971) view "that, at the root, positivism is simply the denial of reflection, that is, of the need to reflect explicitly on the philosophical and social conditions of knowledge".

The classification in these four positions is based on studies of these philosophical traditions and on the task of classifying contemporary epistemological approaches, for example, in knowledge organization, where they have been found it to work very well (e.g., Hjørland 2011b, Hjørland 2013b). In relation to Hoyningen-Huene's (2013) and Achinstein's (2011) classification of views of science only two of these four positions are clearly visible in what is referred from both authors (although their writings may perhaps also be interpreted to involve historicism and pragmaticism). Our suggestion is that historicism and pragmaticism represent answers to the crisis of logical positivism, and that these positions are social epistemological positions opposed

to the individualist epistemological positions of rationalism and empiricism. Rationalism and empiricism are here, as by Achinstein, understood as defending the principal thesis that knowledge has an absolute certain basis (cf., Sosa 1998)[20]. Historicism and pragmatism are *understood as fallibilist, considering all knowledge claims to be open to challenge, revision, correction, or* rejection (not to be confused with epistemological skepticism).

3.1 Rationalism

We saw that the first stage in the conception of science by Hoyningen-Huene (2013, 1-6) emphasized the ideal of the absolute certainty of knowledge and, second, the methodological idea of deductive proof as the appropriate means to realize this ideal. Rationalism mostly took mathematics and geometry as models for all science. The idea is that all knowledge must be deduced from elements of basic truth, which are apodictic certain. They are based on intuitions of what must necessary be the truth. Main representatives of rationalism include Plato and René Descartes.[21]

Achinstein (2011) found that rationalism (in the version developed by Descartes)[22] has been one of the main arguments for three principal theses about science (see Note 23). He describes (347) how Descartes considered these rules to be applicable to the sciences generally, not just to mathematics and he deduced three "laws of nature," the first two of which yield what came to be known as the law of inertia: that moving bodies if left to themselves tend to continue to move in straight lines.

Hoyningen-Huene (2013, 152) found that rationalism is a problematic position: "Neither in mathematics nor in the natural sciences, let alone the other areas of learning, do we believe any longer in the attainability of any sort of immediate certainty."[24] However, despite this criticism, rationalism it is an important impulse, even in modern science (including knowledge organization[25]). An example is Chomsky's linguistics, which explicitly acknowledged Descartes' rationalism. Some versions of ontology as knowledge organization systems likewise seem based on rationalist assumptions. In medicine rationalism and empiricism are used, on what seems to be important positions which are both related to empirical research: Rationalists emphasize the importance of empirical investigation into basic mechanisms of disease, whereas empiricists are interested in whether something works, regardless of causes or mechanisms .[26] Buhr and Starke (1985)[27] found that rationalism has an important core, but that its principles have been generalized in problematic ways. Further works on rationalism include Nelson (2005), Fraenkel, Perinetti and Smith (2011) and Boghossian and Williamson (2020).

Popper's "critical rationalism" (Popper [1934] 1959 and 1963) deserves to be presented. It is rationalist in its emphasis on deductive methods and skepticism towards inductive methods. Popper found that a scientific theory can never be verified because no amount of empirical evidence will ever suffice to prove a theory as contrary evidence might always be found be later research. Popper is therefore a fallibilist philosopher (and in this respect deviates from the former characterization of rationalism). His methodology is the hypothetico-deductive model, according to which research starts from a hypothesis (conjecture), the consequences of which are then deduced. An observation (e.g., an experiment) is then made to see if the deduced consequences fit with the empirical observation. If not, the hypothesis (conjecture or theory) is falsified. Thus, according to Popper, while no amount of experimentation can ever prove a theory right, a single observation or experiment may prove it wrong. For Popper, the characteristics of something deserving the label "science", is that it is formulated in a precise way, that allows it to be falsified. This is also a demand that all scientific concepts are well-defined throughout a research process. As no scientific claim or theory is ever finally verified, the best knowledge is the one that has resisted attempts from the scientific community to falsify it.

Popper's view has been discussed and criticized, including by Kuhn (1962) and by Popper's professed disciple, Lakatos. Lakatos (1976), here cited from Musgrave and Pigden (2016, §2.1), argued that mathematical concepts were end-points rather than starting points in a dialectical process "in which the constituent concepts are initially ill-defined, open-ended or ambiguous but become sharper and more precise in the context of a protracted debate. The proofs are refined in conjunction with the concepts (hence "proof-generated concepts") whilst "refutations" in the form of counterexamples play a prominent part in the process." Lakatos disagreed with Popper that a single experiment can falsify a theory.[28] Thereby Lakatos showed that both the verification and the falsification of theories cannot be made disregarding the conceptual and historical context. Concepts are not "given" as clear-cut understandings but may gain clarity by the research process.

Lakatos' criticism is not just relevant about Popper's version, but as a criticism of rationalism overall, and it points towards the historicist position (see Section 3.3). The same can be said of Lakatos' (1976) critique of formalism, logicism and intuitionism in the philosophy of mathematics.

3.2 Empiricism

The word "empiricism" is difficult: what we consider to be the core in its historical development, the British empiricists, did not consider themselves as empiricists, but said explicitly that they were not (cf. van Fraassen 2002, 32). He also wrote (xiii) that all the philosophers we count as empiricist rejected the positions of their predecessors. The term is today gener-

ally used about the view that knowledge about the physical world is possible only through observation and experiment, not through intuitions, which may be unreliable and therefore cannot be used as basis for deductions. The rationalist belief in intuitions as a scientific method was thus rejected by empiricists. Hoyningen-Huene (2013, 161-2) wrote:

> Regarding this topic, logical empiricists continued the inductivist tradition that goes back at least to the beginning of modern natural science in the seventeenth century. This tradition believes, in some variant or other, that there are procedures that justify the generalization of empirical data to general hypotheses; the core of these procedures is a "principle of induction.

Nickles (2005) wrote that "in the twenty-first century nearly everyone is an empiricist in the everyday sense of taking experience seriously as a basis for knowledge claims about the natural world and human behavior, but most philosophers reject traditional, doctrinaire empiricism — the view that human sense experience provides a special connection of the knowing mind to the world and thus provides a foundation on which knowledge can build, step by step." Nickles listed a range of challenges which changed or ousted classical empiricism (see Note 29). Already the classical rationalists[30] and the founder of the phenomenological tradition, Edmund Husserl, among and others, considered empiricism to be a self-refuting position.[31]

Few, if any, people today would claim that science can do without empirical studies (and thus adhere to "empiricism" in one sense of the term). However, studies can be done more or less "blindly", or theory informed. In the classification of positions used in this article, empiricism is understood as one ideal of doing empirical studies, that contrasts with other positions of doing empirical studies, discussed in 3.3 and 3.4.

It is a widely held view that logical empiricism (and logical positivism and empiricism generally) run into serious troubles at the time when Kuhn (1962) published his book. A basic argument by Kuhn (formerly expressed by Duhem [1906] 1991), Feyerabend 1957, Hanson 1958, and others) is that observations are "theory-laden", which means that there is no clear boarder between observations and theory, and we therefore must view knowledge claims in their theoretical and historical-cultural contexts. As Fleck ([1935] 1979, 38)[32] wrote:

> Cognition must not be construed as only a dual relationship between the knowing subject and the object to be known. The existing fund of knowledge must be a third partner in this relation as a basic factor of all new knowledge. ... What is already known influences the particular method of cognition, and cognition, in turn, enlarges, reviews, and gives fresh meaning to what is already known. Cognition is therefore not an individual process of any theoretical 'particular consciousness.' Rather it is the result of a social activity, since the existing stock of knowledge exceeds the range available to any one individual.

Therefore, the main problem with empiricism is that it does not consider how the observer is influenced by his or her background assumptions.[33] To take this into consideration in scientific methodology requires an alternative perspective (historicism) to which we turn in Section 3.3.

A clear example of empiricism in modern biology is numerical taxonomy (or "phenetics"), which was developed by Sokal and Sneath (1963).[34] This is an approach claiming to be based solely on observable, measurable similarities and differences of the things to be classified. Classification is based on overall similarity: The elements that are most alike in most attributes are classified together. As many characteristics as possible of a set of organisms are described and represented in a database, and classifications are constructed by statistical calculations of correlations. The characteristics must not be chosen from theoretical principles of which are most important, because this introduces an element of subjectivism not approved by empiricism (Sokal and Sneath had to admit, however, that even numerical taxonomy is unable to eliminate subjectivity in classification, cf., Note 35). Numerical taxonomy conflicts with an alternative empirical methodology for classification suggested by Charles Darwin (1859), which will be presented in Section 3.3.

