What is General Philosophy of Science?

Stathis Psillos
Dept of Philosophy and History of Science
University of Athens,
University Campus
15771 Athens,
Greece

> The one monster called SCIENCE that speaks with a single voice is a paste job constructed by propagandists, reductionists and educators (Paul Feyerabend 2011, 56)

> The era of great constructive programs, in which philosophy might hope to systematize and organise all knowledge, is past and gone. But the demand for synthesis and synopsis, for survey and comprehensive view, continues as before, and only by this sort of systematic review can a true historical understanding of the individual developments of knowledge be attained. (Ernst Cassirer 1950, 19)

The very idea of a *general philosophy of science* relies on the assumption that there is this thing called science—as opposed to the various individual sciences. Indeed, unless we take the view that the various individual sciences do not share anything interesting in common in virtue of which they are *sciences*, there must be something like *science in general*. But what exactly is it? And what aspects or features of it lend themselves to philosophical theorising and investigation?

We are all enlightened now! We have taken to heart that the search for necessary and sufficient conditions for something being science is futile. But at least some of us want to resist two current tendencies. The first is the *replacement* of general philosophy of science by the philosophy of the individual sciences. The second—extreme though it is—is the outright *denial* that there is an area of culture, viz., *science*, with a special relation to rationality and objectivity and/or a special claim to knowledge of the world.

In this programmatic piece I will try to make a case for the claim that general philosophy of science is the philosophy of *science in general* or science *as such*. Part of my narrative will make use of history, for two reasons. First, general philosophy of science is itself characterised by an intellectual tradition which aimed to develop a coherent philosophical view of science, *qua* a part of culture with distinctive epistemic features and a distinctive relation to reality. I firmly locate myself within this tradition. But, second, this tradition went through some important conceptual shifts which re-oriented it and made it more sensitive to the actual development of science itself. The historical narrative will focus on three such moments: the defining moment, associated with Aristotle, and two major conceptual turns, related to Kant and Duhem. The pressures on the very idea of a general philosophy of science that followed the collapse of the macro-models of science that became popular in the 1960s, the pressures that lay all of the emphasis on fragmentation and not on integration, can be dealt with, I will suggest, by a new synthesis within general philosophy of science of the constitutive and the historical, in light of the intellectual tradition that has defined it.[1]

I.

I take Aristotle's *Posterior Analytics* to be the birth-certificate of general philosophy of science. This is because Aristotle took it to be the case that there is a mode of knowledge of the world—what he called *episteme*—which is special precisely because it requires a special method for its achievement. But it is also because Aristotle took it that *episteme* (scientific knowledge) requires a view of (and is grounded on) the deep structure of the world, though the investigation the deep structure of the world had also an independent ontological motivation.[2] Aristotle set in motion what we now take it to be an epistemology of science as well as a metaphysics of science. *Episteme*, for Aristotle, is special because it is connected with understanding the reason why things are as they are, where this reason is itself understood as the cause (*aitia*) of the way things are. Accordingly, science—*qua* a special mode of knowledge—is tied to explanation and in particular to a certain mode of explanation which satisfies two demands: a) it captures causes; and b) it is presented as a(n) (asymmetric) demonstrative argument (a deductive syllogism), which is taken to capture the necessity by which the causes bring about their effects. This epistemology was taken to fit with a certain essentialist view of the way the world is: causal explanation is explanation in terms of essences and essential properties, where "the essence of a thing is what it is said to be in respect of itself" (1029b14). There need not be anything very fanciful in this talk about essences—at least for Aristotle. They are posited to distinguish between those properties that are explanatorily basic and those that are not. His key move was in the thought that the way scientific knowledge is structured should reflect the way the world is structured. But it was equally in the thought that scientific knowledge should exhibit unity: it should be organised into a unified theorietical scheme, whose axioms are first principles, being "true and primary and immediate, and more known than and prior to and causes of the conclusion" (71b19-25).

