THE NATURE OF SCIENCE. A DIALOGUE

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Abstract

In this dialogue the view of Paul Hoyningen-Huene as defended in *Systematicity. The Nature of Science* (Oxford University Press, 2013) is presented and criticized. The approach is developed dialectically by the two interlocutors, a series of critical points are debated and an alternative view is introduced. The dialogical form is intended to honor the general philosophical approach of the author summarized in the last sentence of the book, where he states that he sees philosophy as an ongoing, open-ended dialogue.

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STUDENT: Ὁδός Θεωρίας is called this street at the foothills of the Acropolis.

HOYNINGEN-HUENE: This light of Greece and the Attica sky are very inspiring!

STUDENT: Let us walk down the ὁδόν Θεωρίας.

HOYNINGEN-HUENE: You know that I have been thinking about the nature of science for several decades, and my views have now been crystallized also in a written form[1].

STUDENT: The original Greek distinction between ἐπιστήμη and δόξα has been debated and transformed throughout the centuries, but is still with us today.

HOYNINGEN-HUENE: There is a long history of answers to the question "What is science?" It covers, I think, four periods.

STUDENT: Which ones do you have in mind?

HOYNINGEN-HUENE: In the first phase, the original debate was around two traits of scientific knowledge: the epistemic ideal of the absolute certainty of knowledge and the methodological idea of deductive proof as the appropriate means to realize this ideal. Only ἐπιστήμη in sharp contrast to mere belief, δόξα, qualifies as scientific and its certainty is derived from being based on true first principles and deductive proofs. Euclidean geometry best exemplifies this ideal of scientific knowledge. Euclid's *Elements* written at the end of the fourth century BCE is one of the most successful scientific books of all times and cultures, used as a textbook for more than two millennia.

STUDENT: This dichotomy between ἐπιστήμη and δόξα provided a simple, but productive framework from the time of Plato and Aristotle to theorize about scientific knowledge.

HOYNINGEN-HUENE: This lasted until the early seventeenth century, when an important change took place. The epistemic ideal of the certainty of scientific knowledge was retained, but the means by which this ideal was to be achieved was no longer deductive proof, but the "scientific method".

STUDENT: I guess that the four protagonists for this view were Galilei, Bacon, Descartes and a little later Newton.

HOYNINGEN-HUENE: Indeed. The scientific method was mainly conceived of as a set of strict rules of procedure, and it was the strict adherence to these rules that established the special nature of scientific knowledge.

STUDENT: How long does this second phase last?

HOYNINGEN-HUENE: Until the second half of the nineteenth century. During this time the belief in the possibility of secure scientific knowledge erodes, even if this knowledge is produced under the rigid auspices of the scientific method. This erosion manifests itself in the mathematical, the natural and the human sciences.

STUDENT: For the mathematical sciences, the development of non-Euclidean geometries in the course of the nineteenth century was quite dramatic, I think.

HOYNINGEN-HUENE: Yes, since it demonstrated that the belief in the uniqueness of Euclidean geometry, and thus the conviction of its unconditional truth, is unfounded.

STUDENT: And I guess it is the advent of the special theory of relativity and of quantum mechanics that has contributed most to the process of erosion of scientific certainty in the natural sciences, but this took place in the first quarter of the twentieth century.

HOYNINGEN-HUENE: Yes, but the process of erosion of the belief in scientific certainty started earlier, when physics was still in its classical phase. At any rate, especially after the revolution in physics in the first quarter of the twentieth century, the belief that scientific knowledge is not certain and can never be, but is hypothetical and fallible, becomes dominant both in scientific and philosophical circles.

STUDENT: And in this third phase – according to your own periodization – it was also historicism, prevalent in the social sciences and humanities that stressed that all knowledge is historically bound and thus fallible.

HOYNINGEN-HUENE: And at present we are in the fourth phase which started sometime during the last third of the twentieth century. In this phase, belief in the existence of a scientific method, conceived of as strict rules of procedure, has eroded. Research situations 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.

STUDENT: So, where are we now?

HOYNINGEN-HUENE: We must pose the question about the nature of science – this is the central question which we are not allowed to avoid. The old question about ἐπιστήμη, scientific knowledge, must be answered – in a more convincing way and using more convincing arguments.

STUDENT: So, what is your claim?

HOYNINGEN-HUENE: Here is my main thesis: "Scientific knowledge differs from other kinds of knowledge, in particular from everyday knowledge, primarily by being more systematic".

STUDENT: This sounds similar to Albert Einstein's dictum that "[t]he whole of science is nothing more than a refinement of everyday thinking."[2]

HOYNINGEN-HUENE: My thesis is *comparative* in character: science is *more* systematic than other kinds of knowledge. An immediate consequence of my thesis is that it allows for a smooth transition between prescientific (or nonscientific) knowledge and scientific knowledge.

STUDENT: So, your thesis contrasts scientific knowledge with everyday knowledge rather than metaphysics or pseudoscience – is it correct?

HOYNINGEN-HUENE: Yes. And my thesis is *descriptive* not normative. It does not *pre*scribe what property or properties (good) science should or must have, but *de*scribes how science actually is.

STUDENT: So, what is the argument?

HOYNINGEN-HUENE: There are nine dimensions in which science is more systematic than other kinds of knowledge: descriptions, explanations, predictions, the defense of knowledge claims, critical discourse, epistemic connectedness, an ideal of completeness, knowledge generation and the representation of knowledge.

STUDENT: Why do you suggest these nine dimensions and not more? Is this a complete list?