Some recent defenses of a modified empiricism are Fraassen (1980[36], 2002), Aune (2009)[37] and Johansson (2021).[38]

3.3 Historicism (with Kuhn's philosophy)

Historicism is an old tradition in philosophy, mainly developed in Germany in the nineteenth century. Its main characteristic is an insistence on the historicity of all knowledge and cognition. Two dimensions should be considered: the history of the object and of the subject. The historicity of the object is the view that the world is in constant development, and this development is important for science to map. The historicity of the subject can be illustrated by generalizing a quote from Edwards (2010, xvii; here modified): [39]

> Our perspective on the world keeps changing, for many reasons. Scholars and scientists argue about how to interpret the evidence, finding flaws in earlier interpretations. And we, the researchers, keep changing. What we want to know about the world, what we hope to discover there, the concepts and instruments we use, depends on who we are now.

And from Mazzocchi (2015, 1253):

> Scientific research does not take place in a purely theoretical and rational environment of facts, experiments and numbers. It is carried out by human beings whose cognitive stance has been formed by many years of incorporating and developing cultural, social, rational, disciplinary ideas, preconceptions and values, together with practical knowledge. Scientists form their ideas and hypotheses based on specific theoretical and disciplinary backgrounds, which again are the result of decades or even centuries of history of scientific and philosophical thought.[40]

Historicism influenced the philosophy of science in the 20th century mainly by Kuhn's (1962) book *The Structure of Scientific Revolutions*, which was an attack on "positivism" as Kuhn understood the term. The most important aspect of this book was probably the rejection of the positivist idea of what Kuhn labels "incrementalism", that there is a continuous accumulation of an ever-increasing stock of truths. What science gets correct once, stays correct forever, it does not develop theories in conflict with former theories. Nickles (2017) wrote:

> Many scientists, philosophers, and laypersons have regarded science as the one human enterprise that successfully escapes the contingencies of history to establish eternal truths about the universe, via a special, rational method of inquiry. Historicists oppose this view. In the 1960s several historically informed philosophers of science challenged the then-dominant accounts of scientific method advanced by the Popperians and the positivists (the logical positivists and logical empiricists) for failing to fit historical scientific practice and failing particularly to account for deep scientific change.

As we saw in Section 3.2, Kuhn considered observations to be "theory-laden" and refused the individual epistemologies of rationalism and empiricism. Kuhn is famous for introducing the concepts "paradigm" and "paradigm shift" (although they are unclear and have been criticized)[41]. The idea is that the single scientist is trained and socialized in a scientific tradition, and this socialization influences the way he or she looks at the world (or more precisely at the specific scientific discipline and the specific research problems with which she works). The socialization is not just verbal, but also influenced by tacit or implicit knowledge, for example, by doing experiments in a laboratory. A paradigm influences the research questions asked, the methods used, what counts as proper results etc.

We can illustrate this with the different methodological ideals in numerical taxonomy (described in Section 3.2) versus the paradigm founded by Charles Darwin. Darwin's main contribution to classification was not just his view "... all true classification is genealogical ..." (Darwin 1859, 420), but rather his methodology for operationalizing classification based on this principle. Darwin realized that he needed to decide which traits to use in classification, and why. Richards (2016, 90-92) explains:

> One of the main advantages of Darwin's theoretical approach is that, unlike previous approaches, it gave operational guidance. Those shared characters or traits that indicate common ancestry, by virtue of inheritance from a common ancestor, should be used to classify. Those that do not indicate common ancestry are irrelevant. To make this distinction between the characters or traits that indicate ancestry from those that do not, Darwin adopted the terms 'homology' and 'analogy,' [and further developed these concepts].[42]

Darwin's methodological principles are thus deeply connected to his theoretical view on biological evolution, which introduces an element of subjectivity, which empiricism opposes.[43] Therefore, the fundamental difference between empiricism and historicism, as understood here, is the former's ideal of selecting characteristics by disregarding theoretical criteria of relevance, while historicism acknowledge the role of the researcher's theoretical positions, that different methodologies are not neutral, but have to be worked out as a part of the theoretical development of the field. Whereas rationalism and empiricism only consider the attributes of things to be classified, historicism *also* makes theories and traditions important for classification. Historicism considers the attributes of things in addition to consider who have made/constructed/selected the attributions, and how different cultures, traditions and paradigms are considering different attributes.

Concerning research methodology, Mallery, Hurwitz and Duffy (1992) as well as Heelan (1997), D'Agostino (2015) and Hoyningen-Huene and Lohse (2015, 136) interpreted Kuhn's paradigms as analogous to Hans-Georg Gadamer's notion of a linguistically encoded social tradition, and thus his epistemology a form of hermeneutics. Today hermeneutics is accepted as an important philosophy of science. Kuhn seems not, however, to have made the implication for scientific methods, as we shall here suggest: that scientists should not just learn about current research and current methodology but should also be taught the history and philosophy of science. As Ross (1990, 814-5) suggested, many scientists and philosophers

> ... would welcome a rapprochement between science and philosophy. This would, in effect, involve a breaking down of Kuhn's distinction between normal and revolutionary science, so that even during 'normal' periods, scientists maintained more of an interest in fundamental concepts and methodology.

This view is supported by the following quote by Albert Einstein (1949, 683–4):

> The reciprocal relationship of epistemology and science is of noteworthy kind. They are dependent upon each other. Epistemology without contact with science becomes an empty scheme. Science without epistemology is—insofar as it is thinkable at all—primitive and muddled.

This then, is the core of historicist epistemology: That all concepts, observations and deductions must be understood in their social, historical and paradigmatic contexts. For example, concepts such as star and planet,[44] or blackbird,[45] are imbedded within paradigms, and cannot be understood disconnected from the theories in which they are used (this principle is a form of "semantic holism").

Historicism implies the ideal that science develops as a dialog between different views. However, at this point Kuhn's view has been criticized by both Fuller (2000) and Agassi (2008, 306-34) for conservatism and for not defending criticism. Agassi (307) wrote: "Controversy is a vital and regular factor in the scientific tradition. Kuhn did not do it justice". Both Fuller and Agassi preferred Karl Popper's philosophy "critical rationalism" because of its emphasis on scientific criticism. However, Popper's view was opposed to historicism.[46]

In the wake of Kuhn (1962) a controversy between realists[47] and antirealists became important. This is further discussed in Section 4.1.1.

The main difference between rationalism and empiricism on the one side, and historicism and pragmaticism on the other side, is the acknowledgement of the socio-historical dimension of science in the latter positions. Rationalism, empiricism, and positivism understands the scientists as individuals facing parts of the world directly (for example, in laboratories). Historicism and pragmaticism understands the scientists as informed by scientific traditions and subject literatures. Not just direct sense experience, but also the reliance of experts and the social division of cognitive labor become important.[48] For these positions, the library is an important addition to the laboratory as a metaphor.[49] Scientific knowledge grows from interaction with former knowledge and with the world, but not from an uneducated, direct interaction with the world.

3.4 Pragmatism[50] (with Marxism,[51] critical theory,[52] and feminist epistemology[53])

Pragmatism shares the view of historicism described above. Classical pragmatism mostly preferred to speak about "inquiry" rather than scientific research, and to consider common sense a rudimentary form of science (cf., Rydenfelt 2014). Pragmatism's main distinguishing characteristics in relation to historicism is the pragmatic maxim (Peirce 1878):

> Consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object.

Pragmatism emphaticizes the functions of both the research object and the implications of inquiry for practice[54] (although it should not be confused with the everyday language meaning as an attitude with overly tight focus on practicality). It is the category of epistemological theories, that consider goals, teleology,[55] purposes, consequences, interests, and values[56] (in one word: politics[57]) as a central point of view. It has been suggested that science is a moral project (Note 58).

There are, however, obvious, and profound problems associated with the relations between science/inquiry and politics. Politicians should not decide what is true, and it is a really bad thing when people do not search for truth but ignore existing arguments and evidence, and only believe and argue what they want to be true. A prerequisite for science has always been the opposite of using political power to manipulate knowledge, it has always been a critical role of science speaking truth to power. There can be an unholy alliance of ignorance and manipulation that is mutually supportive. In this sense "politicized science" and "political epistemology" are things that is opposed to all academic ideals and which are to be seriously fought. These terms also have quite different meanings, however, some of which falls under our category "pragmatism".[59] "Political epistemology" is also understood (e.g., by Omodeo 2019) in a way that falls under our category pragmatism.

