Science and Realism: The Legacy of Duhem and Meyerson in Contemporary American Philosophy of Science

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Anglo-American epistemology has long recognized its debt to Pierre Duhem: most notably in the so-called "Duhem–Quine" thesis that has been at the center of debates over empiricism and realism. These debates began with the Vienna Circle and have continued through the development of a more historical reflection on the sciences. This development is still ongoing, as can be seen in Hilary Putnam's work on realism. The most prominent figures in this movement of inheritance of Duhem's work, as well as the most controversial, are Kuhn and Feyerabend. But this change in American philosophy of science since, say, the sixties may also draw our attention to another influence, less visible than Duhem's, but just as important: that of Emile Meyerson. One finds references to Meyerson in writings by both Quine and Kuhn. Kuhn, in particular, has explicitly recognized his debt to the author of *Identity and Reality*. In an interview in the French newspaper *Le Monde*,[1] he noted that he had, in philosophy, three major influences, apart from his contemporary, Quine: Duhem (for his *Aim and Structure of Physical Theory*), Meyerson (for *Identity and Reality*), and Koyré, who was responsible for the direct transmission of Meyerson's work to the U.S. Kuhn also recalled that it was Popper himself who advised him to read *Identity and Reality*, a work that proved decisive for Kuhn.

These texts, somewhat forgotten in France after the thirties, were not only translated into English very early (*Identity and Reality* appeared in the U.S. in 1930), but were sometimes reprinted in English editions. In its original language, on the other hand, *Identity and Reality* has been unavailable for some time. In examining certain aspects of Meyerson's work, we will attempt to understand why certain French philosophers, though forgotten in France until recently,[2] have been a source of inspiration for several philosophers of science in the United States.

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1 Holism and Ontology

This essay begins from two footnotes of Quine's. The footnotes in question come from an article that made a thunder-clap on the clear sky of analytic philosophy of science in the U.S.: "Two Dogmas of Empiricism", delivered as a lecture in 1950 and published in 1951. Quine, let us recall, was the one who, after a voyage to Europe in the 1930s, had introduced the work of Carnap and the Vienna Circle to American philosophers. In the wake of close collaboration between Quine and Carnap (as their recently published correspondence attests), a uniquely American form of logical positivism became the dominant movement in American philosophy departments. This movement was also encouraged by the forced immigration, in the thirties and forties, of many European philosophers and scientists, including Carnap, Reichenbach, Tarski, Frank, and Hempel. In his 1951 article Quine attacked the foundations of Viennese logical empiricism, namely the analytic/synthetic distinction and reductionism. These two dogmas are, according to Quine, "at root identical", and rest on a shared illusion: the possibility of distinguishing, in an utterance, between what belongs to experience and what belongs to language. In particular Quine singled out the distinctively neo-positivist idea that an utterance has an empirical meaning, and can as such be subject to empirical confirmation or refutation. Let us note that Quine was engaged here with an interpretation of logical empiricism that had become common, rather than with a serious reading of Carnap. It is too little noticed that Quine appeals to the *Aufbau* itself in his refutation of the second dogma.

> My counter-suggestion, issuing essentially from Carnap's doctrine of the physical world in the *Aufbau*, is that our statements about the external world face the tribunal of sense experience not individually but only as a corporate body.[3]

But it is precisely here that we find a reference to Duhem, and not, as is often supposed, to the celebrated paragraphs[4] on refutation and crucial experiment, but rather to the criticism of the Newtonian method.[5]

Quine does not so much take up the detail of Duhem's argument against refutation, but rather the general philosophy of *Physical Theory*, which one also finds in *To Save the Phenomena*, especially the impossibility of conceiving facts independent of all conceptualization. "An experiment in physics", Duhem writes, is:

> quite another matter than the mere observation of a fact […]. What the physicist states as the result of an experiment is not the recital of observed facts, but the interpretation and the transposing of these facts into the ideal, abstract, symbolic world created by the theories he regards as established.[6]

Their certainty, for Duhem, "always remains subordinated to the confidence inspired by a whole group of theories".[7] It is precisely this point, taken up equally by Meyerson – "It is, as Duhem has justly said, impossible to understand the law, impossible to apply it, without performing the work of scientific abstraction, without knowing the theories which it presupposes"[8] – that interests Quine. The testimony of experience, independent of any theoretical context, is a philosophical myth: "Statements, apart from an occasional collectors' item for epistemologists, are connected only deviously with experience".[9] The critique of refutation, and what

we call "Duhem's problem", are a methodological consequence of this philosophical position, a position also adopted by Meyerson.[10] No statement is in itself refutable, because there is no statement that speaks purely of experience (as the protocol sentences of Carnap's *Aufbau* were supposed to do): even statements of experience are *theory-laden*. A recalcitrant experience therefore does not suffice to refute a theory: refutation is not as simple a matter as we might have thought.[11]

Duhem's idea that a negative experience does not require the rejection of a theory is frequently taken up by the post-Popperians. It was also developed in Quine's philosophy of science in the form of his much-discussed epistemological holism. We find a very explicit formulation of Quine's position in the introduction to his textbook *Methods of Logic*:

> Statements close to experience and seemingly verified by the appropriate experiences may occasionally be given up, even by pleading hallucination"[12] This exactly parallels Duhem's remarks: "When the experiment is in disagreement with [the experimenter's] predictions, what he learns is that at least one of [his] hypotheses […] is unacceptable and ought to be modified; but the experiment does not designate which one should be changed.[13]

We can always preserve of a statement *come what may*, Quine concludes. On the other hand – an idea new with Quine – there are no unrevisable statements. Such are the interconnections assured by the logical relations between statements that every statement, even one taken as "central", is vulnerable to a negative experience. Experience can have consequences anywhere in the system. "Reevaluation of some statements entails reevaluation of others, because of their logical interconnections – the logical laws being in turn simply certain further statements of the system, certain further elements of the field".[14] There is thus no privileged place within the conceptual scheme. Any statement, even one occupying a central place in the system, can be put into question. This is so even for logical laws, which, despite their "decisive position", can be revised, if the revision provides a simplification necessary to the survival of the system.

Here again one can cite Duhem: the apparently unchangeable and necessary principles of physics, even those that cannot be directly subject to experiment, can be overturned in the development of science.

> On that day some one of our hypotheses, which taken in isolation defied direct experimental refutation, will crumble with the system it supported under the weight of the contradictions inflicted by reality on the consequences of this system taken as a whole.[15]

Every statement is thus revisable. This is the meaning of the metaphor, favored by Quine and made famous by him, of a "field of forces" representing "the totality of science",[16] where statements confront experience at the periphery yet redistribute consequences to the interior, even to the most distant statements. There is no break between the periphery and the center, only differences of degree of proximity to experience, always provisional and never measurable: this is precisely the point that signaled Quine's break with the Vienna Circle.

Thus we see that holism is, in Quine, a double-edged sword. Any statement can be revised, but, on the other hand, it is equally true that any statement can be preserved. On this point we can cite another passage from *Methods of Logic*:

> Our system of statements has such a thick cushion of indeterminacy, in relation to experience, that vast domains of law can easily be held immune to revision on principle. We can always turn to other quarters of the system when revisions are called for by unexpected experiences.[17]

For Quine this holds not just for physics, but also for logic (though fundamentally revisable, it can be held immune "on principle", because of its central place and also because of the indeterminacy of translation). This unnoticed consequence is nothing but the flip side of holism, or as Quine calls it, the "logical (rather than epistemological) point of view" on holism. For Quine there is no contradiction in this: the revisability of logic goes along with its immunity – these are just two sides of the same coin.