This is a two-dimensional framework for doing *general philosophy of science*. To put it in modern terms, *general* philosophy of science should be dealing—at least primarily—with two broad and general issues: what makes scientific knowledge distinctive (assuming that it is possible, of course) and what the deeper structure of the world is like (assuming that it has a deeper structure). The two assumptions in brackets are very important. Aristotle took them for granted. Subsequently, they formed the 'battle-field', as Kant put it, of endless philosophical and scientific controversies, which shaped the way the two-dimensional framework of general

[1] Very many thanks to Theodore Arabatzis, Hans Radder and two anonymous readers for useful comments. This piece may best be read in conjunction with my (2006, 2008 & 2011), which offer a lot of the historical and conceptual details. My historical narrative is not meant to be either complete or neutral. Admittedly, it is sketchy, selective, evaluative and written from my own point of view.

[2] I mean: Aristotle defined also a *sui generis* enterprise (what he called first philosophy or first science) which aimed to untie intellectual knots (what he called *aporiai*—puzzles or problems) concerning the being *qua* being, that is the transcategorial attributes of being. This enterprise does not answer the question 'What is there?' by offering (at least in the first instance) a complete description of the kinds of things there are. Rather, it deals with the prior issue of what it is for something to be (as well as with how we might go about dealing with this issue). This kind of enterprise (see *Metaphysics*, book III) is self-standing in that the metaphysical *aporiai* that motivate it and define it (as well as their solutions) lie within metaphysics; their source are the things themselves: the way things are.

philosophy of science was developed and extended. The framework for doing general philosophy of science that Aristotle bequeathed to posterity could be defended or questioned, but it could hardly be neglected.

Taking seriously the Aristotelian framework for general philosophy of science did not require commitment to the Aristotelian science—especially as this was displayed in his *Physics*. Nor—it was realised—did it require adopting the *specific* Aristotelian (essentialist) metaphysics and (deductivist) epistemology of science. This double separation was a key moment in the development of the intellectual tradition of general philosophy of science. It made possible the detachment of genuine philosophical concerns about *science in general* from commitments to particular scientific theories or points of view. It also made possible the proliferation of philosophical views about science and its method, which, as a rule, were shaping the emerging scientific image of the world. The post-Aristotelian science of the 17th century brought with it the need to be subjected to the kind of philosophical examination recommended by the two-dimensional Aristotelian framework: what is so special about it *qua* scientific knowledge and what is the world like for this knowledge to be possible? General philosophy of science, as Cassirer (1950, 11) put it, had thereby "an independent and distinctive role to play in erecting the structure of scientific knowledge".

II.

The split within the framework for doing general philosophy of science that characterised the seventeenth century—the split between empiricism and rationalism—won't concern me here. What's important for my narrative is the following. By the time Hume expressed his scepticism about the possibility of *episteme*, thereby shifting the terrain for general philosophy of science from justification to description, there was a new grand scientific theory available: Newton's. The new theory brought into sharp relief the two-dimensional framework for doing general philosophy of science. On the one hand, there were genuine conceptual difficulties that had to do with the structure of the world as described by Newton's theory—the most central being the nature of space and time and the very possibility of action-at-a-distance. Philosophy was called in, so to speak, to clean up the conceptual mess produced by a novel scientific theory. On the other hand, there was urgent need to ground the very possibility of *episteme*, as this was encapsulated in Newton's theory. The inherited two-dimensional framework for doing *general* philosophy of science was now shaped by a *particular* (though fundamental) theory. Newton's theory became the test-case for the very prospects of general philosophy of science. It was in this context that Kant acted as "the philosophical systematiser of the Newtonian natural science", as Cassirer (1911, 355) put it.

In *Metaphysical Foundations of Natural Science* (1786), Kant took as the task of the metaphysics of nature to show that the synthetic a priori principles of pure natural science are necessary for the very possibility of science in general. Though the a priori source of the universal laws of nature were the transcendental principles of pure understanding—which constitute the object of knowledge in general—these transcendental principles make no reference to any experienceable objects in particular. Kant claimed that these principles could be concretised in the form of mathematical laws of matter in motion. It is no accident, of course, that Kant's laws, which determine the pure and formal structure of motion, where motion is treated purely mathematically *in abstracto*, are akin to Newton's laws of motion. Kant's metaphysical foundations of (the possibility of) matter in motion were precisely meant to show how *Newtonian science* was possible.