Pragmatism is based on the view that all our actions, including our choice of scientific methods, have political consequences. By implication claimed neutral epistemologies are just neutral by claim, not by consequences. It can be said that claimed neutral epistemologies just disguise their subjectivity as objectivity (see further Hjørland 2020). Pragmatism cannot, however, be understood by the intentions of the researchers. For example, although socialist-minded researchers may claim to serve the interests of the working people, liberalists-minded researchers may deny that this is the case. It may always be questioned whether the interests

claimed or intended also are the interests that in the end are supported.[60] It is not just the motivations and intentions of research that matters, it is the outcome, and implications of research may be hard or impossible to predict (cf., Koertge 2000).

The problem of having explicit goals in science is a problem that has split pragmatists already from Peirce and James. Peirce disagreed with William James on the interpretation of pragmatism because he felt that James made it too vulgar and short sighted, and he renamed his own position "pragmaticism" to distinguish it from James' version. Ever since there has been a split between "realist" or "objective" and "antirealist" or "subjective" pragmatists.[61] Peirce (and some other pragmatists along with some Marxists and feminists) obtain, however, that pragmatism and realism are not opposed to each other, but are each other's prerequisites (see further Westphal 2017).

The pragmatic theory of meaning is revealing for how consequences may guide pragmatic thinking. Peirce (1905, 173-4) wrote:

> The rational meaning of every proposition lies in the future. How so? The meaning of a proposition is itself a proposition. Indeed, it is no other than the very proposition of which it is the meaning: it is a translation of it. But of the myriads of forms into which a proposition may be translated, what is that one which is to be called its very meaning? It is, according to the pragmaticist, that form in which the proposition becomes applicable to human conduct, not in these or those special circumstances, nor when one entertains this or that special design, but that form which is most directly applicable to self-control under every situation, and to every purpose. This is why he locates the meaning in future time; for future conduct is the only conduct that is subject to self-control.

This quote gives an idea of some aspects of the pragmatic methodology: to consider conceptions and theories identical if they lead to the same consequences (regardless of their differences in other ways), and always have the consequences in mind. Pragmatism assumes empirical studies as a basis of enquiry, but differs from classical empiricism in several philosophical assumptions:

- Pragmatism has a much richer account of the concept of experience compared to classical empiricists (which is related to phenomenology's "life world" and to feminist epistemology's claim of the relevance of persons broader experiences).
- Pragmatism (at the least in Dewey's version) acknowledge the role of not just science, but also art and everyday life as valid forms of knowledge.[62]
- Pragmatism sees the inquirer as influenced by socio-cultural factors and the process of inquiry as a chain of "unlimited semiosis".[63]
- Pragmatism assumes that realism cannot be proved by science but that it is a necessary assumption in inquiry (cf., Rydenfelt 2014). This may be called "pragmatic realism" or "realistic pragmatism". [64]
- Pragmatism involves the willingness to embrace fallibilism (that we should be open for the possibility that even our best based theories may have to be revised as science proceeds).
- Pragmatism involves the rejection of skepticism (rejection of the view that one can and should try to doubt all of one's beliefs at once). (According to Putnam (1994, 152; italics in original) "it is perhaps *the* unique insight of American pragmatism that someone can be both fallibilist *and* antiskeptical"; see further in Hookway 2008).
- Pragmatists tend to reject sharp dichotomies such as those between fact and value, thought and experience, mind and body, analytic and synthetic, basic and applied science[65] etc.
- Pragmatists favor 'the primacy of practice'. This point is clarified by the way Sarvimäki (1988, 58-9) emphasize that living and acting in the world according to pragmatism constitutes the a priori of human knowledge (cf., Notes 66, 67 and 68).
- Pragmatists tends to reject "the correspondence theory of truth" and to favor "the coherence theory of truth".[69] Hoyningen-Huene (2013, 170; italics in original) found: "The best way to realize this relation of coherence for a given knowledge claim is to embed it into a *system* of knowledge claims."
- In addition to induction and deduction, pragmatism favors abduction, i.e., inference to the best explanation (Peirce's 1903-lecture has the title "Pragmatism as the Logic of Abduction").

We have mentioned some important philosophical principles, and we have on the one hand claimed that political goals are important, and on the other hand that politicized science is a really bad thing that must be fought. The normative principles may be formulated as follows:

In all domains of knowledge there tend to be conflicting views of which claims are correct and which are wrong. Such claims are connected to broader theories, epistemologies, and ideologies, each of which may have hidden assumptions and consequences. The inquirer should – as far as possible- be aware of such different views and on the different goals and values they support and choose his epistemology on an informed basis. This requires a broader knowledge compared to narrow subject knowledge, including historical and philosophical knowledge (Slife and Williams 1995 provides such knowledge for the behavioral sci-

ences and is a model of the kind of knowledge, we here are speaking of). More specifically, pragmatic epistemology implies that no research claim should be considered validated without the inclusion of epistemological arguments. It must be emphasized, however, that the philosophical and historical knowledge of which we are speaking itself is a fallible and developing body of knowledge.

In Section 4.3.2 about social constructivism, we shall see how the pragmatic view and its focus on social interests has been taken up by science studies.

3.5 Conclusion on method

Debates on scientific method are parts of a broader philosophical development, which have been described as historicist and as a strong challenge "to the most favored doctrines of the principal currents of Anglo-American philosophy down to our own day" (Margolis 2009, x).[70] In line with this view Schuster (1995a, 45) considered the scientific method a myth, because facts and tests depend on theory and prior belief:

> If there is always such a cultural loading of the facts available to humans, then this would necessarily entail problems for the standard story of method: Remember, if anything gets into science, into laws and theories, such as subjective belief, cultural baggage, human political, social concern, then we do not have what scientific knowledge is supposed to be, coagulated fact, which has been tested and confirmed.
>
> That is, the standard story of method absolutely demands and requires that pure, 'nuggets' of fact are available from nature with no admixture of human subjectivity, culture, prior belief etc. But, if human facts are shaped or conditioned by human beliefs and aims, then science becomes a much more complex institutional activity--political, social, historical aspects need to be studied to understand how science makes facts, sustain facts, and sometimes changes facts.

Schuster's quote seems a fine conclusion of our section about the scientific method as it moves the problem from rationalism and empiricism towards historicism and pragmatism. Inductive, deductive, and abductive methodologies should be seen as iterative processes taking place in socio-historical and political contexts and within "paradigms".

Notes

1. The selected definitions of "science" in OED for this article are:
   4 a. Paired or contrasted with *art* (see ART *n.*[1] 3a). A discipline, field of study, or activity concerned with theory rather than method, or requiring the knowledge and systematic application of principles, rather than relying on traditional rules, acquired skill, or intuition. See note in etymology, and cf. etymological note at ART *n.*[1] In quots. *a*1387 and *c*1475 in uninflected plural form. In later use coloured by sense 4b.
   b. A branch of study that deals with a connected body of demonstrated truths or with observed facts systematically classified and more or less comprehended by general laws, and incorporating trustworthy methods (now esp. those involving the scientific method and which incorporate falsifiable hypotheses) for the discovery of new truth in its own domain. For more established compounds, as *bio-*, *computer*, *geo-*, *life*, *natural*, *neurophysical science*, see the first element.
   5 a. The kind of organized knowledge or intellectual activity of which the various branches of learning are examples. In early use, with reference to sense 3a: what is taught in universities or may be learned by study. In later use: scientific disciplines considered collectively, as distinguished from other departments of learning; scientific doctrine or investigation; the collective understanding of scientists. Also with modifying word. In the 17th and 18th centuries commonly expressed by *philosophy*; cf. PHILOSOPHY *n.* 5a.
   b. *spec.* The intellectual and practical activity encompassing those branches of study that relate to the phenomena of the physical universe and their laws, sometimes with implied exclusion of pure mathematics. Also: this as a subject of study or examination. Cf. NATURAL SCIENCE *n.* The most usual sense since the mid 19th cent. when used without any qualification. Often contrasted with religion when regarded as constituting an influence on a person's world view or belief system; cf. quot. 1967. Cf. also SCIENTISM *n.* 2.
   c. With *the*. The scientific principles or processes which govern or underpin a (specified) phenomenon, technology, etc. Also: the scientific research into these principles or processes. Usually with *of* or *behind*.
   d. Scientific results obtained from observations, experiments, etc.; scientific data. Frequently with *the*.
2. There are no articles with the title "science" in *Routledge Encyclopedia of Philosophy*, in *Stanford Encyclopedia of Philosophy* or in the *Internet Encyclopedia of Philosophy*. There is one in *Wikipedia* (https://en.wikipedia.org/wiki/Science), which, however, fails to consider different conceptions of the term, and mostly seems to reflect a positivist view (ignoring constructivist and other critical views), which also seems to be the case with *Encyclopedia Britannica* (see below). The *Handbook of Science and Technology Studies* (Felt, Fouché, Miller and Smith-Doerr 2017) also fails to discuss definitions and conceptions of science. The *Encyclopedia of*

Empiricism contains an article "Science" (Downes 1997). Marxist oriented entries appear in *Philosophisches Wörterbuch* (Hörnig 1985, translated in Appendix 1) and in *Europäische Enzyklopädie zu Philosophie und Wissenschaften* (Juul Jensen 1990). *Encyclopedia Britannica* (online) on 2020-04-14 wrote: "Science, any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws. Science is treated in a number of articles. ..."