> When some revision of our system of statements is called for, we prefer, other things being equal, a revision which disturbs the system least […] despite the apparent opposition between this priority and the one previously noted, the one involves the other.[18]

It is because a revision is never merely local, but always "systematic", that any revision must reflect choices and decisions according to what Quine calls "priorities". There is no sense in revising the system unless one keeps it open, at each intermediate stage in the history of science, to revisions that will ensure its survival. "Mathematics and logic, central as they are to our conceptual scheme, tend to be accorded such immunity, in view of our conservative preference for revisions which disturb the system least".[19] Nonetheless there are priorities and conditions that decide the place of a hypothesis in the system. Briefly, we choose on a pragmatic basis[20] the change that disturbs the system least, unless a more wide-ranging revision offers other advantages, in particular *simplification*.

It is with reference to Duhem that Quine draws his most "anti-realist" conclusion: physical theory is not an explanation, but a symbolic representation: after recalling Neurath's metaphor of the boat (the philosopher is "a mariner who must rebuild his ship on the open sea"), he adds:

> We can improve our conceptual scheme, our philosophy bit by bit, while continuing to depend on it for support; but we cannot detach ourselves from it and compare it with an unconceptualized reality. Hence it is meaningless, I suggest, to inquire into the absolute correctness of a conceptual scheme as a mirror of reality. Our standard for appraising basic changes of conceptual scheme must be, not a realistic standard of correspondence to reality, but a pragmatic standard.[21]

Quine concludes with an appeal to "conceptual economy" that hearkens back to both Duhem and Mach, recalling also the "pragmatist" tone of "Two Dogmas".[22] The first concern of holism is conservatism, or, to put it more naturalistically, the survival of the conceptual scheme. Transformations of the system, even radical ones, are gradual. Conceptual change, even major change, can be effected without a sharp break. It is simply because a revision is never merely local, but always systematic, that choices must be made. There is no sense in revising the system unless one keeps it open, at each stage in the development of science, to revisions that will maintain its stability. This is also the meaning of Neurath's metaphor: "Our boat stays afloat because at each alteration we keep the bulk of it intact as a going concern".[23]

This Quinean model of the development of science, at once conservative and revolutionary, was in fact sketched out in a metaphor that Duhem uses in *Physical*

Theory: "Physical science is a system that must be taken as a whole; it is an organism in which one part cannot be made to function except when the parts that are most remote from it are called into play, some more so than others, but all to some degree".[24] And it is remarkable that Duhem, in order to illustrate the difficulty of refutation, uses a biological metaphor: a physicist cannot determine the exact place at which his theory has broken down, just as a doctor

> has to guess the seat and cause of the ailment solely by inspecting disorders affecting the whole body […] The watchmaker to whom you give a watch that has stopped separates all the wheelworks and examines them one by one until he finds the part that is defective or broken […] Now the physicist concerned with remedying a limping theory resembles the doctor and not the watchmaker.[25]

This metaphor shows that Duhem's doctrine of continuity is based on a form of epistemological holism that finds its most developed expression in Quine.

From this point of view, if we now return to "Two Dogmas", we will not be surprised to find reference in the text to another French philosopher – Meyerson. Epistemological holism, the impossibility affirmed by Quine of determining the adequacy of our conceptual scheme as a representation of reality, seems little compatible with the frankly ontological philosophy of *Identity and Reality*. How can we, at this point in the discussion, invoke ontology? We might recall that Duhem did not rule out an ontological order:

> Thus, physical theory never gives us the explanation of experimental laws; it never reveals realities hiding under the sensible appearances; but the more complete it becomes, the more we apprehend that the logical order in which theory orders experimental laws is the reflection of an ontological order.[26]

There is indeed a form of realism in Duhem, in his idea that "these theories are not a purely artificial system, but a natural classification".

But it is clear that this is not Quine's position. The idea of "realities hiding under the sensible appearances" is quite far from his approach, precisely because of his interpretation of the ontological problem. Toward the end of "On What There Is", Quine suggests that from a phenomenalist point of view, ontologies that include physical or mathematical objects are "myths".[27] This notion of "myth", which comes back later in "Two Dogmas", has reinforced conventionalist interpretations of Quine: "The myth of physical objects is epistemologically superior to most in that it has proved more efficacious than other myths as a device for working a manageable structure into the flux of experience".[28] Quine famously compared the ontology of physics (not just that of objects, but also, e.g., that of forces – a topic dear to Meyerson) to that of the Homeric gods. There is in this a clearly instrumentalist conception of ontology (this can be traced back to Mach): "physical objects are conceptually imported into the situation as convenient intermediaries, not by definition in terms of experience, but simply as irreducible posits, comparable, epistemologically, to the gods of Homer".[29]

We might wonder, then, how the empiricism of "Two Dogmas" amounts to a criticism of neo-positivist epistemology, since the neo-positivists more or less adopted wholesale Duhem's idea that physical theory was a symbolic representation and a formal system. We can see this in Carnap's *Logical Syntax*: "it is, in general,

impossible to test even a single hypothetical sentence […] Thus *the test applies, at bottom, not to a single hypothesis but to the whole system of physics as a system of hypotheses*".[30] Clearly what is at stake here is not just holism, but realism as well. Quine's references to Meyerson is not merely out of respect or empty, and perhaps Quine is more serious than we suppose when he appropriates the statement from *Identity and Reality* "L'ontologie fait corps avec la science elle même et ne peut en être séparée ["Ontology is part of the body of science itself and cannot be separated from it".][31] Let us look at the context in which this reference appears more closely. Quine affirms the continuity of ontological and natural scientific questions in the essay "On What There Is". The problem of ontology, according to Quine, is not that of knowing what exists, but of knowing the ontological significance of our discourse – of knowing what *we say* exists. Ontology does not, therefore, have for Quine the task of determining what there is. "What is under consideration is not the ontological state of affairs, but the ontological commitments of a discourse".[32] The ontological question is transformed: "But we have moved now to the question of checking not on existence, but on imputations of existence: on what a theory *says exists*".[33] In order to know "what exists", one must look not to ontology, but to science. What exists is what science, as a whole, "says exists". And just as the only possible response to the ontological question is within science, the philosophy of science is identified by Quine with ontology.

One might, to parody a phrase of Wittgenstein's, say that "it is science (not grammar) that tells us what sort of thing something is". The citation from Meyerson therefore announces Quine's naturalism well before "Epistemology Naturalized". According to Quine's naturalism there is no fundamental difference between the task of philosophy and that of science. Ontology is an enlargement and generalization of scientific achievements. On the other hand, Quine suggests, in "Things and their place in Theories" that epistemology is a "methodology of ontology". The work of ontology is no different from the work of science, and participates in the same process of continual systematic revision. The philosopher's task is that of

> making explicit what had been tacit, and precise what had been vague; of exposing and resolving paradoxes, smoothing kinks, lopping off vestigial growths, clearing ontological slums. The philosopher's task differs from the others', then, in detail; but in no such drastic way as those suppose who imagine for the philosopher a vantage point outside the conceptual scheme that he takes in charge.[34]

There are no more privileged objects than there is a privileged science; there is a continuity, from the middle-size objects whose names we learn in first learning language, to the most sophisticated objects of science. "All objects are theoretical". For Quine, the ontology of science, even when it posits objects quite distant from our experience, is an extension of the ontology of common sense, not because the latter is in some way supreme, but because it is already theorized.[35]