HOYNINGEN-HUENE: I have no systematic theoretical argument for choosing precisely these nine dimensions or that this list is complete. Such a theoretical argument would probably consist of some principle that could be developed such that it yields just these nine dimensions. Lacking such a principle, my procedure to identify these dimensions is, broadly speaking, empirical. It is a matter of trial and error, of "playing around" with different possibilities, as scientists often put it, and finally settling for these nine dimensions without a systematic theoretical argument.

STUDENT: You need to say more about these nine dimensions, but let me first ask what the *scope of application* of your claim is – I guess the natural sciences?

HOYNINGEN-HUENE: No, it is all of science. It covers all disciplines, be they formal, like mathematics, informatics, etc., or empirical, like physics, biology, economics, etc. *Wissenschaft* covers the natural sciences, the social sciences and the humanities and it can be *Grundlagenwissenschaft* or *angewandte Wissenschaft*, that is, basic science, or applied science.

STUDENT: So, the scope of application is extremely broad; it covers nearly everything that is taught in universities in our days.

HOYNINGEN-HUENE: Indeed. Although not all nine dimensions of systematicity have to be realized in each case, of course. My approach does not require that every dimension can be applied to every discipline; for example, prediction is less important in the historical natural sciences than in the experimental sciences. I wish to be very clear on this point.

STUDENT: So, tell me more about these nine dimensions of science and how the increase of systematicity plays the dominant role in them.

HOYNINGEN-HUENE: Let me start with descriptions. Take a concrete example: every day knowledge regarding the classification of human languages can never be as systematic as the one that linguistics provides. In 2009, the authoritative system counted 6,909 living languages that are, at the top level, classified into 116 language families. They comprise between 1,510 (Niger-Congo) and 1 (e.g. Basque) family members. Or take the tendency of quantification in the sciences. Quantitative descriptions are, where applicable, more precise than qualitative descriptions. For example, the quantitative description “The temperature on this day at noon was 30.7° C” is more precise than “On this day at noon, it was really hot”. Second, mostly as a consequence of their greater precision, quantitative descriptions allow for many more different and easily discernible descriptions than qualitative descriptions. Using a household thermometer one can easily distinguish and describe some five hundred different temperature states between -15° and 35° C. Using our qualitative everyday language, we have perhaps two or three dozen descriptions at our disposal, ranging, for example, from “extremely freezing cold” to “extremely burning hot”.

STUDENT: I see.

HOYNINGEN-HUENE: Let me come to the second dimension of science, explanation.

STUDENT: Explanation is an activity. I cannot understand why you call it a “dimension”, but please go on.

HOYNINGEN-HUENE: In our everyday explanatory practices, probably the most important explanatory source is some regularity. For instance, we explain somebody’s being late by maintaining that the person is "always" late, or the failure of our car’s engine to start in the morning by pointing out particular weather conditions in which the engine refuses to start, or the apparently strange behavior of someone by his belonging to some other culture. In all of these cases, we refer to empirical regularities that are at the heart of the explanation. Of course, these regularities are not quantitative; very often they are not even mentioned explicitly, and their epistemic status is often questionable.

Wherever such explanations have scientific counterparts, it is obvious that they are less systematic than the corresponding scientific ones. The latter are typically quantitative, the regularities are made explicit, and their epistemic status must be sufficiently robust in order to make the proposed explanation acceptable. Otherwise, in science, the proposed explanation is refused and competing explanations are sought.

STUDENT: And I guess you have a similar argument for the case of prediction, another important epistemic activity.

HOYNINGEN-HUENE: Yes, prediction is the third dimension in which systematicity manifests itself in science, where we have predictions based on empirical regularities of the data in question, on correlations with other data sets on theories and laws on models or on dephi methods.

STUDENT: This seems straight-forward. But it is the defense of knowledge claims, the question of the validity of scientific knowledge which has traditionally been seen as the main distinctive feature of science. How do you consider this issue? To call all the diverse efforts that millions of scientists exert in order to validate the results of their epistemic activities "systematic" does not seem to shed much light on them!

HOYNINGEN-HUENE: Listen, with respect to the defense of knowledge claims, which is my fourth dimension, of course, there are vast differences among the sciences, indeed. In the philosophy of science, there are a host of expressions designating the ways by which the sciences attempt to secure high quality of their knowledge claims, including: proof, verification, empirical or inductive support, justification, certification, confirmation, corroboration, validation, critical test, disconfirmation, falsification, refutation, organized skepticism, and the like.

STUDENT: Exactly. And behind all the expressions many sophisticated tools are hidden, which when employed appropriately will yield valid scientific knowledge one way or another. To call them all "systematic" does not seem to make any difference.

HOYNINGEN-HUENE: Wait until I am through with my thoughts! It took me decades to get at it, and you have to be patient to get the complete picture that I want to convey.

All these expressions can be divided into two groups, depending on two conceptions about how the sciences operate regarding the enhancement of their knowledge claims. According to the first conception, science is seen to improve its knowledge claims primarily by positive measures regarding hypotheses. The details of these measures vary widely, but their common claim is that they positively support a hypothesis. According to the other conception, science reaches higher quality knowledge claims by negative measures. The underlying idea is that it is in principle not possible to find positive support for empirical knowledge claims. The only possibility is to engage in a sustained attempt to diagnose and subsequently eliminate errors.

STUDENT: I see.

HOYNINGEN-HUENE: Empirical generalizations, models and theories differ from one another in important respects. With respect to procedures of error elimination, however, they can often be treated similarly: the basic idea is to confront these theoretical constructs with empirical data. This basic pattern is the same in daily life, since we check our generalizations for their correctness. But science is more systematic in defending the knowledge claims associated with empirical generalizations, models and theories.