3. OED on the term "natural philosophy": "Now chiefly historical. The study of natural bodies and the phenomena connected with them; natural science; (in later use) spec. physical science, physics." Isaac Newton's (1687) magnum opus, Principia Mathematica has the full title: *Philosophiæ Naturalis Principia Mathematica*. This demonstrates that natural philosophy was not a precursor of natural science, but just another name for it.
4. OED on Natural history: "**1.** A work dealing with the properties of natural objects, plants, or animals; a systematic account based on observation rather than experiment. Now chiefly in the titles of books dealing with the wildlife of a particular region or the biology of particular organisms.
   2 **a.** The facts relating to the natural objects, plants, or animals of a place; the natural phenomena of a region as observed or described systematically.
   b. In extended use: the details *of* any subject, esp. as regarded chronologically.
   3 **a.** Originally: †the branch of knowledge that dealt with all natural objects, animal, vegetable, and mineral (*obsolete*). Now: the study of animals and other living organisms, esp. as presented in a popular rather than in a strictly scientific manner.
   †**b.** Things that form the subject matter of natural history. *Obsolete*. *rare*$^{-1}$."
   Kuhn (1962) used the term "natural history" about the preparadigmatic stage of science. When there is no organizing paradigm a field of science consists of unstructured and random fact gathering.
5. Brock (2016, 2): "Until William Whewell coined the word 'scientist' in 1834, those who devoted all, or part, of their lives to the study of the natural world were referred to as 'natural philosophers'. By the 17th century, however, specialization had begun, and natural philosophy tended to refer to the more mathematical and quantitative interpretations of nature. Those involved in the study of plants and animals were said to practice natural history, and those studying the properties and reactions of different kinds of matter and their exploitation to improve the human condition, were referred to as chemists [or alchemists as the two kinds were often difficult to separate at that time]." (Until chemistry became part of natural philosophy with Robert Boyle (1626-1691) it was generally in low esteem).
6. Ross's (1990) claim that scientists have left the more philosophical aspects of science to the philosophers may perhaps be questioned because scientists are important contributors to philosophy; take, for example, Albert Einstein, Niels Bohr, Thomas Kuhn as examples.
7. Haack (1993a,49) wrote that the term "scientific" is often used as an all-purpose term of epistemic praise, meaning "strong. Reliable, good". This is caused by the impressing success of the natural sciences.
8. Concerning the relations between science in the narrow meaning and philosophy, it is also relevant that the natural sciences generally became "independent" about 1850 and established their own "Facultatis Naturalis" (faculty of science). "Independence" in this connection meant autonomy and freedom from philosophical control and judgment.
9. Mahner 2007, 543): "The factual and formal sciences, the technologies, and the humanities are all research fields producing genuine knowledge, which on the whole is either (approximately) true or else useful, and contributes to the understanding of the world and its inhabitants. For this reason, one might argue that they should all be included in a broad conception of science. This is for example done in the German intellectual tradition, where the name of almost any field of knowledge is dignified by the ending '-wissenschaft' (-science), including the humanities, which are called *Geisteswissenschaften* (sciences of the mind). So there is bioscience alongside 'music science', just as there is computer science alongside 'literature science'. Consequently, if a practitioner of a *Geisteswissenschaft* is told that what he does is not science, he will most likely be offended. It comes as no surprise that such a broad, if not inflationary, construal of 'science' aggravates the problem of demarcation (see, e.g., [Poser, 2001]). By contrast, most other traditions and languages separate the arts and humanities from the sciences already terminologically, so that no offense is given by calling the humanities nonscientific. Yet even so, the question remains of what to do with mathematics and technology. While some authors include both of them in the sciences (e.g., [Kuipers, 2001] classifies them as explicative research programs and design programs, respectively, within a broad conception of a *scientific* research program), others assert that neither mathematics [Lugg, 1987] nor technology [Bunge, 1983] are sciences. In any case, taking into account the preceding overview, the common post-positivist picture, which admits more categories than just sense (i.e., science) and nonsense (i.e., all the rest) [...]. One the

one hand, there is science including mathematics and technology; on the other there is nonscience including the arts and humanities as good nonscience, so to speak, for it too is viewed as producing true, reliable, or at least valuable knowledge, respectively, and finally pseudoscience as bad nonscience, for its knowledge claims are unjustified."

10. When history was established as a university discipline in USA in the spirit was "scientific". Novick (1988, 25; italics in original): "Did late-nineteenth-century American historians, and especially that large portions of them who had studied in Germany, really think that *Wissenschaft* easily and naturally translated as 'science'; that *wissenschaftlich* historical study meant the adoption of the (allegedly) purely empirical and neutral approach of the natural sciences? Such a suggestion beggars the imagination. Yet, as we shall see shortly, there is much to suggest that most historians believed something of the sort."
11. The most extreme conception of psychology as science is Watson (1913): "The behaviourist views psychology as a purely directive experimental branch of natural science". During its history as a university discipline, different schools have clearly disagreed on the epistemological foundation of psychology (between positivism and hermeneutics, among others), and on its status as science or "studies".
12. Margolis (2009, x) described developments in his personal view as follows: "I see the larger themes in a more contested way than I had [in 1983 when he wrote the first edition of *Culture and Cultural Entities*]: the flux of the world as opposed to assured invariances; the historicity of thought as opposed to the universalizing aptitude of our cognitive faculties; the second-natured cultural transformation of our biological aptitudes as opposed to any mere biologism; the constructed nature of knowledge, perception, thought, science, and understanding as opposed to any pre-established correspondence between cognition and world; and now, more commandingly than ever, the 'natural artifactuality' of the self or person as opposed to the assumption that all the materials of the human sciences fit neatly within the scope and competence of the physical sciences. You may well hesitate before endorsing any of these notions, but you cannot doubt that they constitute a strong challenge to the most favored doctrines of the principal currents of Anglo-American philosophy down to our own day. I can only say that, for my part, I have followed the argument where it has led: what I've discovered (what I believe I've discovered) promises a sort of rapprochement among the principal movements of Western philosophy unwilling to yield on rigor but open to surpassing all the troubling stalemates of the preceding century."
13. A search in *Web of Science*, Core collection 2020-04-26 showed WC=ENVIRONMENTAL SCIENCES with 1,346,692 hits, with the most productive source titles being: ENVIRONMENTAL SCIENCE TECHNOLOGY (41,025), SCIENCE OF THE TOTAL ENVIRONMENT (36,403), CHEMOSPHERE (29,669), WATER SCIENCE AND TECHNOLOGY (23,712) and ATMOSPHERIC ENVIRONMENT (22,375), whereas WC= ENVIRONMENTAL STUDIES gave 297,395 hits, with the most productive source titles being: SUSTAINABILITY (19,623), ENERGY POLICY (12,995), URBAN STUDIES (7,939), ENVIRONMENT AND PLANNING A (7,208) and REGIONAL STUDIES (6,298).
14. Sadegh-Zadeh (2015, 856-65) developed a 10-dimensional construct of science based on his own research and on Bunge (1983, 197 ff.). These dimensions were: 1. Community, 2. Society, 3. Domain, 4. Problems, 5. Goals, 6. Axiomatic basis, 7. Conceptual basis, 8. Methodological basis, 9. Deontic basis and 10. Research product.
15. Born (1924) was the first publication in which the term "Quantenmechanik" (German for "quantum mechanics") was used. However, many scientists were involved in developing this theory, both before and after 1924. See, for example, https://en.wikipedia.org/wiki/History_of_quantum_mechanics
16. Fuller (1998) claimed that scientists persist in accounting for themselves in terms of a common method despite the well-confirmed sociological perception that the various sciences share no common methods.
17. Bauer (1992, vii) wrote: "Perhaps the central fallacy is that there exists an entity called 'science' about which sweeping generalizations can be made; for example, that science is characterized and defined by the scientific method (which, it is widely supposed, can be defined rigorously and unambiguously)".
18. Whewell's position is described by Achinstein (2011, 350) as "holistic, since one most confidently infers the truth not of an isolated hypothesis, but of a system of hypotheses". This is here understood as more related to the historicist and pragmatic positions but will not be further discussed in this paper.
19. The ambiguities in the labels used for epistemological positions can be exemplified. The pragmatic philosopher William James (1912), for example, referred to his position as "radical empiricism", while pragmaticism and empiricism in the present article are understood as fundamentally conflicting positions. Another example is Kuhn (1962), which according to the book itself criticized "positivism" and according to the "received view", replaced it with "a historical turn". However, one of the leading logical positivists, Rudolf Carnap, suggested