Here we find again a connection with Meyerson. The work of science, even in the context of naturalized epistemology, is ontological: as Meyerson had already said, science does not content itself with establishing laws. "Whatever opinion or system one supposes to prevail from a strictly philosophical point of view, one must admit that science itself is and remains a creator of ontologies".[36]

Beginning in *Identity and Reality*, Meyerson affirms that

> the ontological character of scientific explication is ineffaceable […] there is not, there cannot be, in the natural evolution of scientific theories, any phase where ontological reality would disappear, and at the same time the concept of conformity to law remain standing[37]

Meyerson was the first to propose a model of the evolution of science in which ontological change defines scientific change (even if it is governed, as always for Meyerson, by the principle of identity). Moreover, it is these changes of ontology that allow him to describe, in *Identity and Reality* and *Explication in the Sciences*, the conceptual changes made in the history of the sciences. These changes are always motivated by the emergence of a new ontology: "the scientific intellect imperiously demands an ontological reality, and if science did not permit the creation of a new one, it would certainly be powerless to destroy the old one."[38]

There is no ontology independent of or prior to science: from this point of view, Meyerson is paradoxically less of a metaphysician than Duhem, and he prefigures Quine, even if Quine's ontology relativizes and radicalizes Meyerson's. (Quine proposes, in *Theories and Things*, that any ontology can be reinterpreted in the terms of any other via a "proxy function".) The Meyersonian conception of ontology allows Quine, beginning in 1951, to make ontology immanent. This leads in his work to a final dissolution of the "question of transcendence" – that of the adequacy of physical theory to reality, or, as he put it in 1981, "the question whether or in how far our science measures up to the *Ding an sich*."[39] On this point, Quine is far from Meyerson. But it is from Meyerson that he takes the idea of an immanent ontology, which is central for his work beginning with "Two Dogmas". And one might say that it is over this point – realism – and not over holism that he breaks with Carnap.

For Quine, it is not possible that the philosopher take up "a vantage point outside the conceptual scheme that he takes in charge." "There is no such cosmic exile", he concludes in *Word and Object*. Carnap had already said as much in his *Logical Syntax*. But for Quine, ontology, once relativized, is not taken less seriously, and ontological relativity is in no way the dissolution of ontological questions. For Carnap, the question of a theory's ontology is not a theoretical question, but a question that calls for a practical decision about the structure of our language. For Quine, by contrast, the question is more complicated because on his view "our theory of nature grades off from the most concrete fact to speculations about the curvature of space-time […]. Existential quantifications of the philosophical sort belong to the same inclusive theory".[40] General ontological questions, for Quine, are not a matter of language, or of the choice of a "conceptual scheme", any more than ordinary scientific hypotheses are. The essential disagreement between Quine and Carnap is over ontology. Quine recognizes this at the beginning of his essay "On Carnap's Views on Ontology", which was a response to Carnap's article "Empiricism, Semantics, and Ontology". And we have suggested that the break represented by "Two Dogmas" comes not over epistemology but over the status of ontology. In sum, for Quine there is a continuity between talk about experience and talk about things, and ontology cannot be a matter of linguistic decision.

From this point of view, the appeal to Meyerson in *From a Logical Point of View* is paradoxically appropriate, even if Meyerson seems to postulate an independent reality from which science extracts or reconstructs its elements. Meyerson's realism

requires that we take the ontology of science "seriously", while at the same time taking account of the changes of ontology that have occurred in the history of the sciences. This is the only ontology we have at our disposal.

It is because Quine's naturalism shares this approach to ontology that it does not exclude realism, even a "robust realism", as he says in *Theories and Things*. Naturalism is "the recognition that it is within science itself, and not in some prior philosophy, that reality is to be identified and described";[41] it is the "abandonment of the goal of a first philosophy prior to natural science."[42] Even if we do not know whether our theory of the world or our ontology is the best or the only one possible, we must take it to be true. "We continue to take seriously our own particular aggregate science, our own particular world-theory or loose total fabric of quasi-theories, whatever it may be."[43] Truth is *immanent*, and questions of *reality* cannot be posed except from within our system of the world. "There is no extra-theoretical truth". This obviously poses a problem, which we will attempt to clarify. Quine's naturalism, since it incorporates ontological questions into natural science, is a specific form of naturalism (irreducible, among others, to its cognitivist successors and by-products). Its ontological and realistic "theses" (found in the essays "Speaking of Objects" and "Ontological Relativity") are inseparable from a radical skepticism about the possibility of determing a "natural", preconceptual ontology, even by the most refined scientific methods. In a more recent text, Quine writes:

> These reflections on ontology are a salutary reminder that the ultimate data of science are limited to our neural intake, and that the very notion of object, concrete or abstract, is of our own making, along with the rest of natural science and mathematics. It is our overwhelmingly ingenious apparatus for systematizing […] our intake, and we may take pride.[44]

Ontology is "a human option", and the notion of reality "is itself part of the apparatus; and sticks, stones, atoms, quarks, numbers, and classes are all utterly real denizens of an ultimate real world, except insofar as our present science may prove false on further testing."[45]

Is there the same notion of ontology at work in this radical naturalism as there was in the quotation from Meyerson in "Two Dogmas"? Is there, in Meyerson's philosophy of science, the possibility, taken up by Quine, of an ontology immanent in science? The question remains to be posed. But it was probably this idea of Meyerson's, along with his reading of Duhem, that led to the decisive shift in Quine's philosophy and that gave direction to his break with the "dogmas" of logical empiricism, i.e., with those of classical analytic philosophy of science.

2 Philosophy of Science and Realisms

We often, and rightly, consider the shift in American philosophy of science during the years 1960–1980 (initiated by Kuhn, Lakatos, Feyerabend, Putnam, and Hacking) as a break with mainstream philosophy of science based in logical positivism. This shift in philosophy of science had two aspects: a radically new conception of the *nature of science*, and an equally new approach to resolving the problems of

philosophy of science – an approach joined, inevitably, to a redefinition of scientific methodology. In effect, what was put in question during this period was the status of philosophy of science, as a result of the discovery in Anglophone philosophy of the historicity of science. There is here an important rupture, which today certainly might lead, with the benefit of hindsight, to a discussion of the oft-noted differences between two styles of philosophy of science, French and Anglo-American. The connection of these two traditions in the philosophy of science is perhaps not at first so obvious, nor is it clear how they can engage each other in argument. Kuhn's *Structure of Scientific Revolution* was published in the moribund *Encyclopedia of Unified Science*. Yet the return to French philosophy accomplished by Quine during the 50s and subsequently in a different way by Kuhn, Lakatos, and Feyerabend, was not surprising. This return coincided with, or justified, a new anti-positivism, and a questioning of the "dogmas of empricism", Carnap's as well as Popper's, both verificationism and falsificationism.

As Hacking has noted, there is considerable agreement, despite their various differences, between the Logical Empiricists and Popper.