This distinctively epistemological a priori justification of the possibility of *episteme* came with a penalty: there cannot possibly be (scientific) knowledge of the world *as it is in itself*. Hence, the special non-inductive, transcendental, method of getting knowledge that could nonetheless yield unconditional generality and certainty can only apply to the phenomena, and this because its products (the general principles of pure science) are partly constitutive of the phenomena. There is no guarantee, however, that the world (as it is in itself!) will co-operate with the thus produced and justified synthetic a priori principles. Far from being unique, indispensable and unrevisable, Kant's own framework for science came to grief by developments in the formal and empirical sciences—notably the development of non-Euclidean geometries and the General Theory of Relativity.

Despite all this, in Kant's hands, the two-dimensional framework of general philosophy of science underwent an important conceptual shift. The metaphysical dimension of the received Aristotelian way of doing general philosophy of science was downplayed. Kant's own understanding of the metaphysics of science was in sharp contrast with that of his predecessors: metaphysics, Kant thought, was the science of synthetic a priori judgements. There was no longer an insight into the deep structure of the world *as it is in itself*. The epistemological dimension of the received Aristotelian way of doing general philosophy of science was re-shaped: the way scientific knowledge is structured should not necessarily (in fact it cannot and does not) represent the way the world is structured, since it is partly constituted by the way the mind is structured. Still, Kant, like Aristotle, laid emphasis on the regulative idea of the unity of *episteme*: it is this systematic unity of scientific knowledge that shifts it from being "a mere contingent aggregate" to being "a system connected according to necessary laws". This "systematic unity of knowledge" is "*the criterion of the truth* of its rules" (A647/675).

III.

After Kant, as Cassirer (1911, 355) put it, no-one seriously doubted that "the sciences, in particular, mathematics and the exact sciences furnish the criticism of knowledge with its essential material". But Kant had tied the prospects of general philosophy of science *too* closely with the prospects of an individual (even if fundamental) theory. The very failure of the categorical framework and the a priori forms of pure intuition that Kant took for granted (embodied in Newtonian mechanics and Euclidian Geometry) made it vividly clear that that general philosophy of science should not tie its overall approach to the metaphysics and epistemology of science with any *particular* scientific theory.

Yet, if we take Kant's lesson to heart (as his great successors did), philosophy of science could still raise the general issue of how scientific knowledge is related to experience and what role constitutive—though revisable—principles play in the constitution of the object of scientific knowledge. General philosophy of science after Kant was tied to viewing *science in general* as being in the process of continuous development, in the sense of denying that there is a fixed and immutable set of principles that make scientific knowledge possible and distinctive and constitute its object. Actual theories—embodying distinct and separate constitutive principles—might come and go, but it is still the job of general philosophy of science to settle the issue of the relation between the 'rational' and the 'factual'. This renegotiation of the role of a priori and a posteriori elements in science and its method shaped the golden era of general philosophy of science, which can be found in the fusion (in Continental Europe) of two views about *science in general*: the thought (expressed by Poincaré) that the spontaneity of understanding finds its locus in the free choice of conventions which determine (at least partly) the content of scientific theories (without, however, the conventions being either arbitrary or totally cut off from experience); and the thought (expressed by the members of the Vienna Circle) that the newly developed formal logic and probability theory can provide the tools for a formalisation and explication of key scientific concepts and, more importantly, for an account of how theories are confirmed, and hence are rationally licensed, by evidence.

The two-dimensional framework for doing *general philosophy of science* was marked by neo-Kantian elements. The metaphysics of science was (further) downplayed; metaphysics itself ended up being meaningless precisely because it transgresses the bounds of meaningful discourse captured by logic, mathematics and science. The epistemology of science was further inflated. It inherited from Kant the search for constitutive a priori principles as well as the task of an explication of existing scientific theories (as in the case of Einstein's theories of relativity); but it was set into a new logical framework in which it was conceived as logic of science, focused on the logical analysis of the language of science.

IV.