that science is governed by "linguistic frameworks" in a way that corresponds to Kuhn's "paradigms" (see Tsou 2015). *If* such an interpretation is correct, it either undermines the distinction between "positivism" (which may be understood as attempts to combine "empiricism" and "rationalism") and "historicism" (and then challenges our suggested classification), or it makes the term "positivism" ambiguous. Our understanding is, however, that the distinction between "rationalism" and "empiricism" on the one side and "historicism" on the other side is important and fruitful (and the difference between Kuhn and Carnap's positivism is supported by Tsou 2015). A third objection could be that the classification of Marxism as a version of pragmatism seems odd, but it is in the following based on the interpretation that they have the political dimension of knowledge in common. The choice of labels is in some way arbitrary, and the suggested classification could alternatively have been describing rationalism and three different forms of empiricism, but that alternative has not been preferred here and seems to agree with Kuhn's criticism of positivism.

20. Sosa (1998, abstract): "Some foundationalists are rationalists who rely on intuition and deduction. Others are empiricists, in a broad sense, and accept observation and induction or abduction or yet other ways to support beliefs by means of other beliefs. What they have in common is that they are all willing to hazard a positive view about what in general makes a belief epistemically justified in the way required for it to be a case of knowledge; and they all propose something of the following general form: belief b is justified if and only if either b is foundationally justified through a psychological process of direct apprehension p (such as rational intuition, observation, introspection, and so on) or else b is inferentially justified through a psychological process of reasoning (such as deduction, induction, abduction, and so on) ultimately from beliefs all of which are acquired or sustained through p. If one rejects all forms of such foundationalism, then a question remains as to what distinguishes in general the cases where a belief is epistemically justified from the cases in which it is not. Can anything general and illuminating be said about what confers epistemic justification on a belief, and what gives a belief the epistemic status required for it to constitute knowledge (provided it is true)?"
21. Levins and Lewontin (2009, 1-5) also described the Cartesian method as reductionist, "as a way of finding out about the world entails cutting it up into bits and pieces (perhaps only conceptually) and reconstructing the properties of the system from the parts of the parts so produced. But Cartesianism is more than simply a method of investigation; it is a commitment to how really things are [an ontological position]. The Cartesian reductionist method is used because it is regarded as isomorphic with the actual structure of causation [...]. Cartesian reduction as a method has had enormous success in physics, in chemistry, and in biology, especially molecular biology." Levins and Lewontin then explain the problems of generalizing this reductionist ontology and point to fields where this method is problematic and defend a dialectical method in which causation and explanation goes both from parts to wholes and from whole to parts. In this connection a trend towards post-reductionist science represented by the "complexity approach" should be mentioned, cf., Bechtel and Richardson (2010), Heylighen, Cilliers and Gershenson (2007) and Morin (2008).
22. Achinstein (2011) based his description of Descartes' rationalism on his *Rules for the Direction of the Mind*, English edition 1988 and *Principles of Philosophy* (Descartes 1971). Descartes' Rules *for the Direction of the Mind* contained 21 rules (of 36 planned), of which the first 12 deal with his proposed scientific methodology in general. It was written about 1628 and was not published during the author's lifetime. The first Latin edition was published in 1701 (*Regulae ad directionem ingenii*). Achinstein (2011) cites from an English translation (Descartes 1988). The full English translation of the 21 rules is freely available in Wikisource: https://en.wikisource.org/wiki/Rules_for_the_Direction_of_the_Mind
23. Achinstein (2011, 346-7) wrote: "The view is a form of Rationalism according to which, although experience can suggest ideas to the scientist, whether these ideas are true can be known only by pure thought of a sort characteristic of mathematics.[...] By 'certainty' Descartes does not mean 'beyond reasonable doubt' (by analogy with a criminal legal standard), but 'beyond any possible doubt' (as he envisages being the case in mathematics).[...] the only way to obtain truth that is justified beyond any possible doubt is to employ what he calls 'intuition' and 'deduction'. The former he characterizes as 'the indubitable conception of a clear and attentive mind which proceeds from the light of reason. His examples include one's thought that one exists, that one is thinking, that a triangle has three sides, and that 2 + 2 = 4. Their truth is immediately evident to us just by thinking them. By 'deduction,' Descartes means a continuous, uninterrupted train of reasoning to some proposition that follows necessarily from other propositions known with certainty. Example: an inference from 2 + 2 = 4 and 3 + 1 = 4 to 2 + 2 = 3 + 1." (Concerning an alternative explanation of why 2+2=4 see Barnes, Bloor, and Henry 1996, chapter 7).
24. It should be mentioned, however, that Edmund Husserl, the founder of the phenomenological tradition in

philosophy, saw phenomenology as "First philosophy", and as "an a priori science that proceeds from the first-person perspective and primarily aims at revealing essential structures of consciousness" (Berghofer and Wiltsche 2020, 3) and (p. 7): "Essential laws can and must be immediately grasped; like certain mathematical truths they present themselves not to sensory intuition, but to categorial or eidetic intuition." However, Husserl made a turn towards historicism, Berghofer and Wiltsche (2020, 11) wrote: "Yet, as the later Husserl came to realize, static phenomenology is but one possible approach, and a limited one at that. Instead of taking fully constituted objectivities as a starting point, one can also focus on the *becoming* of these objectivities, their 'history of objectivation,' as Husserl puts it (Husserl 2001a, 634), and thus on the sedimented layers of constitution that underlie our experience of objects."

25. Hjørland (2013a) and elsewhere has argued that facet analysis and logical division are methods in classification based on rationalism. To this can be added that much ontology development in computer and information science also seems to be based on rationalism. This conclusion is reached, because these approaches (a) do not describe an empirical methodology (b) do not include a historical-cultural dimension (c) do not consider political analyses of values, goals, interests and consequences in their methodological principles.
26. Bluhm and Borgerson (2011, 204; italics in original) wrote: "2.1 Two Traditions in Medicine. Modern medicine has inherited two competing approaches to the care of patients, rationalism and empiricism. These terms, taken from the medical literature, are not used in the standard philosophical senses. *Rationalists* in medicine, for instance, do not only reason from first principles. Rather, they emphasize the importance of empirical investigation into basic mechanisms of disease. (The designation "rationalist" was likely picked to highlight the role of reason in this approach.) *Empiricists* in medicine are thought to be interested in whether something works, regardless of causes or mechanisms. Again, the use of the terminology does not correspond to classic philosophical accounts of empiricism. The rationalist/empiricist debate in medicine is, in philosophical terms, better described as a debate between empiricist approaches to medicine at different levels. While empiricism (in the philosophical sense) prevails in medicine, there are vigorous ongoing debates about whether it is more appropriate to ask questions about basic mechanisms of disease at the micro-level (pathophysiology) or whether it would be better simply to investigate what works at the level of the average patient (as in RCTs)."
27. The first sentences in Buhr and Starke (1985,1010; here translated): "Rationalism: Name for an epistemological position that isolates the rational level of cognition and assumes that only thinking (reason) can find the truth. Rationalism also seeks the criterion of truth in thought. It rejects the sensual level of cognition as deceptive and confused, unsuitable for actual cognition".
28. Musgrave and Pigden (2016, §2.2) wrote: "This is related to Duhem's [1991] thesis that, generally speaking, theoretical propositions—and indeed sets of theoretical propositions—cannot be conclusively falsified by experimental observations, since they only entail observation-statements in conjunction with auxiliary hypotheses".
29. Nickles (2005) lists the following challenges which changed or ousted classical empiricism:
    (1) The linguistic turn;
    (2) The holistic turn;
    (3) Rejection of the analytic-synthetic distinction;
    (4) Rejection of the scheme versus content distinction by Donald Davidson;
    (5) Rejection of the correspondence theory of truth;
    (6) Rejection of the linear-foundational model of justification;
    (7) Anti-Kantian Kantianism;
    (8) Rejection by Karl Popper (1902-1994) and the positivists of the traditional identification of empiricism with inductivism;
    (9) Rejection of the imagist tradition that treats cognitive states or contents as little pictures before consciousness;
    (10) Rejection of "the myth of the given", by Sellars and others, the idea that subjective experience provides a special, direct, infallible, nonnatural connection of knowing mind to known world;
    (11) the failure of phenomenalism and sense datum theories of perception; and, more generally,
    (12) rejection of the whole Cartesian-Lockean conception of cognition and language;
    (13) The failure of attempts to define knowledge precisely as justified true belief; which inspired
    (14) externalism versus internalism in epistemology;
    (15) Recognition of the importance of tacit versus explicit knowledge (knowledge-how vs. knowledge-that) and of embodied knowledge, for example, skilled practices that we cannot fully articulate;
    (16) The feminist introduction of gender variables into epistemology;
    (17) Competing attempts to naturalize and socialize epistemology;
    (18) The postmodern critique of empiricism. Postmodernists, including Richard Rorty and radical feminists and sociologists, regard empiricism, epistemology in general, and, indeed, the entire Enlightenment project to replace a tradition-bound

life. (A closely related article by the same author is available at: http://science.jrank.org/pages/9140/Empiricism-Twentieth-Century-Beyond.html).