> Popper and Carnap assume that natural science is our best example of rational thought […]. Both think there is a pretty sharp distinction between *observation* and *theory* […]. Both agreed that there is a fundamental difference between the *context of justification* and the *context of discovery* […]; the philosophies of Carnap and Popper are timeless: outside time, outside history.[46]

In order to arrive at Kuhn's philosophy, one need only reject these conclusions one by one: Kuhn's claims (like Feyerabend's, though there are differences), even if they are not always framed in this way, bear exactly on this common body of beliefs shared by Carnap and Popper: "whenever we find two philosophers who line up exactly opposite on a series of half a dozen points, we know that in fact they agree about almost everything. They share an image of science".[47] It is this image that is drawn into question beginning in the 1960s, precisely with instruments of thought inherited from French philosophy of science – notably that of Duhem and Meyerson. This explains the considerable interest we find in their works during this period.[48] It is in Duhem, as we have seen, that we find the first formulation of the dependence of experience on theory, whose immediate consequence, recognized by Quine as well as Kuhn, Feyerabend, and Lakatos, is that there is no demarcation between statements of observation and of theory. This dependence of experience on its conceptual context does away with the myths of refutation and crucial experiment. Lakatos takes up this point in "Falsification and the methodology of scientific research programmes".[49]

Meyerson earlier evokes in *Identity and Reality* "the close dependence of experiments upon scientific theories".[50] And later in the *Cheminement de la pensée* Meyerson wrote:

> However much one tries to stick to facts, no matter how much effort one makes to exclude every hypothesis, ontology cannot be excluded from physics […]. Duhem has indisputably shown that an experiment in physics is not just the observation of a phenomenon, but is rather the theoretical interpretation of this phenomenon and that "the statement of the result of an experiment implies, in general, an act of faith in a whole group of theories."[51]

And here it must be recalled that these theories have as their aim precisely to find out the being of things, their essence, and finally to explain the behaviour of objects in terms of this essence, the disposition of particles, of molecules and atoms in bodies, of electrons in the atom.[52]

It may seem strange at first to see Meyerson appeal to Duhem for purposes contrary to Duhem's own, at least until we look closer: ontology, for Meyerson, is not to be found anywhere except in science ("in terms of this essence, the disposition of particles"). And science cannot perform this work through laws alone, but only by presupposing certain objects (posits, as Quine would say), such as "pure silver […] the mathematical lever, the ideal gas, or the perfect crystal… abstractions created by the theory."[53] For "we only attain laws by violating nature, by isolating more or less artificially a phenomenon from the whole, by checking those influences that would have *falsified* the observation. Thus the law cannot directly express reality."[54] Meyerson continues his "ontological" interpretation of Duhem in chapter XI of *Identity and Reality*:

> Duhem establishes, with great exactness, that only the theoretical interpretation to which phenomena are subjected by the physicist makes possible the use of instruments. He concludes that between phenomena really observed and the result of an experiment formulated by a physicist a very complex intellectual elaboration intervenes.[55]

This argument was reprised by Kuhn and Feyerabend, but Meyerson adds:

> These deductions indicate […] to what a degree the physicist is attached to the concept of *thing* […]. And it is easy to see why it is impossible to state [an] experiment without speaking of [an] hypothesis. This is because the experiment has to do with something created by this latter; and, of course, the statement when formulated will imply an act of faith in a theory, for it will have to do with the object the essence of which is the basis of the hypothesis in question.[56]

Science creates objects, and it is in *positing* the existence of its objects[57] (an expression of Meyerson's that Quine takes over) that it achieves its explications. Clearly Meyerson's concept of explication overlaps with the explication rejected by Duhem. More precisely, Meyerson affirms, through his concept of explication, that it was in vain that Duhem tried to exclude all metaphysics from science: metaphysics, or ontology, is natural, immanent in scientific activity. It is on the basis of this philosophical principle that the thesis of *Identity and Reality* is established, namely the constant role of the principle of identity in different stages in the history of science (through principles such as those of *conservation*). The scientist is engaged in ontology, in "pressing his thought into the ontological mold, in giving to it the form of an hypothesis about the reality of things".[58] He does so without knowing it, like the ordinary man, "comme il respire" (to take up a lovely formulation Meyerson used in *Explication in the Sciences* and quoted by Koyré in his article on Meyerson.[59] In *Explication in the Sciences* Meyerson wrote that "scientists, as soon as they bring atoms and ether into play, implicitly reason as if these were not concepts, but real things"[60] In sum, the scientist has a natural tendency to engage in ontology. Meyerson speaks of "the tendency to create fictitious entities for the purpose of explanation", which is "so strongly rooted in us that it was necessary to put us on guard against it by a special declaration […] the famous 'Ockham's razor'".[61] It is

in this light that we can interpret the central role that the concept of conservation has in Meyerson's work.

> Any statement of conservation tends to give rise to an explanatory theory. That is why when confronted with anything that is said to be conserved and which is at first, of course, only a scientific abstraction […] we feel a sort of irresistible need to hypostasize it ontologically, to transform it into a *being*.[62]

This tendency to posit theoretical objects explains the origin and development of notions such as that of movement or inertia,[63] or simply the transformations of the notion of physical object. In a quite different style, one can recall Quine's Voltairean aphorism: "physical objects, if they did not exist, would […] have had to be invented".[64]

It is clear from this point of view why Meyerson, as well as Duhem, would be cited by anti-positivism in its opposition to the traditional philosophy of science derived from logical empiricism. We sometimes forget that Meyerson read, at the end of his life, not only the work of Moritz Schlick (at Einstein's urging, he read Schlick's writings on relativity[65] , but also the work of the Vienna Circle and the early Wittgenstein, to which he dedicated a note in *Le Cheminement de la pensée.*[66] Meyerson was well aware of the proximity of the Vienna Circle (initially called the Ernst Mach Society) to Mach, and therefore to Comte.[67] In the note, Meyerson expresses surprise that Comte is hardly cited by the Circle. Meyerson is one of the first serious critics of the Viennese tradition, whose theses "on many essential points disagree completely with those [he, Meyerson] presented." It is not at all therefore an accident that Meyerson's critique of positivism reappears later in the post-Popperian critique of neopositivism. What is at stake however, namely realism, is more than just the rejection of positivism, as Meyerson shows in the *Cheminement* by his remarks on Eddington (whose ideas he compares to the realism of Sommerfeld), as well as his lucid critique of both the operationalism of Bridgman and the pragmatism of Dewey.[68]

Meyerson takes up, as we have seen, certain themes from Duhem, but he also connects Duhem with Comte and Mach because of his "phenomenalism": "discussions in physics make no sense if one tries to abandon the assumption that objects exist independent of sensation. The affirmation of the existence of a reality, that never changes".[69] Duhem admired Mach's *Mechanics*, but Meyerson engaged in a radical critique of Mach in all his works. The most remarkable form of this rejection appears in Meyerson's discussion of Einstein in *The Relativistic Deduction* (1924). The special theory of relativity (1905)[70] was frequently imagined to be an illustration of the theses of postivism, and later of logical empiricism.[71] The whole aim of *The Relativistic Deduction*, as the title indicates, is to present, contrary to positivism, a deductive, explicative system that posits the existence of an independent reality. Distinguishing clearly between relativity and relativism, Meyerson notes (citing Kneser):

> The principle of relativity is, as a matter of fact, the principle of the non-relativity of the real; it demands that the reality implied by the observed phenomena of nature remain immutable with respect to possible modifications of viewpoint and system of measurement, that it be, according to the current expression, invariant with respect to the Lorentz transformations.[72]

Meyerson chose Einstein to confirm his thesis in *Identity and Reality*. He saw, in the theory of 1905, and later in the general theory of relativity of 1915, the use of a principle of *identity*, which one might also call in this context a principle of invariance. For Meyerson, relativity theory, which proposes the invariance of laws under the Lorentz transformations, just as Galileo had proposed the invariance of laws under change of point of view (for example, that of a sailor on land and of a sailor on a boat in motion), is much more realistic than pre-Einsteinian theories.[73] As Sommerfeld, who inspired Meyerson, said: the aim of theories of relativity is to find what is *not* relative. Relativity became for Meyerson the very model of a theory that is explicative and ontological.