STUDENT: This is unsurprising.

HOYNINGEN-HUENE: I am glad that you agree. Now, the same is the case when we try to establish causal claims, as is typical for the empirical sciences. But also in historical sciences the situation is similar.

STUDENT: What do you mean?

HOYNINGEN-HUENE: What is the historian's basic task?

STUDENT: What is it?

HOYNINGEN-HUENE: According to an important suggestion in the literature, it is “to choose reliable sources, to read them reliably, and to put them together in ways that provide reliable narratives about the past”.[3]

STUDENT: Is it that?

HOYNINGEN-HUENE: Both in the historical cultural sciences and in the historical natural sciences like cosmology, earth history or paleontology.

STUDENT: And what is the difference between the activities of the professional historians to procure the reliability of their stories and the corresponding activities of common people when telling stories?

HOYNINGEN-HUENE: Clearly common people also rely on certain data that they interpret and then process into a story. But it is equally clear that immeasurably less care is usually exerted when these stories are composed. Just imagine someone telling that story about why, against all his intentions, he was late again, or someone telling the story of his life to a potential new lover. As in professional historiography, these stories are in danger of being somehow bent toward the goal that they are supposed to reach. However, with respect to the sources, their interpretation and their composition into a story, they are far less systematic than the professional historian's ones.

STUDENT: And you have mentioned critical discourse as the fifth dimension of science that is also supposedly connected with systematicity.

HOYNINGEN-HUENE: Exactly. Here systematicity does not concern scientific knowledge itself, but rather the special social organization of science that bears on the specificity of its product. Roughly speaking, the social norms and the social institutions that constitute the *social* organization of scientific communities must be conducive to the exertion of the *cognitive* norms that must be operative for the enterprise to reach its institutional goal. In the present perspective, this goal is the maintenance and even increase of the systematicity of scientific knowledge.

STUDENT: But here there is a sudden shift in your line of argument. Up to now you have been talking about the qualities of knowledge that supposedly makes an enterprise scientific, and now you are talking about the social production process that supposedly results in scientific knowledge. So, is whatever is produced in modern universities scientific knowledge?

HOYNINGEN-HUENE: My point is this. In order to maintain the high quality of its knowledge, science must be constantly attentive to avoid errors that may have various origins. With respect to the social structure of science, the scientific community must be organized in such a way that all knowledge claims are scrutinized by its members from many possible different points of view. We are thus looking for the social reflection of something epistemological: the highly systematic defense of knowledge claims.

STUDENT: This is a valuable point. But this highlights the social presuppositions of a specific kind of criticism that yields scientific knowledge and is not connected with increased systematicity. Criticism can lead to the destruction of a system, I have always thought.

HOYNINGE-HUENE: The term “critical” signifies the goal of probing claims; the term “discourse” signifies the involvement of various members of the community; and the term “institutionalized” signifies some sort of social organization and order, hence a special kind of systematicity.

STUDENT: I do not know whether you have ever served in the military as I did. But I am telling you, the life and activities in the barracks are as systematic as they can be, but they have little to do with science.

HOYNINGEN-HUENE: This analogy is entirely confusing. You confuse 'being strictly ordered' with 'being more systematic in regard to knowledge'. A military camp is certainly not a more systematic social institution in regard to securing the quality of knowledge. As far as I know, military camps are not meant to secure knowledge quality and they certainly do not do a better job in that regard than research institutions!

STUDENT: Anyway, tell me more about the dimensions of epistemic connectedness and completeness.

HOYNINGEN-HUENE: Here again systematicity is the key to describing knowledge as scientific. In an abstract characterization epistemic connectedness means the existence of manifest connections of knowledge to other pieces of knowledge, although the nature of these connections is left unspecified. There is a remarkable drive for completeness in mathematics, in physics, in chemistry, in biology, in the earth sciences, in the historical sciences…..

STUDENT: ….and in stamp collecting!

HOYNINGEN-HUENE: This is a bad joke!

STUDENT: Then let me give you a more serious counter-example with respect to epistemic connectedness. Theological systems of propositions routinely manifest a series of diverse connections ranging from how deities inhibit nature to the kinds of rituals that must be followed to please those deities to imperatives how to lead one's life. How do they differ from a system of scientific propositions?

HOYNINGEN-HUENE: If theology is understood as the discipline that sets out to articulate the beliefs of a given religion and to put them into a systematic order, then it is a scientific discipline.

STUDENT: What you suggest is *Religionswissenschaft* and nobody would question that. But theology is the discipline the subject matter of which is God, and it is as systematic and epistemically connected as it gets, with a long history, much longer than modern science in any case.

HOYNINGEN-HUENE: In the early eighteenth century, it was scientifically legitimate (although controversial) to establish a role for God in planetary theory: Newton postulated that God prevents any seriously accumulating instability of the planetary system by correcting planetary orbits.[4] God's role in planetary theory ended with Laplace declaring that in his theory, he no longer needed the hypothesis of God.[5] Similary, in nineteenth-century geology and paleontology, God was invoked by some British authors in the theory of catastrophism. This theory postulated a number of deluges, analogous to the Flood, in order to explain geological and paleontological data. Again, this was undoubtedly part of science, though controversial. Thus, it is impossible to state or to deny in general whether God is a legitimate part of science, especially of scientific explanations; it depends on the particular discipline and on the historic time.

STUDENT: I see. So depending on the context and the circumstances, God can be a legitimate part of science!