30. A classical rationalist argument against empiricism is: Empiricism claims that all knowledge comes from experience. This claim is, however, either derived from experiences, in which case it may be wrong given other experiences, or it is not based on experiences. In the last case it confirms the rationalist claim about the existence of fundamental principles of knowledge that are not due to experience.
31. Berghofer and Wiltsche (2020, 5) wrote: "Husserl broadens his criticism [of psychologism] to include classical empiricism as an ultimately self-refuting position. One of Husserl's main arguments is that empiricism "destroys the possibility of the rational justification of mediate knowledge, and so destroys its own possibility as a scientifically proven theory" (Husserl [1900] 2001b, 59). Husserl's point here is that empiricism does not allow for the possibility of immediately grasping substantial epistemological principles, including principles that would govern any form of inferential reasoning. As a consequence, mediate (i.e., inferential) justification and knowledge would be impossible if empiricism were true. It is interesting to note that one of the most vocal contemporary critics of empiricism, Laurence BonJour, makes basically the same point when he accuses empiricism of amounting to 'intellectual suicide' [BonJour 1998]".
32. Fleck (1979) is an English translation of a German book from 1935, which means that Fleck predated Kuhn (1962).
33. Slife and Slife (2014, 576; italics in original): "The general point here is that empiricism is not a conception or method for mapping an objective reality; it is an ideology for illuminating various aspects of an *interpreted* reality. That this reality is interpreted is not necessarily negative. It is only negative if one accepts the prejudice against prejudice and then overlooks that this acceptance is itself a prejudice. All methods and epistemologies, in this sense, are interpretations of reality. What is pivotal from this perspective is not only being aware of this interpretation but also taking it into account when considering method outcomes, especially power and economic relations."
34. A basic idea of numerical taxonomy goes back to the French botanist Michel Adanson (1763), who suggested that equal weightage should be given to all the characters while classifying plants.
35. Richards (2016, 124-5): "There are at least two sources of subjectivity in phenetics [or numerical taxonomy]. The first is in the choice and coding of characters: what gets identified as a character and how it gets coded requires judgment. And it isn't clear that the notions of 'unit of information' and 'unit character' [as suggested by Sokal and Sneath 1963] are helpful in determining what counts as a character. A second source of subjectivity in phenetics is that different coefficients of similarity generate different OTUs [Operational Taxonomic Units] and ranks. There are three kinds of coefficients of similarity – association, correlation, and distance, each with multiple associated algorithms, and it is not clear why on purely *observational* grounds one coefficient of similarity or algorithm is better than another. Some algorithms may be easier to use, but that doesn't seem satisfactory. Perhaps it is up to the judgment of individual systematists. If so, then isn't phenetics subjective ...?"
36. van Fraassen (1980) called his version of empiricism "constructive empiricism" and is based on the criticism of logical positivism in the wake of Kuhn (1962).
37. Aune (2009) is a defense of the empiricist view as opposed to rationalism. It partly accepts classical views of empiricism, but does not consider the arguments by Kuhn (1962) or the pragmatic position, which is strange since he formerly wrote a book about rationalism, empiricism, and pragmatism (Aune 1970). Aune's revised empiricism (2009, 238) rejected two principles of classical empiricism: "Two assumptions once thought distinctive of a responsible empiricism must be firmly set aside. One is the assumption that our empirical knowledge or well-founded opinion must rest on a foundation of subjective experience. Not only does our empirical knowledge fail to rest on anything that deserves to be called a foundation, but the nature of our subjective experience is also, as I noted, quite questionable, generating on-going controversy among philosophers and even empirical scientists. The other objectionable assumption is that inherently unobservable objects are unknowable and cannot meaningfully be described or referred to."
38. Johansson (2021, 51) call his version of *nominalistic empiricism*. His book contains the chapter 3: "Empiricism from Ockham to van Fraassen", which (48-51) ends with his own six component empiricist stance. However, his account seems not able to distinguish the epistemological positions in, for example, two schools of biological taxonomy, numerical taxonomy and Darwinian genealogical classification, and is therefore not seen as a challenge to the classification of epistemologies suggested in the present article.
39. The original quote from Edwards (2010, xvii; italics in original) was: "What keeps historians in business? Why do they keep on writing new accounts of, say, the French Revolution or the Second World War? Don't we already know everything about those events? In fact, we

don't. There is always more to learn about the past. Historians continually discover previously unknown documents, letters, drawings, photographs, artifacts, and other kinds of evidence that reveal new aspects even of history's best-known episodes. On top of that, our perspective on the past keeps changing, for many reasons. We argue about how to interpret the evidence, finding flaws in earlier interpretations. And *we* keep changing. What we want to know about the past, what we hope to discover there, depends on who we are now."

40. As stated by Henri Poincaré (1905, 159):"It is often said that experiments should be made without preconceived ideas. That is impossible. Not only would it make every experiment fruitless, but even if we wished to do so, it could not be done. Every man has his own conception of the world, and this he cannot so easily lay aside. We must, for example, use language, and our language is necessarily steeped in preconceived ideas. Only they are unconscious preconceived ideas, which are a thousand times the most dangerous of all."
41. See Klee (1997, Chapter 7: The Revenge of Historicism) for a fine introduction to Kuhn's theory.
42. Richard's quote continues (2016, 91-2): "Darwin reinterpreted homologies to be structural similarities due to common ancestry, and analogies to be functional similarities due to adaptation by natural selection. The former then, but not the latter, were a good guide to ancestry and genealogy. In his *Origin*, Darwin explicitly dismissed the value of analogies for classification: 'It might have been thought (and it was true in ancient times thought) that those parts of the structure which determined the habits of life, and the general place of each being in the economy of nature, would be of very high importance in classification. Nothing can be more false. No one regards the external similarity of a mouse to a shrew, or a dugong to a whale, of a whale to a fish, as of any importance. These resemblances, though so intimately connected with the whole of life of the being, are ranked merely as "adaptive or analogical characters.' (Darwin 1859, 414) [...] He [Darwin] was proposing a special similarity method based on the theoretical foundation of classification as the representation of the evolutionary tree."
43. Whether or not Darwin considered himself an empiricist, is a different story. There are indications that he felt that empiricism is such a strong ideology, that it was impossible to go up against it, and that he therefore claimed to follow the empiricism (inductionism) of Francis Bacon. In his autobiography he proclaimed that he worked "on true Baconian principles, and without theory collected facts on a wholescale scale". (Here cited from Lennox 1997, 78-80).
44. According to Kuhn's theory of scientific paradigms Ptolemaic astronomers might learn the concepts "star" and "planet" by having the Sun, the Moon, and Mars pointed out as instances of the concept "planet" and some fixed stars as instances of the concept "star." However, after a paradigm shift, Copernicans might learn the concepts "star," "planet," and "satellites" by having Mars and Jupiter pointed out as instances of the concept "planet," the Moon as an instance of the concept "satellite," and the Sun and some fixed stars as instances of the concept "star." Thus, the concepts "star," "planet," and "satellite" got a new meaning and astronomy got a new classification of celestial bodies.
45. Fjeldså (2013, 141) describe how many kinds of birds until very recently were considered blackbirds or subspecies of blackbirds: "Thus, rather than treating these blackbirds as different subspecies or as closely allied species, we can regard them as only convergently similar, as the males independently developed a black plumage, contrasting the yellow bill, as an effective means of demonstrating dominance within their territory. [...] Nowadays, new data are being obtained at an intense rate. Many well-known and widespread 'species' have been found to have more complex population structures than had been assumed, and some may even represent a collection of different species that are only superficially similar ..."
46. Popper (1957) is a book criticizing historicism, as he understood the term. There is a general understanding that Popper used the term in a narrow and problematic way. About the reception and criticism of the book see the Wikipedia article: https://en.wikipedia.org/wiki/The_Poverty_of_Historicism. Popper rejected the inductive method (and thus classical empiricism and logical positivism), but he thought that theories could be falsified. This seems to conflict, however, with the insight in the theory-laden nature of observations. If the observation report: "this is a black swan" is theory-laden, then the observation does not falsify the theory "all swans are white". We are now dealing with two theories about whether it is a swan, we observe, and how can we tell which one is correct? Therefore, Popper's theory is not based on the same (hermeneutic) view as that of Kuhn. Perhaps the reader finds it absurd to suggest that the observation "this is a black swan" is theory laden. But in biological systematics, the definition of species is clearly theory-dependent, and as said elsewhere in this article, the concept "blackbird" has recently changed rather dramatically. So, whether the black bird you observe is a swan or not, is a theory. For a developed criticism of Popper's position see Haack (2009), chapter 5: "The Evidence of the Senses: Refutations and Conjectures".