In the midst of the neo-Kantian turn, a thought matured that was shared neither by Kant nor by the Logical Positivists, viz., that science has a history and that general philosophy of science should give a role to this history and perhaps even devise a certain 'historical method' to address issues in the epistemology of science. This kind of shift is found in Duhem's *Aim and Structure of Physical Theory* (1906)—though there are elements of it in Poincaré too.

Duhem argued for what he called the "autonomy" of physics which was supposed to rest on the fact that physics does not aim to explain the phenomena, nor to describe the reality 'beneath' them: it only aims to embed descriptions of the phenomena in a unified and comprehensive mathematical framework. Metaphysics was taken to be bound up with any attempt to offer explanation by postulation—that is, explanation in terms of unobservable entities and mechanisms. The autonomy of science from metaphysics, Duhem thought, is secured by advancing and defending a certain instrumentalist view of science. A popular claim made repeatedly against him was that his approach to science was 'too positivistic': if all that science offers is a classification of experimental laws, it is left totally mysterious why it is something to be valued at all. Duhem did borrow from Kant the idea of the unity of scientific representation and defended the aim of a unified organisation of the experimental laws, but the objection was still in the air that this move is not enough to explain why science is anything more than a convenient scheme for classification.

His considered answer to the problem of the value of science—which was motivated, at least partly, by his religious commitments—was in the idea that as science progresses, it tends towards a natural classification of experimental laws, that is a classification which would present "an order which would be the very expression of the metaphysical relations that the essences that cause the laws have among themselves" (1893, 68). Unification is valued because it is a means to an end, the end being approaching what Duhem calls "the perfect theory", viz., the theory which, *qua* natural classification, would amount to " the complete and adequate metaphysical explanation of material things" (ibid.).

There are many interesting points that could be made here, but the most pertinent for my narrative is this. Duhem conceives of *science in general* as a deeply historical process and turns to history to ground its objectivity and claim to knowledge. This, I claim, is a major conceptual turn in tradition I have tried to characterise. The static Kantian conception of the (synthetic a priori) principles of science is replaced by a historical conception. By the same token, the dynamic conception of principles—what came to be known as relativised a priori principles—of Poincaré and the Logical Positivists is put in a firmly historical context. History, then, becomes part of the fabric of *general philosophy of science*. This is what Duhem highlights when he talks about "the importance in physics of the historical method". [3]

> The legitimate, sure, and fruitful method of preparing a student to receive a physical hypothesis is the historical method. To retrace the transformations through which the empirical matter accrued while the theoretical form was first sketched; to describe the long collaboration by means of which common sense and deductive logic analysed this matter and modelled that form until one was exactly adapted to the other; that is the best way, surely even the only way, to give to those studying physics a correct and clear view of the very complex and living organization of this science.

The historical method—the historical investigation of the conceptual processes that led to an adaptation between matter (empirical laws) and form (mathematics)—was taken to be an essential way to do philosophy of science.[4] This is because the historical point-of-view unravels the constitutive interplay between empirical-factual investigations and mathematical-formal frameworks in the development of scientific theories. It would not be too much off the mark to say that for Duhem, the historical method shows the dynamic connection between a posteriori (empirical) and a priori (mathematical) elements in science, a connection which is revealed, amidst the change of theories, in the continuity there is in the mathematical form in which the empirical facts are embedded.

Both enterprises that shaped *general philosophy of science* (the epistemology of science and the metaphysics of science) are historicized. Duhem turns to history (and not to transcendental arguments) to ground the objectivity of science and the distinctive character of scientific knowledge. History acts as a guide to our epistemic attitude towards science (and scientific knowledge, in particular): it warns us against dogmatism and scepticism. Duhem sees in the history of science a mixture of continuity and rupture in theoretical change and takes it that part of the role of history is to teach humility when it comes to the cognitive aspirations of science, since many attempted theoretical explanations were later on abandoned; but at the same time, to ground some kind of epistemic optimism, based on the pattern of formal *and* material continuity in theory-change. The metaphysics of science too becomes the investigation of the historical development that leads to a unified scientific image of the world.

V.