HOYNINGEN-HUENE: And let me come to the last two dimensions. The generation of new knowledge also follows a more systematic pattern…..

STUDENT: …. I have always thought that new knowledge is the product of a creative process and that originality has something to do with breaking a routine, and avoiding customary trains of thought!

HOYNINGEN-HUENE: It is true that the creative process of coming up with new and even revolutionary ideas is often not a very orderly procedure. This, however, is not a contradiction to my main thesis, which is a comparative one: it only states that scientific knowledge is more systematic than comparative knowledge from other domains, especially everyday knowledge.

STUDENT: And what is the last dimension?

HOYNINGEN-HUENE: It concerns the representation of knowledge. Think of mathematical functions as representational devices and of how graphs increase the possibilities of visualization. The periodic system in chemistry has received an almost iconic character, i.e. the representation of the systematic order of the chemical elements. And in Charles Darwin's groundbreaking *On the Origin of Species* published in 1859, the only diagram on pages 116 and 117 depicts something familiar today: the increase of diversity of life of a (hypothetical) genus in the course of evolution, accompanied also by the extinction of several species.[6] This is the first depiction of the evolutionary tree of life. Clearly, the idea behind all of these representations of knowledge is to have a representation of some body of knowledge that, due to its specific visual quality, can be grasped quickly and accurately. It is obvious that the sciences were forced to develop means of representation vastly more systematic than our everyday measures because of the vastly larger amount of information generated in the sciences.

STUDENT: So, these are all the dimensions in which you claim that systematicity makes a difference, these nine and no more.

HOYNINGEN-HUENE: Let us recall Goethe: "Wer Großes will, muss sich zusammenraffen; In der Beschränkung zeigt sich erst der Meister."[7]

STUDENT: This philosophical analysis of the concept of systematicity is your answer to the question "What is Science?"

HOYNINGEN-HUENE: Yes.

STUDENT: Are you sure that this is a good strategy to grasp the nature of science?

HOYNINGEN-HUENE: Of course.

STUDENT: Since the beginning of Western philosophy questions of the sort "What is X?" were supposed to trigger an inquiry which would lead to a definition of X and through this to the determination of the nature or essence of X. So, the nature or essence of X, in our case of science, is systematicity, this is the result of your philosophical analysis?

HOYNINGEN-HUENE: No. Throughout centuries, expectations of an answer to a "What is X?" question have evidently been based on metaphysical assumptions about the existence and properties of the essence of things. In modern times, these assumptions have become problematic, to say the least. But I want to avoid controversial philosophical presuppositions, so I do not want to discuss the general question of whether there are essences or not, and which properties they might have. Such controversial presuppositions constrain the acceptance of what is based upon them. So, I have answered the question "What is science?" in a sense that is as free from these metaphysical presuppositions as possible.

STUDENT: But you do not answer this question by giving necessary and sufficient conditions either?

HOYNINGEN-HUENE: A general question such as the one that I am concerned with, asking for some specific communalities of a large class of items, may not have an answer in terms of necessary and sufficient criteria, applying to each and every item in the whole class. So, this entire approach is fundamentally wrong. But the lack of this kind of answer to the question definitely does not render it a pseudo-question. There is a third way to answer the question, the way that I have suggested.

STUDENT: It is the analysis of family resemblance.

HOYNINGEN-HUENE: Yes, it is the way that Wittgenstein has shown us. "[W]ir dehnen unseren Begriff der [Wissenschaft] aus, wie wir beim Spinnen eines Fadens Faser an Faser drehen. Und die Stärke des Fadens liegt nicht darin, daß irgend eine Faser durch seine ganze Länge läuft, sondern darin, daß viele Fasern einander übergreifen."[8]

STUDENT: So, rather than answering the question at an abstract level, the turn to the context is suggested, in order to obtain the concrete meaning of "systematicity" as a kind of overlap of its use in different contexts.

HOYNINGEN-HUENE: Exactly. Our understanding of the concept of systematicity cannot be achieved at an abstract level. The feeling of fairly thin air, of vagueness, of not really knowing what we are talking about would persist. It seems to me that this impression is both correct and unavoidable. The reason is that in the *actual* use of the term "systematicity", some context always exists. The term then receives a richer and more concrete meaning due to that context – as I have specified it in discussing the nine dimensions.

STUDENT: But is this all?

HOYNINGEN-HUENE: What do you mean?

STUDENT: Let us suppose that we have clarified the *concept* of systematicity in these nine dimensions of science. What kind of accomplishment would that be?

HOYNINGEN-HUENE: I can then claim that science is more systematic than other kinds of knowledge in these dimensions.

STUDENT: But this claim would be nothing more than a conceptual claim, a claim based on a specific kind of conceptual analysis.

HOYNINGEN-HUENE: No, not at all. My approach is empirical. Look at science. See the systematicity in these nine dimensions. You will then find out that what makes scientific knowledge scientific in contrast to common sense knowledge is that it is more systematic in these ways.

STUDENT: But the aim of this descriptive endeavor is not to provide a more or less accurate representation of what takes place in these nine dimensions of science as you call them, i.e. classes of scientific activities really, but to offer an analysis of the concept of science by means of clarifying the use of the concept of "systematicity" in these nine dimensions.

HOYNINGEN-HUENE: Look, I try to address a general question, namely 'What's so special about science?' by non-substantial and non-metaphysical means, namely by applying the Wittgensteinian method to the real historical and contemporary scientific practice. This is why I favor the provision of case-studies and exemplars instead of conceptual analysis.

STUDENT: "Die Ergebnisse der Philosophie sind entweder falsch oder trivial." This is what my teacher in Tübingen, Herbert Keuth, used to tell me. I have always thought that this was not correct – but what do you think?