47. Realism is explained by Rescher (2006, 386): "Realism has two indispensable and inseparable components: the one existential and ontological, the other cognitive and epistemic. The former maintains that there indeed is a real world: a realm of concrete, mind-independent, objective reality. The latter maintains that we can to some extent secure adequate descriptive information about this mind-independent realm, and that we can validate plausible claims about some of the specifics of its constitution. This second contention obviously presupposes the first".
48. Compare Levi (2006, 384-5): "Scientific method is now conceived of as constituted by the background information, programs for routine expansion, and research programs that direct the demands for information that inquirers currently endorse. This ever-changing body of method is, indeed, self-correcting as compared to exclusive reliance on programs for routine expansion via consulting authorities or, for that matter, consulting only the testimony of the senses. But just as routine expansion via the testimony of the senses can on some occasions be a legitimate way of obtaining new information, so can the consultation with experts. The use of authorities judged to be reliable sources of information is surely vital to the success of scientific inquirers who must engage in a division of cognitive labor."
49. Hjørland (2005, 141-3, Part 4: Empiricism's relation to literature and libraries ("read nature not books") presented empiricism strange neglection of the role of literature and libraries in science, at the least implicitly.
50. For a short overview of pragmatism see Legg and Hookway (2019). The inventor of pragmatism, Peirce (1905, 163), wrote "For this doctrine he [Peirce, speaking in third person about himself] invented the name pragmatism. Some of his friends wished him to call it practicism or practicalism (perhaps on the ground that πρακτικός [transcribed into the Latin alphabet as: 'praktikos'] is better Greek than πραγματικός [transcribed into the Latin alphabet as: 'pragmatikos']). But for one who had learned philosophy out of Kant, as the writer, along with nineteen out of every twenty experimentalists who have turned to philosophy, had done, and who still thought in Kantian terms most readily, praktisch and pragmatisch were as far apart as the two poles, the former belonging in a region of thought where no mind of the experimentalist type can ever make sure of solid ground under his feet, *the* latter expressing relation to some definite human purpose. Now quite the most striking feature of the new theory was its recognition of an inseparable connection between rational cognition and rational purpose; and that consideration it was which determined the preference for the name pragmatism."
51. One version of Marxism is Hörnig (1985) translated in Appendix 1. For a different Marxist interpretation of science based on Antonio Gramsci see Omodeo (2019). (Although Hörning is explicit about its Marxist perspective, he does not reveal on which specific interpretation it is based. This is probably the perspective developed by Nikolai Bukharin, also presented by Omodeo 2019).
52. About critical theory and pragmatism see, for example, Ghiraldelli (2006).
53. Haack (1993b) is an article by a philosopher who is both inspired by classical pragmatism and consider herself to be a feminist, but which is highly critical towards the concept "feminist epistemology" (and also towards politicized epistemology in general). A possible response to her arguments is that feminist epistemology is about general principles for research, illuminated by the following quote from Code (1998): "The impact of feminism on epistemology has been to move the question 'Whose knowledge are we talking about?' to a central place in epistemological inquiry. Hence feminist epistemologists are producing conceptions of knowledge that are quite specifically contextualized and situated, and of socially responsible epistemic agency".
54. Levi (2006, 378) wrote: "Charles Peirce (see Peirce) and John Dewey (see Dewey) made the topic of inquiry the central problem of their pragmatic philosophies and both took inquiry to have the character of practical deliberation aimed at choosing policies suited to promoting the goals of deliberating agents. Unlike Dewey, Peirce thought that inquiry whose results is the fixing of belief ought to have goals that are distinct from the moral, political, economic, prudential, and aesthetic concerns that agents also have. Nonetheless, Peirce, like Dewey, thought of inquiry as seeking to realize some goal or solve some problem, and thought of the intelligent conduct of such goal-directed inquiry as analogous in this respect to practical thinking".
55. "Teleology means the explanation of phenomena in terms of the purpose they serve rather than of the cause by which they arise, thus pragmatic classification emphasizes the purpose the classification serves. Peirce (1902, EP II, 127) wrote: "All natural classification is then essentially, we may almost say, an attempt to find out the true genesis of the objects classified. But by genesis must be understood not the efficient action which produces the whole by producing the parts, but the final action which produces the parts because they are needed to make the whole. Genesis is production from ideas. It may be difficult to understand how this is true in the biological world, though there is proof enough that it is so. But in regard to science it is a proposition easily enough intelligible. A science is defined by its

problem; and its problem is clearly formulated on the basis of abstracter science". Bruhn Jensen (2021, 2ff.) discussed the epistemological views of aiming at considering "What is, what ought to be, and what could be" in inquiry.

56. Pihlström (2017) wrote about values in pragmatism: "A key idea in Rescher's axiology and metaethics is that the pragmatic principle of rational evaluation through purposive efficacy should be extended to the normative area. Values, no less than methods employed in factual belief-acquisition, ought to be pragmatically assessed; they are not just 'matters of taste'. What is decisive in such assessment is the capacity of our values to contribute to the realization of human interests. Hence, philosophical anthropology is needed in the pragmatic legitimation and rational criticism of values".
57. For a fine historical overview of scientific method as a political and rhetorical issue, see Schuster and Yeo (1986).
58. Johannessen and Olaisen (2005, 1261-2): "Science is for systemic thinking a moral project (Bunge, 1989). If science is not constructed as a moral project, it will not only lose its legitimacy but also its direction, which is the search for truth, and can thus be a means to achieve unethical goals."
59. The term "political science" has the standard meaning as the academic discipline studying politics but may also in some contexts be understood as politicalized science.
60. Hacking (1999, 95-9), for example, discuss "the science war" where physicist Alan Sokal challenged social constructivists. He wrote: "In terms of the unmasking of established order, constructionists are properly put on the left. Their political attitude is nevertheless very much not in harmony with those scientists who see themselves as allies of the oppressed, but also feel like the special guardians of the most important truths about the word, the true bastions of objectivity. The scientists insist that in the end, objectivity has been the last support of the weak. Here is a disagreement: It is a rather messy matter, a sticky point involving deep-seated but ill-expressed attitudes. Who is on the left?" (See also Sokal and Bricmont 1998).
61. Wittich (1985, 967; translated from German) criticized James' position from a Marxist point of view: "In this context, the difference between the Marxist-Leninist criterion of truth determined by practice and that of utility, as expressed by the idealistic philosophy of pragmatism, deserves attention. W. James (1907, 73) explains the truth criterion of utility, which he advocates, as follows: "If it turns out that theological ideas are valuable for real life, they become true for pragmatism in the sense that they are ... useful". In fact, statements of the type 'There is a God' or 'God has the property of being almighty, omniscient, omnipotent, etc.', are practically not used in this case, but rather statements of the type 'It is advantageous for a certain group of people (e.g., the ruling capitalist class) to claim that there is a god with this and this properties'. However, this statement is confirmed by the practice of class society as true and not only since W. James. At the same time, it clarifies the social function of religion. Pragmatic truthfulness therefore relates to the view that the truth of religious statements is advantageous for a certain group of people, but not to the religious statements themselves [...]. The development of the truth criterion of practice by Marxism gave the old materialistic doctrine of knowledge as an adequate reflection of objective reality a solid scientific basis".
62. Bernecker and Pritchard (2011) contains the following chapters about "kinds of knowledge": 25. Inductive Knowledge, Alexander Bird; 26. A Priori Knowledge, Laurence BonJour; 27. Perceptual Knowledge, David Sosa; 28. Self-Knowledge, Sanford Goldberg; 29. Testimonial Knowledge, Jennifer Lackey; 30. Memory Knowledge, Sven Bernecker; 31. Semantic Knowledge, Peter Ludlow; 32. Scientific Knowledge, Peter Achinstein; 33. Logical and Mathematical Knowledge, Otávio Bueno; 34. Aesthetic Knowledge, Matthew Kieran; 35. Moral Knowledge, Robert Audi; 36. Religious Knowledge, Linda Zagzebski.
63. Chandler and Munday (2016, electronic source, no. pagination): "Unlimited semiosis: The term coined by Eco to refer to the way in which, for Peirce (via the interpretant), for Barthes (via connotation), for Derrida (via freeplay), and for Lacan (via 'the sliding signified'; see slippage of meaning), the signified is endlessly commutable—functioning in its turn as a signifier for a further signified. In contrast, while Saussure established the general principle that signs always relate to other signs (see relational model), within his structuralist model the relationship between signifier and signified is portrayed as stable and predictable. See also difference."
64. Rescher (2006, 388): "... bearing this pragmatic perspective in mind, let us consider this issue of utility and ask: What can this postulation of a mind independent reality actually do for us? The answer is straightforward. The assumption of a mind-independent reality is essential to the whole of our standard conceptual scheme relating to inquiry and communication. Without it, both the actual conduct and the rational legitimation of our communicative and investigative (evidential) practice would be destroyed. To be evidentially meaningful, experience has to be experience of something. And nothing that we do in this cognitive domain would make sense if we did not subscribe to the conception of a