This point is yet more interesting when we recall that Einstein himself was won over by Meyerson's interpretation. Until the early 1920s, Einstein presented himself (in accordance with numerous interpretations) as a disciple of Mach, even associating his doctrine, at one time, with what he called *Mach's principle*. It is remarkable that Einstein's turn against Mach, well described by Gerald Holton in his essay "Mach, Einstein, and the Search for Reality"[74] occurred at the same time as his first contact with Meyerson. They met in 1922, when Einstein was invited to a meeting of the Société Française de Philosophie, and their discussions continued through the publication of *The Relativistic Deduction* and a review of it by Einstein in the *Revue Philosophique*. Einstein's turn against Mach was apparently strengthened by his reading *The Relativistic Deduction*. During the meeting of the Société, Meyerson presented his critique of Mach, and he made it clear that, on his view, "between Mach's ideas and Einstein's theory there seems to be no truly intimate or necessary connection. One can certainly be an adherent of relativity [theory] while being convinced that no science is possible that does not posit, in the first instance, an object persisting outside of consciousness, and that, as a consequence, science cannot avoid the task of making clear how it conceives this object, through the modifications that the progress of our knowledge imposes on this image. Indeed it seems to me that Einstein's attitude confirms this point of view".[75] One the same occasion Einstein objected to Mach as a philosopher:

> Mach's system studies relations that exist among the data of experience; the totality of these relations is, for Mach, science. But this is a bad point of view: in sum, what Mach did is a catalogue and not a system. Mach was as awful at philosophy as he was good at mechanics.[76]

This surprising claim shows clearly that there is a connection between Meyerson's views and Einstein's move toward realism. If this connection is not one of cause and effect, it is at least one of convergence, Einstein finding in Meyerson terms and arguments appropriate for his rejection of Mach's views.

Meyerson clearly influenced Einstein's philosophical development. One can particularly trace this influence in his correspondence with his friend Michel Besso, a convinced Machian. It is in a 1917 letter to Besso that Einstein first presents his doubts about Mach, in a discussion of a manuscript by Friedrich Adler (physicist, Austrian politician, and translator of Duhem). Regarding Mach's philosophy, Einstein wrote: "It cannot give birth to anything living, it can only exterminate harmful vermin".[77] In a much later letter to Besso (1948), he elaborates on this point, in a tone remarkably reminiscent of Meyerson:

> It is interesting, by the way, that Mach rejected the special relativity theory passionately […]. The theory was, for him, inadmissibly speculative. He did not know that this speculative character belongs also to Newton's mechanics, and to every theory which thought is capable of. There exists only a gradual difference between theories, insofar as the chains of thought from fundamental concepts to empirically verifiable conclusions are of different lengths and complications.[78]

Meanwhile, in a letter to Schlick Einstein seems to change course and follow Meyerson in opposing neopositivism. He reproaches Schlick:

> In general, your presentation does not correspond to my style of thinking, in as much as I find your overall orientation so to speak too positivist […]. I put it to you squarely: physics is an *attempt at the conceptual construction of a model of the real world and its nomological structure* […]. In sum, I object to the failure to clearly separate *the reality of experience and the reality of being*.

One cannot help but notice the similarity between the realist positions defended by Einstein and by Meyerson. This similarity is confirmed if we keep in mind not only relativity theory, but also Meyerson's position on the Copenhagen interpretation of quantum physics. Meyerson's reservations about the latter were, like Einstein's, on ontological grounds: in *Réel et determinisme dans la physique quantique* (1933), he affirms that Bohr and Heisenberg could not have done otherwise than to posit an independent reality: "The quantum physicist, in as much as he is a physicist, certainly thinks as a realist, cannot think otherwise than as a realist".[79] "Quantum physics, like any other physics, presupposes a real outside of me".[80] Phenomenalist interpretations are, for Meyerson, an admission of failure, in fact "a sort of homage paid to the idea of a real explication": "If the least possibility offers itself, we see researchers come back to a concrete image, realizable in thought, a *Weltbild*".[81] Meyerson's thought can thus help us understand the particular brand of realism gradually adopted by Einstein, which one might call, adopting an expression of Putnam's, *natural realism*, or following Arthur Fine, a *natural ontological attitude*. This realism affirms the necessity, presented by Meyerson in *Identity and Reality* and developed in the *Cheminement de la pensée*, of an ontology inherent in science:

> This [ontological] aspiration is entirely supported by science, which, in this respect as in many others, *is nothing but a particular form of philosophy*, but a philosophy necessarily realist, incapable of divesting itself of an ontology.[82]

Einstein, who, in his review of *The Relativistic Deduction*, recognized only that "All science is founded on a realistic philosophical system", went further (and here again we see the influence of Meyerson) in a letter to Schrödinger (1935): "The real problem is that *physics is a kind of metaphysics*; physics describes 'reality'. But we do not know what 'reality' is. *We know it only through physical description*".[83]

The problem here posed goes beyond the context of Einstein's philosophy, as the debates over realism in the late 20th century show: in affirming the connection between science and reality, we hesitate between an immanent ontology and a robust realism that claims this "posited" reality as the only reality. This contradiction, which structures the whole of Quine's work, was formulated by Meyerson in *The Relativistic Deduction*. Meyerson recognized that "Although the Einsteinian physicist, like all physicists, is basically a realist, the very suc-

cess of his deduction leads him to a structure that is just as basically idealistic".[84] Quine, in 1950, taking up in a naturalist vein the phrase "L'ontologie fait corps avec la science elle-même et ne peut être séparée" (In French in Quine's text : "Ontology is part of the body of science itself and cannot be separated from it")[85] and inscribing it in the context of a relativized ontology (it is science that tells us *what exists*) could not but end up with a radicalized form of the duality of realism described by Meyerson. The realist side of Quine, constantly reiterated in his work, applies only locally. The conceptual scheme, "the whole scientific system, ontology and all, is a conceptual bridge made by us". Realism is "robust" because it is immanent to our language and to our understanding of science. The content that we give to the word "reality" is produced by our scientific discourse, and integrated into an "immanent epistemology". This is the limit of Meyerson's influence, and the full radicalism of Quine, who owes to Meyerson even his conception of naturalism.

Meyerson is far from thinking, contrary to Duhem or to certain interpretations of Duhem, that science and its ontology are exempt from testing by experiment. "No one will dream of developing a scientific theory without showing to what extent it is confirmed by experience".[86] It is in the face of recalcitrant experience that changes of theory occur. We find this aspect of Meyerson's philosophy again in Kuhn, who is not really the idealist one often supposes from a cursory reading of *The Structure of Scientific Revolutions*. Kuhn affirms that a change of theory does not occur except when there is a general recognition of difficulties and failures of the current theory, what he calls anomalies.[87] In the essay "Hegel, Hamilton, Hamelin, et le Concept de Cause",[88] Meyerson takes up from this point of view the adage "a theory is no good unless one can show that it is false". He writes:

> This is evident for a scientific theory that accommodates itself to no matter what observations and experiments is a theory that is so flexible and inclusive as to be decrepit; it is useless even from the point of view of the simple prediction of facts, and does not persist even for a moment unless there is no other to put in its place.