HOYNINGEN-HUENE: "The results of philosophy are either false or trivial", this is a strong claim.

STUDENT: I disagree. I believe that the results of philosophy are both true and important.

HOYNINGEN-HUENE: This is also a strong claim!

STUDENT: In order for the results of philosophy to become substantial and important, one should stop asking "What is X?" – questions altogether. This is the more radical path that I favor. For, what kind of answers can we get when we ask such a question? We have agreed that we cannot get to the essences of things. We cannot provide necessary and sufficient conditions for the respective concept. And the descriptions of the use of the respective concept in different contexts will just give us some information about the meaning of “X”, quite a trivial result really.

HOYNINGEN-HUENE: But to stop asking the “What is X?” – question altogether is equivalent with stopping philosophy.

STUDENT: Not at all. Φιλοσοφία is the love of wisdom, and wisdom does not exhaust itself in the casual knowledge of the use of certain concepts. Wisdom manifests itself in theoretical discourse and in practical activities, and it is much more complex and difficult to attain than it is to learn the skill of providing the meanings of concepts.

HOYNINGEN-HUENE: "What is Truth?", "What is Justice?", "What is Freedom?" – answering these kinds of questions has always been regarded as the task of philosophy.

STUDENT: The point is this. There is no specific matter that philosophy has to address or a specific type of question that it is its privilege to answer. "We are not students of some subject matter but students of problems. And problems may cut right across the borders of any subject matter or discipline."[9]All cognitive and practical activity starts with a problem, and we individually and collectively try to solve problems successfully by mobilizing all resources available from a diversity of sources. Philosophical problems are problems on the border of our knowledge; they emerge at the limits of our problem-solving activity, be it theoretical or practical.

HOYNINGEN-HUENE: "For this feeling of wonder shows that you are a philosopher, since wonder is the only beginning of philosophy".[10]

STUDENT: "[M]άλα γὰρ φιλοσόφου τοῦτο τὸ πάθος, τὸ θαυμάζειν: οὐ γὰρ ἄλλη ἀρχὴ φιλοσοφίας ἢ αὕτη." This feeling of wonder, τὸ θαυμάζειν, as Plato called it, triggers our problem-solving activities. I have always shared Popper's view about "the mistaken belief that one can philosophize without having been compelled to philosophize *by problems which arise outside philosophy* – in mathematics, for example, or in cosmology, or in politics, or in religion, or in social life. […] Genuine philosophical problems are always rooted in urgent problems outside philosophy, and they die if these roots decay. In their efforts to solve them, philosophers are liable to pursue what looks like a philosophical method or technique or an unfailing key to philosophical success. But no such methods or techniques exist; in philosophy methods are unimportant; *any* method is legitimate if it leads to results capable of being rationally discussed. What matters is not methods or techniques but a sensitivity to problems, and a consuming passion for them; or as the Greeks said, the gift of wonder."[11]

HOYNINGEN-HUENE: Θαυμάζειν.

STUDENT: Let me work out what emerges if we adopt this stance. All these dimensions of science that you have been concerned with are different kinds of problem-solving activities undertaken by human beings acting in a very specific, tight institutional context.

HOYNINGEN- HUENE: You should elaborate on that.

STUDENT: The image that the scientific community likes to project of itself, and indeed the image that the general public has of this community is that of rationality par excellence. The scientific community is regularly viewed, both from within and from outside, as the archetype of institutionalized rationality. Is this an accurate picture? If this is the case, then what does scientific rationality precisely consist in, how did it emerge, and how is it sustained? And if scientific rationality is to be valued positively, which concrete political institutions and informal social attitudes are needed to protect and foster it?

HOYNINGEN-HUENE: I see, you want to inquire into the nature of science by focusing on scientific rationality.

STUDENT: I think we can learn more about science if we proceed by posing these kinds of questions and by trying to answer them.

HOYNINGEN-HUENE: I don't think so. But go ahead!

STUDENT: A very important line of thought in modern philosophy which came to dominate the discussion for centuries conceptualized questions of scientific rationality as questions of the appropriate scientific method. Ever since Bacon a view has been suggested according to which successful scientific endeavor consists in the application of a set of appropriate methodological rules by impartial scientists mainly aiming at the provision of true explanations with the help of theories. Although there have been variations of this theme, modern philosophy of science has expended considerable effort in analyzing this method in a more precise form, and the general tenet was that the result of this scientific endeavor, scientific knowledge, enjoyed a special status, largely due exactly to the way that it has been produced: namely it enjoyed this status because it applied the appropriate scientific method. Important variations of this position have been suggested by the logical positivists, but also by Popper and many contemporary scientific realists.

HOYNINGEN-HUENE: This view was challenged by a series of philosophers, historians and sociologists of science in the second half of the 20th century, of course. Kuhn, Feyerabend and the strong programme in the sociology of science have attacked the traditional view of science with all its positive connotations from different angles, stressing different aspects of scientific activity. The very goal of science as the systematic endeavor to produce reliable knowledge of phenomena has been questioned.

STUDENT: The contemporary discussions that I have been listening to in different fora oscillate between these two extreme views. Some still defend the possibility of essentially a formal rule of scientific rationality in the tradition of logical positivism. Different versions of Bayesianism should be subsumed here. Its vocal defenders insist that Bayesian theory constitutes an objective theory of scientific inference. That is, given a set of prior probabilities and some new evidence, Bayes' theorem dictates an objective way to obtain updated posterior probabilities in the light of evidence.[12] And a series of so-called postmodern theorists radicalized further the views of Kuhn, Feyerabend and the strong programme in the sociology of science denying the status of rationality to the scientific endeavor and its products.