mind-independent reality. And since this is not a learned fact, then it is (and must be!) an assumption whose prime recommendation is its utility." Further (393; italics in original): "(The 'real world' thus constitutes the *object* of our cognitive endeavors in both senses of this term – the *objective* at which they are directed and the *purpose* for which they are exerted.) And, further, reality is also to be seen as the ontological *source* of cognitive endeavors, affording the existential matrix in which we live and move and have our being, and whose impact upon us is the prime mover for our cognitive efforts." Further (395-6): "We accordingly arrive at the overall situation of dual 'retrojustification'. All the presuppositions of inquiry are ultimately justified because a 'wisdom of hindsight' enables us to see that by their means we have been able to achieve both practical success and a theoretical understanding of our place in the world's scheme of things. Here, successful practical implementation is needed as an extra-theoretical quality control monitor of our theorizing. And the capacity of our scientifically devised view of the world to underwrite an explanation of how it is that a creature constituted as we are, operating by the means of inquiry that we employ, and operating within an environment such as ours, can ultimately devise a relatively accurate view of the world is also critical for the validation of our knowledge". Further (397; italics in original): "To be sure, this sort of idealism is not substantive but methodological. It is not a denial of real objects that exist independently of mind and as such are causally responsible for our objective experience. Quite the reverse: it is designed to facilitate their acceptance. But it insists that the justificatory rationale for this acceptance lies in a framework of mind-supplied purpose. For our mind-independent reality arises not from experience, but *for* it; that is, for the sake of our being in a position to exploit our experience to ground inquiry and communication with respect to the objectively real.

Accordingly, what we have here is an object-level realism that rests on a presuppositional idealism at the justificatory infralevel. We arrive at a realism that is founded, initially at least, on a fundamentally idealistic basis. In sum, paradoxical though it may seem, we obtain a realism the tenor of whose justifying basis is thoroughly idealistic." See also Pihlström (2014) for a broad discussion of the relation between pragmatism and realism.

65. A problem for pragmatism is the distinction between fundamental research (science done without any intention to solve practical problems) and applied research (science done in order to solve specific problems, e.g., developing new medicines). It seems to be an implication of the pragmatic view that all science is applied science. It is a historical fact, however, that fundamental research often has had the greatest long-term importance, also from a pragmatic perspective. Peirce and other classical pragmatist were certainly interested in and contributed to fundamental research and committed to advancing scientific rationality and objectivity. As with many other kinds of dualisms pragmatism rejects a hard dichotomy between basic and applied science. However, it is increasingly a problem on how to manage this problem: societies invests in science and higher education with clear expectations of benefit from this research (see also Hörnig 1985, Appendix 1). Societies must manage research in order to get useful knowledge, but on the other hand such initiatives may limit the possibilities of science to make fundamental progress because science that is subject to strong social, political and economic pressure may lose its critical role of "speaking truth to power" and to view problems from fundamental perspectives (see further Carrier and Nordmann 2011). Hörning (1985) from a Soviet-Marxist point of view claimed to have solved this problem but seems not to have. There are indications that attempts in the administration of science to increase its productivity and relevance may (at the least sometimes) be counterproductive. See, for example, Rodriguez-Navarro (2009). On the other hand, as public expenditure for research is now exceptionally large, it seems difficult keeping researchers on the pay-role without any demands. This problem seems hard to deal with, but its relation to pragmatism will not be further discussed in this article.
66. Sarvimäki (1988, 58-9; italics in original) listed the following characteristics of the pragmatic theory of knowledge:
    1. Man is primarily an actor, living and acting in a biophysical, a socio-cultural and a subjective world.*
    2. Living and acting in the three worlds constitutes the *a priori* of human knowledge.
    3. Since living and acting constitutes the *a priori* of knowledge, knowledge is constructed in such a way that an application of well constructed knowledge will directly or indirectly serve living and acting.
    4. When knowledge becomes part of an acting system, it functions as an internal action determinant.
    5. There is a continuous interaction between knowledge and action so that knowledge is created in and through action and so that experiences that the actor acquires through action influences subsequent action.
    6. Value-knowledge, factual knowledge, and procedural knowledge are three types of knowledge connected to three types of internal action determinants. Having value-knowledge means knowing what fulfills the criteria of good values. Having factual knowledge

means having true beliefs about the three worlds in which one is living. Having procedural knowledge means knowing how to carry out a specific act or act sequence.

7. Knowledge can be unarticulated or articulated. Unarticulated knowledge is, for instance, tacit knowledge, familiarity, knowledge by acquaintance. Knowledge can be articulated in everyday language, science and art.

*Sarvimäki's (1988) "three worlds" are here understood as metaphorical speech. There is one world, in which we may distinguish the bio-physical, the socio-cultural and the subjective world (compare Hjørland 2019).

67. About "Philosophy of Praxis" see also Vogel (2017).
68. Zalabardo (2019) considered two conflicting theories about how scientists ascribe predicates to things: (a) The primacy of reference theory (b) the primacy of practice theory. He wrote that it may be tempting to think of them in this way (183-4): "Pragmatic procedures are used in our day-to-day lay-person determinations of the representational status of predicates. The features they focus on are only contingently related to the representational status of predicates, so the procedures can produce false results. The referential procedure, by contrast, focuses on the facts that determine whether a predicate is representational. Hence, when correctly applied, the referential procedure produces infallible results, and can be used to validate the verdicts reached by pragmatic procedures. Applying the referential procedure is a job for the philosophers, who specialise in the language-world connections that the procedure focuses on. They will be able to determine whether the verdicts reached by lay people using pragmatic procedures are correct or incorrect." For example, we may believe that something is gold by ascribing some predicates to it using our common-sense. However, a chemical analysis may say that it is not (ascribe other predicates to it). We may think that the chemical approach is not pragmatic (in the sense of theory-laden), and therefore infallible. But Zalabardo (2019) argues that it is not infallible, and that the referential procedure presumes that we are able to single out at least some properties directly, without the mediation of predicates or concepts, which (185) "strikes me as wildly implausible and I'm not even sure whether it has any contemporary advocates [...] that the kind of unmediated access to properties that it contemplates is not to be had". Unfortunately, although Zalabardo's arguments are important they do not provide normative principles on how, according to the pragmatic view, inquiry should be done.
69. Haack (2009) is a philosopher strongly influenced by classical pragmatism. She developed the view "foundherentism" as an alternative to both foundationalism and coherentism.
70. A more comprehensive quote from Margolis (2009, x) is: "I see the larger themes in a more contested way than I had [30 years ago in the first edition of the book]: the flux of the world as opposed to assured invariances; the historicity of thought as opposed to the universalizing aptitude of our cognitive faculties; the second-natured cultural transformation of our biological aptitudes as opposed to any mere biologism; the constructed nature of knowledge, perception, thought, science, and understanding as opposed to any pre-established correspondence between cognition and world; and now, more commandingly than ever, the 'natural artifactuality' of the self or person as opposed to the assumption that all the materials of the human sciences fit neatly within the scope and competence of the physical sciences. You may well hesitate before endorsing any of these notions, but you cannot doubt that they constitute a strong challenge to the most favored doctrines of the principal currents of Anglo-American philosophy down to our own day".

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