Thus Meyerson anticipates, here again, the anti-positivist reactions of Kuhn and Feyerabend. Meyerson, like Duhem, affirms that an isolated experiment cannot suffice to refute a theory; but this is because, for him, a theoretical change is *also* an ontological change. This leads him to formulate a conception of the history of science close to that of Feyerabend, for whom scientific changes do not take place in the absence of an "alternative" theory, and to that of Kuhn, for whom a paradigm is not rejected unless it is in a lamentable state.

> Thus a physical theory, as is easily shown by an examination of the whole history of the sciences, does not disappear unless it is succeeded by a new theory; the scientific reality that dies is of necessity born again in a new reality.[89]

Far from being the simplistic continuist one might suppose, Meyerson proposes a reading of the history of science that is in fact the true precursor of the 1960s.

3 Toward Anthropology

Meyerson was without doubt one of the first, with Duhem, to see the true nature of scientific change as it was later explored by Kuhn. In a paragraph of the *Cheminement de la pensée*, titled "Les Revolutions dans les sciences physiques" he suggests that the history of science, as it is usually presented, leaves out the resistance that always opposes new ideas, or presents it "in a way that only the innovator himself would find justified, his opponents appearing as men of ill-will, or of mediocre intelligence, incapable of grasping the clearest evidence". According to Meyerson, we must re-examine history and recognize the resistance of normal science to change:

> And if one takes the trouble simply to examine, without preconceived notions, the polemics of this great period, one quickly sees where the resistances come from and that none of them is without possible justification.[90]

Elsewhere he elaborates on this point, criticizing the usual reading of the chemical revolution:

> The arguments of the phlogiston chemists were in no way absurd, nor were they unscientific (contrary to what men insufficiently informed in the documents of the history of science have often maintained) […]. Lavoisier violated the most essential rules of chemical argument as they were firmly established at that time.[91]

Here we find exactly the formulation of the proprieties of normal science as Kuhn defined it in *Structure*. Perhaps it was through Koyré that this specific mode of interpreting historical scientific texts was transmitted, as many of the essays collected by Kuhn in *The Essential Tension* suggest.

This is precisely the problem of incommensurability. From the very beginning of *The Structure of Scientific Revolutions*, the theme of "incommensurable ways of viewing the world" is raised by the problem of historians' access to "how things were before", and of the scientificity of past science.

Historians confront growing difficulties in distinguishing the "scientific" component of past observation and belief from what their predecessors had readily labeled "error" and "superstition".[92]

It is a matter of considering past theories with the attention that Meyerson and Koyré advocated, not as receptacles of error, but as part of science. What Kuhn and Feyerabend most object to in philosophy of science before them is not so much its rationalism as its conception of past theories as errors, and of history as a succession of refutations and corrections, even provisional ones. From this point of view we can understand better the meaning of a remark of Hacking, for whom the center of the philosophical revolution introduced by Kuhn is "a different relation of science to its past". This is not a matter of a formal respect for the past, a kind of principle of charity adapted to the history of science; rather it is a matter of a different relation to experience:

> If these out-of-date beliefs are to be called myths, then myths can be produced by the same sorts of methods and held for the same sorts of reasons that now lead to scientific knowledge. If, on the other hand, they are to be called science, then science has included bodies of belief quite incompatible with the ones we hold today. Given these alternatives, the his-

> torian must choose the latter. Out-of-date theories are not in principle unscientific because they have been discarded.[93]

The thesis of incommensurability, for Kuhn, applies to paradigms of both intelligibility and rationality: each scientific revolution displaced "the standards by which the profession determined what should count as an admissible problem or as a legitimate problem-solution".[94] But paradoxically Kuhn sees the need for, as Koyré had already suggested, a principle of universal intelligibility.

> What has made the assumption of universal translatability so nearly inescapable is, I believe, its deceptive similarity to a quite different one, in this case an assumption that I share: anything which can be said in one language can, with imagination and effort, be *understood* by a speaker of another. What is prerequisite to such understanding, however, is not translation but language learning. Quine's radical translator is, in fact, a language learner.[95]

Returning again to Quine, we see that what is at stake here is the anthropological dimension of the question of incommensurability. The principle of identity, elaborated in Meyerson's early works, brings anthropology and philosophy of science together in a particularly fruitful way, just as it did in interesting discussions between Meyerson and Lévy-Bruhl. A whole chapter of the *Cheminement de la pensée* is dedicated to the connection between "The physicist and primitive man".[96] In light of Lévy-Bruhl's work on participation and his interpretation of pre-logical mentality, Meyerson argues that the scientist of the past, like the primitive, "did not depart for all that from the general stamp of our intellect".[97] When we attribute to the primitive (or the past scientist) a mode of thought different from ours, we refuse to see that he reasons as we do: "The primitive judged wrongly, but he nonetheless thought as we habitually do, and we cannot pretend that he was illogical without affirming at the same time that our own way of thinking is too".[98]

If we follow Lévy-Bruhl, then (despite many interpretations to the contrary) we must attribute to the primitive a form of common rationality. The question of logic is to be posed, not at the level of individual psychology, but at the level of a comparative study of diverse types of collective mentality. It is this comparativism that determines Lévy-Bruhl's method, and it is no way relativist: it is more a matter of showing the difficulty of defining logic once one gives up trying to ground or define it in terms of a single type of human mind or a transcendent rationality:

> I do not assert (today less than ever) that there exists a mentality peculiar to "primitive peoples". There is, in their mentality, a large part which they have in common with us. Equally there is in the mentality of our societies a part (larger or smaller according to the general conditions beliefs, institutions, social classes, etc.) which is common to it and to that of primitive peoples.[99]

Ethnography does not aim to establish either insurmountable differences in thought, or the psychological unity of the human species. It aims to bring to light, by the affirmation of what is shared between the primitive and the non-primitive, an *immanent plurality* in thought. And this is precisely the way, according to Meyerson, and later, Kuhn, that the history of science should proceed. The connection that Meyerson's principle of identity creates between anthropology and philosophy of science makes *identity* a condition on the discovery of conceptual *diversity*. In an essay on the interest of Lévy-Bruhl's theory of participation for the history of science Hélène Metzger has discussed

this similarity between the work of the ethnologist and that of the historian of science, in their study of universal schemas that *make it possible to cognize differences*.[100]

The appeal to anthropology also allows us to de-dramatize relativism, and especially to defuse the Davidsonian critique of "conceptual schemes" and paradigms as sources of relativism. In his "Reflections on My Critics"[101] Kuhn replies to a similar objection from Popper, who criticizes the "dogma […] [that] different frameworks are like mutually untranslateable languages".[102] Kuhn recognizes that we can only examine the paradigms of the past from within our own, but he argues that this does not keep us from examining them. This is precisely the work of the historian of science. To do the history of science is to learn how to translate historical languages into our terms. We translate "ancient theories in modern terms", and we learn, for example, to read historical documents differently. "Part of learning a language or a theory", Kuhn wrote, "is learning to describe the world within which the language functions" and to "acquire the knowledge of nature that is built into the language".[103] The new task given to the historian of science resembles, for Kuhn, not so much translation as the learning of a foreign language or culture, which is perfectly accessible provided we perceive the distance between a distant paradigm and ours and learn where they differ. With time, we can learn the language of the other culture in this way, which does not mean interpreting or conceptualizing it in our language, but rather learning to predict the reactions of the other, and making his strangeness familiar – "something that the historian regularly learns to do (or should) when dealing with older scientific theories".[104] This conception of incommensurability has nothing in common with extreme relativism: it recognizes a new task for philosophy of science, a descriptive one, in showing that the only way to describe the experience of the other is to take the measure of his distance from us.