HOYNINGEN-HUENE: But there is also a series of "middle ground positions", of course.

STUDENT: Indeed. Some argue for a relativized and historicized version of the original Kantian conception of scientific a priori principles and examine the way in which these principles change and develop across revolutionary paradigm shifts.[13] Others acknowledge that science is a fundamentally social enterprise, but honor the traditional spirit of modern philosophy at the same time by positively insisting on the possibilities of scientific objectivity and scientific progress and on the possibility of the acceptance or rejection of beliefs on the basis of evidence as the cornerstones of scientific rationality.[14]And there is a growing interest in science in the context of application, I think.[15]

HOYNINGEN-HUENE: But I am curious to hear what your own ideas about scientific rationality are! In the end, they are supposed to shed a better light on the nature of science than systematicity theory does!

STUDENT: I think that a synthetic theory of scientific rationality is the appropriate one, encompassing both the individual and the collective level. Scientific rationality has regularly been discussed either on the basis of models of individual rationality centered around issues such as the confirmation of hypotheses with the help of evidence, testing procedures, theory choice, etc. *or* on the basis of models of group rationality centered around issues of how scientists organized in epistemic communities interact in producing scientific knowledge. My view is that scientific rationality encompasses both levels, the individual and the collective level, and that it does not do to provide accounts of them in a paratactic way. Scientific rationality emerges spontaneously as a result of the different forms of interaction, both cooperative and competitive, among individual scientists organized in diverse institutional structures which make up what we call "science".

HOYNINGEN-HUENE: I can see the intuition, but this is too ambitious and very *unsystematic*, if I may say so.

STUDENT: Given the scope, I do not make any pretense to totality or completion. What should be delivered is only a framework to be filled-in and advanced further by epistemologists whose task is to develop criteria and standards of knowledge, truth and rational belief; by historians whose task is to make visible those historical features of the practice of science that affect its content; by sociologists, political scientists and economists whose task is to inquire into the working properties of the formal and informal institutions which make up the rules of the game of science and decisively structure and channel the scientific activities; and by constitutional lawyers whose task is to transform the ideals and abstract institutional rules into constitutional provisions of politics in which science is to flourish.

HOYNINGEN-HUENE: So, philosophy of science is to provide the scaffold for a perpetually unfinished project.

STUDENT: "Wie Schiffer sind wir, die ihr Schiff auf offener See umbauen müssen ohne es jemals in einem Dock zerlegen und aus besten Bestandteilen neu errichten zu können."[16]

HOYNINGEN-HUENE: This is indeed a wonderful image conveyed by Otto Neurath!

STUDENT: This image implies a procedural conception of science created by imperfect biological organisms with a limited cognitive capacity in interaction with artefacts in a specific social context. The scientific enterprise is a social process, and it consists of the attempts of the participants to this process to provide answers to puzzles and solutions to problems. The scientific enterprise is embedded in certain practices employed by the participants and unfolds according to normative standards that have emerged in a long evolutionary process of trial and error. There is a history to the scientific enterprise, a history that includes the more and less successful attempts to answer specific "Why?-questions" and "What is the case?-questions", the development of more and less accurate means of representation devised to answer such questions, and the permanent change of institutional constraints under which the participants engage in their activities. The positive task is to *describe this process* and the normative task to *enable the further existence* of those characteristics of the process that we value positively and to *hinder those that we evaluate negatively*.

HOYNINGEN-HUENE: Such a normative theory of scientific rationality must address a principal issue, the role of values in science, in order to be convincing, however.

STUDENT: Yes, these can be epistemic values, like accuracy, simplicity, consistency, fruitfulness, etc., or non-epistemic values (i.e. aesthetic, moral, political, social and religious values) like beauty, honesty, integrity, freedom of expression, etc. There is, naturally, value pluralism.

HOYNINGEN-HUENE: Is there some kind of external ultimate criterion or justification process that can be used in order to judge the superiority of different values that (should) play a role in science? In other words, is there an ultimate justification for values and other normative structures?

STUDENT: The quest for an ultimate justification of values and rules is a manifestation of the vain quest for certainty originating in the idea of a positive, sufficient justification. That this is problematic was already seen in the context of ancient skepticism, I would say. More specifically in the context of the discussion of Agrippa's five tropes.[17] Hans Albert calls it the Münchhausen Trilemma. The demand for a justification for everything leads to a situation with three alternatives, all of which are unacceptable: an infinite regress which seems to arise from the necessity to go further and further back in the search for foundations, and which, since it is in practice impossible, affords no secure basis; a logical circle in the deduction, which arises because, in the process of justification, statements are used which were characterized before as in need of foundation, so that they can provide no secure basis; and finally the breaking-off of the process at a particular point, which, admittedly can always be done in principle, but involves an arbitrary suspension of the principle of sufficient justification.[18]

HOYNINGEN-HUENE: Infinite regress and a circular argument seem clearly unacceptable.

STUDENT: Yes. One is inclined to accept the third possibility, for the simple reason that no other way out of the situation is thought to be possible. Of statements where one is prepared to break off the foundation process, it is customary to use words such as "it is self-evident", "it is based upon immediate knowledge" and the like. But in effect what it amounts to is the dogmatic suspension of the justification process. At some point one declares a specific step in the argumentation as an Archimedean point, but this is nothing other than a dogma, and all that we have is justification by recourse to a dogma.