Duhem tied his historical turn to a certain historiography of science, viz. one that stressed the elements of continuity and rejected the view of theory-change as the way Athena emerging fully armed from Zeus's head. Hence, he was using history as a

---

[3] Duhem presented this method, in the first instance, as a method in science education. But it should be clear he also meant it as a more general method for the study of science.

[4] As he put it: "to give the history of a physical principle is at the same time to make a logical analysis of it" (1906, 269).

guide to the future: as a way to show how there can be revolutions without incommensurability; how the physics of each epoch "is nourished" by past physics and "is pregnant with the physics of the future" (ibid.). This gradualist conception of science was heavily contested when Duhem's historical approach to philosophy of science was re-invented in the 1960s. When Thomas Kuhn pleaded for 'a role of history' in the introductory chapter of *The Structure of Scientific Revolutions*, he was fully aware that history did already have a role—especially among the French *epistemologists*. So, his plea was for a *new* role for history, and in particular one that was based on the rejection of the cumulative-developmental model of science.

There is, certainly, a way in which history was assigned a *new* role within general philosophy of science and this was related to the structure and the testing of the macro-models of scientific growth that became popular in the 1960s and 1970s. Models of scientific growth, such as Kuhn's and Lakatos's, presented the unit of scientific appraisal (the scientific paradigm, the scientific research programme) as an evolving dynamic structure that follows a rather tight historical pattern. Kuhn emphasised both the element of historical tradition that characterises normal science (seen primarily as a rule-governed—or exemplar governed—activity) as well as the element of change that characterises revolutionary episodes (seen primarily as an abrupt change not-fully-accounted-for in terms of reason and evidence). Lakatos stressed the element of continuity and looked for clear-cut criteria of progressiveness in the transition from one research programme to another, which could underpin a notion of developmental rationality of science. But both took issue with a conception of science in general which had taken it to be subject to rules by means of which theories are appraised (e.g., a formal system of inductive logic and degrees of confirmation). And both took it that their macro-models of science reflected—and hence were licensed by—the actual *historical* development and succession of scientific theories.

It was precisely the generality and context-insensitivity of these history-oriented macro-models of science that led to their disrepute. One reaction that became prominent in the 1970s was that the individual sciences are not similar enough to be lumped together under the mould of a grand unified scheme of how science works. Leaving behind macro-models of science, philosophers of science started to look into the micro-structure of individual sciences. Part of the motivation for this shift had to do with the critique and the subsequent collapse of simple-minded reductive and hierarchical accounts of how science was ordered. Diversity became the name of the game. Unity was taken to be *almost* reactionary!

The ensuing Kuhnian wars that shaped much of general philosophy of science had a deep impact on both the metaphysics and epistemology of science. A notable irony was that the emerging epistemological relativism was related to Kuhn's flirting with neo-Kantianism. A Kant-inspired distinction between the world-in-itself, which is epistemically inaccessible to scientists, and the phenomenal world, which is constituted by the scientific paradigm's concepts and categories, and is therefore epistemically accessible to scientists, was set on wheels, since Kuhn took it that there was a plurality of phenomenal worlds, each being dependent on, or constituted by, some scientific community's paradigm—and, of course, no way to tell which of them cuts nature at its joints. The emerging credo—associated with social constructivism—was that a philosophical view of science could (and should) be dissociated from attributing to science any special cognitive status; any claim to objective truth; and any license to tell us what the world is like. The world was well lost and with it went any cognitive privilege that science was supposed to have.

It was in this precise context that general philosophy of science—with its concerted focus on well-known issues of the epistemology and metaphysics of science such as scientific realism, normative naturalism, theories of confirmation, rationality in theory-change and the like—aimed to defend its own intellectual heritage by raising a dam against the onslaught of relativism and constructivism.

VI.

The way forward, as I see it, is the defence and advancement of the autonomy of general philosophy of science by means of a new synthesis within the two-dimensional framework for doing general philosophy of science of the two major conceptual shifts noted above: let's call them the constitutive and the historical. We need a fresh perspective on *general philosophy of science*; but don't we, first of all, need a fresh conception of *science in general*?