The work of the historian of science thus turns out be similar to that of Quine's linguist undertaking radical translation: it is a matter of reading a foreign language in order to give it meaning, to integrate it into our language. The possibility of translation is the basis not only of the history of science but also of the growth of knowledge. There is an indeterminacy to translation, but it is this indeterminacy that makes the growth of science possible. This point was also made by Koyré, in his beautiful, and very critical, review of Louis Rougier's book, *La Scolastique et le Thomisme*.[105]

> Nothing is more variable than the collections of "truths" admitted and believed at different times by different social groups. Again, nothing is more variable than mental attitudes, both individual and social […]. It is obvious that a primitive who believes in magical causes […] and a physicist who studies the laws of motion have quite different mental attitudes […]. But inside their mentality and their beliefs they think […] in the same way. Despite the *material* differences there is a *formal* identity of thought. This is not, I believe, an *a priori* claim. The profound analyses of Lévy-Bruhl on the one hand, and of Meyerson on the other, have, I believe, firmly demonstrated this formal identity of the categories of thought.[106]

If we translate correctly the propositions "written by those who preceded us", that is to say, "if we are willing to seek out the theories that give these propositions their true sense", then we can "translate them into the language of the theories

accepted today" and see the truth in them. Meyerson takes up the same theme in an even more optimistic form, and reverses Duhem's conclusion:

> The science of the past is every bit as useful as that of today for the study of these processes. One might even say more useful. For by the very fact that this science is *outdated*, that we no longer believe in it, we are able to observe it more impartially. Indeed, however hard we try, we cannot attain such impartiality toward the science of today. The latter, its methods and its results, are among the most essential components of our intellectuality.[107]

Meyerson proposes, as a criterion of translation, the "identity" of the human mind.

> It is here that the history of science is in danger of making us feel awkward, since it shows a thought process whose course follows the same principles as ours does, yet the conclusions it arrives at are so different from those we are used to.[108]

The parallel between history of science and anthropology has proven itself especially fruitful, for Koyré and others from Quine and Kuhn to Foucault, and it seems to me that the whole approach implicit in these remarks, one that connects anthropology and history of science, defines a theme specific to contemporary philosophy, and maybe one of its central inspirations.[109]

Endnotes

1 "Entretien de Christian Delacampagne avec Thomas S. Kuhn", *Le Monde,* 5–6 Feb., 1995.
2 Until a recent revival, thanks to a group of French researchers : see e.g. Brenner, 1990, 2003, Bitbol and Gayon, 2006.
3 Willard Van Orman Quine, "Two Dogmas of Empiricism", in Quine, 1961, p. 41.
4 Duhem, 1906; transl. pp. 183–190.
5 Ibid., transl. pp. 190–208.
6 Ibid., transl. p. 159.
7 Ibid., transl. p. 163.
8 Meyerson, 1908; transl. p. 31.
9 Quine, 1982, p. 2.
10 Meyerson, 1931, p. 125.
11 Duhem, 1906; transl. p. 184.
12 Quine, 1982, p. 2.
13 Duhem, 1906; transl. p. 187.
14 Quine, 1961, p. 42.
15 Duhem, 1906; transl. p. 216.
16 Quine, 1961, p. 42.
17 Quine, 1982, p. 2.
18 Ibid.
19 Ibid.
20 See Quine 1961, p. 79.
21 Ibid.
22 See Ibid., p. 46.
23 Quine, 1960, p. 4.
24 Duhem, 1906; transl. pp. 187–188.
25 Ibid., transl. p. 188.
26 Ibid., transl. p. 26.

27 Quine, 1961, p. 19.
28 Ibid., p. 44.
29 Ibid., p. 44.
30 Carnap, 1934; transl. p. 318.
31 Quine quotes this sentence from Identité et realité (1961, note 20, p. 45).
32 Quine, 1961, p. 103.
33 Quine, 1969, p. 93. Emphasis mine.
34 Quine, 1960, p. 275.
35 See Laugier 1992.
36 Meyerson, 1931, p. 125. All translations from this text J. E.
37 Meyerson, 1908, p. 385.
38 Ibid., p. 435.
39 Quine, 1981, p. 22.
40 Quine, 1969, p. 98.
41 Quine, 1981, p. 21.
42 Ibid., p. 67.
43 Quine, 1960, p. 24. See also 1961, p. 79.
44 Quine, 1995, p. 260.
45 Ibid.
46 Hacking, 1983, pp. 5–6.
47 Ibid.
48 *Identité et réalité* was first translated into English in 1930 (Folcroft); *La déduction Relativiste* (with Einstein's review as an appendix) in 1985 (Reidel); *L'explication dans les sciences* in 1991 (Kluwer). Duhem's trans-Atlantic success, though it came later, was even greater: A translation of *La théorie physique (The Aim and Structure of Physical Theory)* appeared in 1962 (Atheneum), *L'évolution de la mécanique* in 1980 (Kluwer), *Sôzein ta phainomena* (*To Save the Phenomena*) in 1985 (University of Chicago, reprinted in paperback), excerpts from *Système du monde* (as *Medieval Cosmology*) in 1987 (University of Chicago), *Les origines de la statique* (Kluwer, 1991) and even *La science allemande* (*German science*, Open court, 1991). During this time only Meyerson's *L'explication dans les sciences* (Corpus) and Duhem's *La théorie physique* (Vrin), *L'évolution de la mécanique* (Vrin), and *Le Système du monde* (Hermann) have been in print in their original language. An abridged French version of *Le Système du monde* was edited by Anastasios Brenner under the title *L'aube du savoir* (Hermann, 1997).
49 Lakatos, 1995.
50 Meyerson, 1908, pp. 391–392. This passage probably influenced Quine, and may have led him to later read Duhem.
51 Cf. Duhem 1906, transl. p. 183.
52 Meyerson, 1931, p. 125.
53 Meyerson, 1908, p. 31.
54 Ibid.
55 Ibid., p. 368. Translation modified.
56 Ibid.
57 Ibid.
58 Ibid., p. 387.
59 Koyré, 1931, p.217.
60 Meyerson, 1921, p. 85.
61 Ibid., p. 61.
62 Ibid., p. 120.
63 See Meyerson, 1925.
64 Quine, 1982, p. 1.
65 See Schlick, "The Philosophical Significance of Relativity" and "Space and Time in Contemporary Physics" in *Philosophical Papers,* vol. 1.
66 Meyerson, 1931, pp. 787–790.