HOYNINGEN-HUENE: So, you seem to contend that there is no possibility of an ultimate justification of values or statements.

STUDENT: Indeed. Typically, the argumentation is suspended at some point in favor of the "ultimate" given that the respective philosopher favors.

HOYNINGEN-HUENE: How can this dogmatism and the Münchhausen Trilemma be avoided then?

STUDENT: By substituting the principle of critical examination for the principle of sufficient justification. In accord with this principle, a discussion of the problems of epistemology, philosophy of science, or ethics need not refer back to ultimate reasons in order to be convincing or "rational". Instead, problems that arise in the sphere of cognition and the sphere of praxis are to be discussed and solved in light of already existing solutions. The application of the principle of critical examination means that solutions are to be creatively discovered, they are to be weighted in reference to certain values and standards, and, on this basis, the preferred solutions to problems are to be decided upon. Solutions are not to be judged to be good or rational by virtue of being based on certain knowledge or ultimate values. Instead, our solutions in all areas of cognition and action are fallible, but they can be improved by critical discussion.

HOYNINGEN-HUENE: I see, you discard the idea that certain rules of scientific inference are immanently rational as dogmatic.

STUDENT: Yes. In contrast, I think that the critical discussion of the rules producing scientific knowledge aiming at their modification and revision on the basis of weighing the various feasible alternatives with regard to different criteria and values is a way of escaping dogmatism, without sliding into an anarchic position of "anything goes".

HOYNINGEN-HUENE: Well, critical discourse is one of my nine dimensions….

STUDENT: ….this middle ground position between dogmatism and relativism consists of three essential ingredients: pluralism, fallibilism, and revisionism.

HOYNINGEN-HUENE: But this is too vague, you have to be more specific!

STUDENT: A pluralist account positively acknowledges the existence of many values, epistemic and non-epistemic alike. Pluralism is fundamentally different than relativism since pluralism does not involve a renunciation of judgment and commitment as relativism does. A pluralist engages with what she disagrees, poses critical arguments and proposes alternatives – an attitude very far away from the relativistic "whatever". Besides, relativism does not necessarily imply pluralism: the requirement to treat equally all alternatives that do exist does not entail the requirement to have many alternatives. If all agree on one alternative and there is no active search for other alternatives, relativism has nothing to oppose to monism.[19]

HOYNINGEN-HUENE: And what does fallibilism include?

STUDENT: Fallibilism is the position that all our knowledge, activities, principles, positions and rules are prone to error. In all areas of cognition and action human beings constantly make mistakes, but they are able to learn from them. A fallibilist treats all problem solutions as hypothetical: she provisionally accepts them instead of searching for a final justification for them. The fallibilistic attitude can be applied to all areas of human activity: science, politics and even religion – the existence of God can be treated as hypothetical postulate to be critically discussed, for example. What concerns us more here, criteria and values can all be accepted as hypotheses amenable to criticism.

HOYNINGEN-HUENE: And I guess you want to say that fallibilism and the acceptance of the principle of critical examination naturally lead to revisionism, right?

STUDENT: Exactly. Revisionism is the position that all our beliefs and problem solutions, fallible themselves, are amenable to revision – and possibly to a progressive one. Revisionism is a corollary of the procedural view that I have suggested for science – any static ideal would not be compatible with it.

HOYNINGEN-HUENE: I can see the scope and function of these three ingredients of your position, which is very different from my own indeed.

STUDENT: According to this middle ground position there is a discrete and specific role of scientific methodology which can be viewed as a technological discipline.

HOYNINGEN-HUENE: And what does this technology look like?

STUDENT: This technology operates with *hypothetical* rather than *categorical imperatives*.

HOYNIGEN-HUENE: This seems obvious.

STUDENT: Having accepted that the quest for certainty is vain and that the attempts to provide final justifications for our values are futile, the main endeavor consists in provisionally accepting a series of values and normative criteria that have emerged and then inquiring into how the different methodological rules help to achieve them.

HOYNINGEN-HUENE: But how can you judge the performance of different sets of methodological rules?

STUDENT: It is only necessary to hypothetically presuppose certain values, often specified with the help of certain performative criteria, and then to investigate the degree to which the explanatory and other scientific activities guided by these rules can fulfil these criteria. Accuracy is such a value which can be further specified in the specific context, say as qualitative or quantitative accuracy, empirical fit, etc., and a critical discussion of certain rules can take place with respect to whether at a certain point of time they are accurate or close to being accurate. However, if accuracy is not accepted as a criterion or epistemic value, then their quality can be judged according to other criteria, such as, for example, beauty.

HOYNINGEN-HUENE: But don't we, in fact, ostracize the domain of values to a relativistic heaven?

STUDENT: No, not at all. Values are not to be viewed as impervious to critical discussion as the positivistic dogma demanded for decades. Nor are they ostracized to an indifferent relativistic universe. Values, as normative principles of the highest generality, can be themselves critically debated. However, the outcomes of such discussions are always of a provisional character, the results of human endeavour themselves, amenable to further debate and criticism. An Archimedean point of departure does not exist in this case; nor does it in any other case. There can just be moments or longer periods of consensus about what are supposed to be the highest virtues of the rules of the game of science, crystallizing the fallible outcomes of the ongoing discussion. There is, to put it differently, no ultimate justification of the rules of science, but a provisional consensus, if at all, about the most general normative standpoints and the highest principles, a consensus amenable to revisions.

HOYNINGEN-HUENE: I would not disagree with that – this is similar to my dimension of critical discourse, with a normative twist.