We may well think of the various sciences as possessing historical essences—along the lines in which species are said to possess historical essences. Part of the reason that led to the development of this view in the philosophy of biology was that traditional accounts of essentialism failed to do justice to the complexity of species—there are simply no necessary and sufficient condition for species-membership. At the same time, however, species present a unity which suggests that perhaps there was some kernel of truth in the traditional essentialist conceptions. But essences need not be sets of intrinsic properties; they can be historical in that they specify a genealogical nexus such that a certain entity is a node of this nexus. The essence of the species *is* simply this historically conditioned network of relations among its members. This is a "unity of descent" as Charles Darwin put it. Defenders of this view, however, argue that it is consistent with this historical essentialism that there are important similarities (e.g., genetic factors) among the members of the species. Some go as far as to argue that there can be homeostatic property clusters that ground these similarities. But they insist that a) these need not be (and in almost all cases are not) shared by all and only the members of the species; and b) they do not constitute an intrinsic essence (at least as traditionally understood) which explains species-membership. In analogy with this, we may well think of the various sciences (as they have actually and historically been individuated) as having historical essences. The key thought here would be that what constitutes a science is a genealogical nexus of theories (and perhaps practices). The various sciences then can be taken to be species of a genus: *science in general*.

There is an advantage in viewing *science in general* this way. It is now commonplace that there are important diversities among the various sciences and that none of the criteria or the macro-models that have been used to characterise science can capture (or explain away) this diversity. The conception noted above allows philosophers of science to accommodate and study the diversity. But at the same time, it is true that there is enough unity among each individual science to count as a separate science (having, I'd suggest, its own historical essence) and enough unity among the various sciences (despite their distinct historical essences) to count as being members of the same genus: *science*. The (similarity-based) unity of the genus does not seem to warrant the conclusion that there is a genus essence—even a nominal one. Nonetheless, the members of the genus have important methodological and conceptual similarities among each other, the most significant of which, I think, go back to the two Aristotelian requirements we started which, viz., a special claim to knowledge and a special relation to reality.[5] If we think of science as a genus, we—general philosophers of science—do not have the option not to address issues in the metaphysics and epistemology of science. Science *as such* is a theoretical abstraction and general philosophy of science is the laboratory of this theoretical abstraction.

Whatever else it does, science aims to tell us something about the world at large (including the biological world, the social world etc.) and what it does tell us about the world at large is constrained and/or guided by the way the world is. With a bow to Aristotle, science is a distinctive cognitive enterprise whose epistemic credentials are a function of its reliance on certain methods, including the search of a unified and coherent image of the world. With a bow to Kant, the connection of science to the world is not 'uncontaminated' by the spontaneity of the understanding and its conceptual categories, especially as these are expressed in the use of mathematics in science. With a bow to Duhem, what science tells us about the world, as well as the reasons to take what it tells us seriously, are issues that are determined historically, by looking at the patterns of convergence in the scientific image of the world.

The relation of science to reality, the credentials of scientific knowledge, the deep structure of the world as it is described by science and the very possibility of a unified (but not necessarily reductive) account of it are not issues that can be successfully dealt with at the level of individual sciences. This is not to imply that the philosophies of the individual sciences cannot have useful input on these issues. But, by focusing on aspects or layers of reality, they lack the conceptual resources and the power of abstraction that are required for a more global perspective on reality—for seeing the whole picture. Putting together the scientific image of the world, looking at the various interconnections among the 'partial' images generated by the individual sciences, and clearing up tensions and conflicts is precisely the kind of job that general philosophy of science is meant to do. To put it in Sellarsian terms, general philosophy of science offers the space in which the various images of the world provided by the individual sciences are fused together into a stereoscopic view of reality. Why, one may ask, is this more stereoscopic view of reality required? Because, ultimately, the world is one and we want to have a view of it that is as coherent, unified and complete as possible, though not necessarily reductive.