67 Ibid., p. 115.
68 Ibid., p. 25. See also pp. 796–800.
69 Ibid., p. 118.
70 See Einstein, 1987, *Collected Papers* vol. 2 for discussions.
71 See the works of Petzoldt, Schlick, and P. Frank. See also Meyerson, 1925.
72 Meyerson, 1925, p. 50.
73 Ibid., p. 55.
74 Holton, 1968, pp. 637–673.
75 Einstein, 1922, p. 111.
76 Ibid., pp. 111–112.
77 Quoted in Holton, 1968, p. 657.
78 Quoted in Ibid., pp. 648–649.
79 Meyerson, 1933, p. 48.
80 Meyerson, 1931, p. 118.
81 Ibid., p. 49.
82 Ibid., p. 117
83 Quoted in Arthur Fine, 1986, p. 125. Emphasis mine.
84 Meyerson, 1925, p. 99.
85 Meyerson, 1908, p. 7.
86 Meyerson, 1921, p. 514.
87 Kuhn, 1977, pp. 202–211.
88 *Revue philosophique* 96 (1923), pp. 33–55.
89 Meyerson, 1931, p. 589.
90 Ibid., pp. 547–548.
91 Ibid., p. 483.
92 Kuhn, 1962, p. 2.
93 Ibid., p. 2–3.
94 Ibid., p. 6.
95 Kuhn, 2000, p. 61.
96 Meyerson, 1931, pp. 49–88.
97 Ibid., p. 83.
98 Meyerson, 1931, p. 83.
99 Lucien Lévy-Bruhl, 1975, pp. 125–126. Translation modified by J. Elliott
100 Metzger, 1930, pp. 15–24.
101 Lakatos and Musgrave, 1970, p. 267.
102 Ibid., p. 56.
103 Ibid., p. 270.
104 Ibid., p.277.
105 Paris, Gauthier Villars, 1925.
106 *Revue philosophique* 99 (1926), p. 466.
107 Meyerson, 1921, p. 528.
108 Meyerson, 1931, p. 85.
109 Many thanks to Jay Elliott for his work on the English version of this text, and to Michel Bitbol, Alain Boyer, Christian Bonnet, Anastasios Brenner, Frédéric Fruteau de Laclos, Isabelle Peschard, Elie Zahar for fruitful discussions of Meyerson's work, and of various versions of this paper.

Bibliography

Bitbol, Michel et Gayon, Jean (2006), *L'Épistémologie française*, 1830–1970, Paris, PUF. 2006.
Brenner, Anastasios (1990), *Duhem : science, réalité et apparence. La relation entre philosophie et histoire dans l'œuvre de Pierre Duhem*, Paris, Vrin, »Mathesis«.

Brenner, Anastasios (2003), *les origines françaises de la philosophie des sciences*, Paris, PUF.
Carnap Rudolf (1934), *Logische Syntax der Sprache; The Logical Syntax of Language*, transl. Amethe Smeaton, London, Kegan Paul, 1937.
Duhem Pierre (1903), *L'Évolution de la mécanique*, Paris, Vrin, 1992; *The Evolution of Mechanics*, transl. M. Cole, Alphen aan den Rijn, Sijthoff and Noordhoff, 1980.
Duhem Pierre (1906), *La Théorie physique, son objet et sa structure*, Paris, Vrin, 1981; *The Aim and Structure of Physical Theory*, transl. P. Wiener, Princeton, N.J., Princeton University Press, 1962.
Duhem Pierre (1905–1906), *Les origines de la statique*, 2 vol., Paris, Hermann. *The Origins of Statics*, transl. G.F. Leneaux *et al*., Kluwer, 1981.
Duhem Pierre (1908), *Sauver les phénomènes. Essai sur la notion de théorie physique de Platon à Galilée*, Paris Vrin, 1982. *To Save the Phenomena*, transl. E. Doland and C. Maschler, Chicago, Chicago University Press, 1969.
Duhem Pierre (1913–1959), *Le système du monde. Histoire des doctrines cosmologiques de Platon à Copernic*, 10 vol., Paris, Hermann; *Medieval Cosmology*, partial transl. Roger. Ariew, Chicago, Chicago University Press, 1985.
Duhem Pierre (1915), *La science allemande*, Paris, Hermann; *German Science*, transl. J. Lyon, La Salle, Open Court, 1991.
Duhem Pierre (1997), *L'aube du savoir: épitomé du* Système du monde, A. Brenner, (ed.), Paris, Hermann.
Einstein Albert (1987), *Collected Papers*, vol. 2, Princeton, N.J., Princeton University Press.
Fine Arthur (1986), *The Shaky Game: Einstein, Realism, and the Quantum Theory*, 2nd ed., Chicago, University of Chicago Press, 1996.
Hacking Ian (1983), *Representing and Intervening*, Cambridge, Cambridge University Press.
Holton Gerald (1968), "Mach, Einstein and the Search for Reality", *Daedalus*, 97, pp. 637–673.
Koyré Alexandre (1931), "Die Philosophie Emile Meyerson", *Deutsch-Franzôsische Rundschau*, 4, pp. 197–217.
Koyré Alexandre (1926), "Compte rendu de *La Scolastique et le thomisme*" par L. Rougier, Gauthier Villars, 1925, *Revue philosophique*, 1926, pp. 462–468.
Kuhn Thomas (1962), *The Structure of Scientific Revolutions*, Chicago, University of Chicago Press.
Kuhn Thomas (1977), *The Essential Tension*, Chicago, University of Chicago Press.
Kuhn Thomas (2000), *The Road since Structure*, James Conant and John Haugeland (eds.), Chicago, University of Chicago Press.
Lakatos Imre (1995), "The methodology of scientific research programmes", *Philosophical papers*, volume I, edited by John Worrall and Gregory Currie, Cambridge, Cambridge University Press.
Lakatos Imre, Alan Musgrave (eds.), (1970), *Criticism and the Growth of Knowledge*, Cambridge, Cambridge University Press.
Laugier Sandra (1992), *L'anthropologie logique de Quine*, Paris, Vrin.
Laugier Sandra (2003) (ed.), "Après la Structure – Kuhn, les révolutions scientifiques et l'incommensurabilité", *Archives de Philosophie*.
Lévy-Bruhl Lucien (1949), *Les Carnets*, Paris, Presses universitaires de France; *The Notebooks on Primitive Mentality*, transl. Peter Rivière, New York, Harper and Row, 1975.
Quine Willard Van Orman (1960), *Word and Object*, Cambridge, Massachusetts, MIT Press.
Quine Willard Van Orman (1961), *From a Logical Point of View*, 2nd ed., Cambridge, Massachusetts, Harvard University Press.
Quine Willard Van Orman (1969), *Ontological Relativity*, New York, Columbia University Press.
Quine Willard Van Orman (1981), *Theories and Things*, Cambridge, Massachusetts, Harvard University Press.
Quine Willard Van Orman (1982), *Methods of Logic*, 4th ed., Cambridge, Massachusetts, Harvard University Press.
Quine Willard Van Orman (1995), "Naturalism; Or, Living Within One's Means", *Dialectica* 49/2, 251–261.

Metzger Hélène (1930), “La philosophie de Lévy-Bruhl et l’histoire des sciences”, *Archeion*, 12, pp. 15–24.
Meyerson Émile (1908), *Identité et réalité*, Paris, Vrin, 1951; *Identity and Reality*, London, George Allen and Unwin, 1930.
Meyerson Émile (1921), *De l’explication dans les sciences*, 2 vols, Paris, Payot; transl. *Explanation in the Sciences*, Dordrecht, Kluwer, 1991.
Meyerson Émile (1923), “Hegel, Hamilton, Hamelin et le concept de cause”, *Revue philosophique*, 96, pp. 33–55.
Meyerson Émile (1925), *La Déduction relativiste*, Paris, Payot; transl. *The Relativist Deduction: Epistemologival Implications of the Theory of Relattivity*, Dordrecht, Reidel, 1985.
Meyerson Émile (1931), *Le Cheminement de la pensée*, Paris, Alcan.
Meyerson Émile (1933), *Réel et déterminisme dans la physique quantique*, Paris, Hermann, “Actualités scientifiques et industrielles”.
Rougier Louis (1925), *La Scolastique et le thomisme*, Paris, Gautier Villars.
Schlick Moritz (1979), *Philosophical Papers*, Henk L. Mulder and Barbara F.B. Van de Velde-Schlick (eds.), transl. Peter Heath, 2 vol., Dordrecht, Reidel.