STUDENT: You said indeed earlier that the term "critical" signifies the goal of probing claims, the term "discourse" signifies the involvement of various members of the community and the term "institutionalized" signifies some sort of social organization and order, hence some sort of systematicity.

HOYNINGEN-HUENE: Indeed.

STUDENT: What I am saying is that systematicity is a less relevant characteristic of science. It is the *appropriate institutionalization of the possibility of criticism* that is vastly more important, I think. Since it offers the means to facilitate the correction of errors when scientific problem solving activities are taking place. The anchoring of the freedom of criticism in the institutional framework of society is the *collective* condition that must prevail and enables procedural rationality to manifest itself.

HOYNINGEN-HUENE: I see.

STUDENT: Scientific explanatory activities unfold within the intricate institutional framework of modern science. It is a historical contingency that the informal and formal institutions of modern science have come to prevail in a long evolutionary process in the West. On the one hand the *informal institutions* encapsulating the critical tradition coming from Ancient Greek philosophy weakened in the course of many centuries and were revived during the Scientific Revolution; and on the other hand the emergence of *competitive political structures*[20] considerably increased individual freedom, allowing at the same time criticism without pernicious consequences for the critic. In the modern era an intricate institutional matrix has come to prevail in most parts of the world, which has further cemented the freedom of expression that naturally gives rise to a plurality of opinions and fosters the competition among different views.

HOYNINGEN-HUENE: And of course the gradual historical development of the set of organizational structures characteristic of modern universities is eminently important, as I was mentioning before.

STUDENT: Yes, since they enabled the pooling of a vast array of resources – intellectual and material – dedicated to the constant generation and criticism of solutions to abstract theoretical and practical problems.

HOYNINGEN-HUENE: But in the end, what differentiates scientific activities from other activities unfolding in ordinary life?

STUDENT: Scientific activities are embedded in these broader normative structures of the modern world, as I said. What appears to distinguish them from the other activities unfolding in ordinary life (including the religious ones) is *the possibility of criticism,* the criticism which is enabled by social and cultural arrangements as they are encapsulated in the institutional framework of science. This framework acts as a corrective to the error prone problem-solving activities in which scientists, like ordinary people, are engaged; the errors range from fallacious mental models that do not give an accurate representation of the environment to fallacious inferences (including confirmation biases, erroneous probabilistic calculations and much more).

HOYNINGEN-HUENE: Do you mean that it is the institutions of science that permit scientists to circumvent their inherent cognitive limitations?

STUDENT: Yes. Scientists can get around some of their cognitive limitations when unfolding their activities within the institutions of modern science. Professional associations by organizing professional meetings, for example, provide fora for the criticism of theoretical views and empirical findings by experts. Journals provide public arenas, external media, where the collective product of an international community of scholars, motivated by prestige, fame or wealth, can be published, codified and undergo refinement over the longer term, that is beyond the life-span of single individuals. This collective outcome is produced by inquirers criticizing each other's work, largely under conditions of anonymity, a process that bestows on it a high level of epistemic trustworthiness. So, institutions like these ones ensure that the collective outcome of the endeavors of fallible inquirers engaging in their activities guided by different motives is to a great degree epistemically more reliable than the collective outcomes produced by individuals acting in different institutional settings.

HOYNINGEN-HUENE: Such as for example?

STUDENT: Such as within the institutional framework regulating religious sects, for example.

HOYNINGEN-HUENE: I certainly agree with that.

STUDENT: It is by developing a *cognitive-institutional view of scientific rationality* that we will gain better insights into science, I think. The key element is the *criticism* that is possible in the scientific enterprise, which is more extended because of the prevalence of the *liberal dimension* in which scientists usually find themselves operating, which for its part is due to the institutional framework in place. Of course, we need to learn more about the concrete ways that the institutional framework must be formed so that we can succeed in eliminating errors. The fundamental objective, thus, is to study the scientific mind and its institutional environment in tandem: scientific reason is not only in the mind, but also in the world. But here we are. This is the old building of the modern University of Athens at the end of the ὁδόν θεωρίας.

ENDNOTES

[1] The views of Hoyningen-Huene on the nature of science are drawn freely from his book *Systematicity*. When Hoyningen-Huene or the student are quoting or discussing views from other authors, then an endnote with the respective reference is provided.
[2] Einstein (1936/1982, p. 290).
[3] Howell and Prevenier (2001, p. 2).
[4] Newton (1730/1952, Query 31).
[5] See Ball (1919, p. 418).
[6] Darwin (1859/1964).
[7] Goethe (1802, p. 70): "He who would do great things, must display restraint; The master shows himself first in confinement". (English translation).
[8] Wittgenstein (1953/1958, § 67): "[W]e extend our concept of [science] as in spinning a thread we twist fibre on fibre. And the strength of the thread does not reside in the fact that some one fibre runs through its whole length, but in the overlapping of many fibres".
[9] Popper (1963/1989, p. 67).
[10] Plato, Theaetetus (section 155d).
[11] Popper (1963/1989, p. 71f.)
[12] Howson and Urbach (2006).
[13] Friedman (2001, 2002).
[14] Kitcher (1993, 2001), Longino (1990, 2002, 2013).
[15] Carrier and Nordmann (2011).
[16] Neurath (1932/1933, p. 206): "Like sailors we are, who must rebuild their ship upon the open sea, never able to dismantle it in dry dock or to reconstruct it there from the best materials". (English translation).
[17] Sextus Empiricus, Outlines of Pyrrhonism (Book 1, ch. IE´).
[18] Albert (1968/1985, p. 18f.)
[19] Chang (2012).
[20] Jones (2003), Bernholz et al. (1998).

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