This search for a stereoscopic view of reality is particularly important when it comes to the metaphysics of nature. Given the current inflation of metaphysics in general philosophy of science, there is a genuine demand that it be suitably connected with the scientific image of the world. There are serious obstacles to overcome. No particular science, let alone a particular scientific theory, can yield general metaphysical conclusions. Each science has its own specific and particular subject matter, whereas the object of the metaphysics of nature is general and domain-independent: it concerns the fundamental deep structure (or building blocks) of reality as a whole, abstracting away from its specific scientific descriptions. But if the metaphysics of nature is fully disconnected from the particular images of the world as they are offered by the various sciences, it ends up being an illegitimate free-floater, whose justification is up for grabs. This tension can be overcome within general philosophy of science which can provide the space for an examination of the

[5] One might wonder: is the first requirement of the Aristotelian framework not enough to have a general philosophy of science? My answer is negative for two reasons. The first is historical and has to do with the kind of tradition that has shaped general philosophy of science. The second is conceptual: the special claim to knowledge is special precisely because, and to the extent in which, science does have a special relation to reality.

possibility of a unified account of the actual deep structure of reality by generalisation over, and abstraction from, the perspectives on reality offered by the various sciences.

After Kant, we know that we need to abstract away, as far as possible, from the individual sciences and scientific theories and to investigate the prospects of a scientific image of the world as a whole: its scope and its structure. We know also that we need to figure out what part of the scientific image of the world is up to us, what part is due to nature and how the two parts are related to each other. But after Duhem, we know that history should be accorded the role it ought to have in understanding the scope and structure of the scientific image. History is able to free us from searching the illusory view from nowhere in putting together the scientific image. But it can also give us a sense of connectedness and continuity within this growing and ever-changing image. Hence, it can help us construct the stereoscopic view of reality that science offers without losing sight of the issue of how theory, experience and observation are related to reality.

General philosophy of science has to deal with abstractions so that it remains *general*, that is, able to cover—or be relevant to—the various individual sciences and to inform the particular philosophical endeavours. The abstractions still involve the examination of the relations between mathematical frameworks and empirical reality; the role of experience and of convention in the specification of the object of scientific knowledge; the grounding of rationality and objectivity of science; the relation of theory to evidence and the modes and means of scientific representation. But their investigation has to be historically informed and grounded. General philosophy of science examines the abstract forms of science to which history adds the matter. In my view, the historical-cum-conceptual form that the scientific realism debate has taken in the last twenty years is a good example of this interplay between the abstract and the concrete.

General philosophy of science—being itself rooted in a long intellectual tradition with elements of continuity and change—help us not lose sight of the wood for the trees, which is that *science in general* is by far the best way we humans have invented to push back the frontiers of ignorance and error; how this is possible, and how and to what extent science has actually moved through history to achieve it are two major issues worthy of serious philosophical attention.

References

Aristotle. *Posterior analytics*. Second edition 1993. Oxford: Clarendon Press.

Cassirer, Ernst. 1911. *Substance and function*. William Curtis Swabey & Mary Collins Swabey (trans.) Chicago: Open Court.

Cassirer, Ernst. 1950. *The problem of knowledge: Philosophy, science, and history since Hegel*. William Woglom & Charles Hendel (trans.) New Haven: Yale University Press.

Duhem, Pierre. 1893. Physics and metaphysics. In R. Ariew & P. Barker (eds.) *Pierre Duhem: Essays in the history and philosophy of science*. (1996), Indianapolis: Hackett.

Duhem, Pierre. 1906. *The aim and structure of physical theory*. P Wiener trans.). Princeton: Princeton University Press.

Feyerabend, Paul. 2011. *The tyranny of science*. London: Polity Press

Kant, Immanuel. 1786. *Metaphysical foundations of natural science*. (James Ellington trans.) Indianapolis and New York: The Bobbs-Merrill Company, INC..

Psillos, Stathis. 2006. Philosophy of science, history of. In Donald Borchert ed.

Encyclopedia of philosophy, 2nd edition. volume 7. Detroit: Macmillan Reference USA. pp. 503-516.
Psillos, Stathis. 2008. Philosophy of science. In Dermot Moran (ed.) *The Routledge companion to the 20th century philosophy*. London: Routledge, pp. 618-657.
Psillos, Stathis. 2011. Scientific realism with a Humean face. In Juha Saatsi & Steven French (eds) *The Continuum companion to philosophy of science*. London: Continuum, pp. 75-95.