Research orientation and teaching projects

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Since the beginning of my research I have been convinced that there exists a unity of human thought, especially in its higher forms. It seems impossible to me to keep separate, in watertight compartments, the history of philosophical thought and that of religious thought, in which the former is always immersed, be it to draw inspiration, be it to mount opposition to the latter.

This conviction, once transformed into a principle of research, has proven fruitful for the development of medieval and modern thought, even in the case of a philosophy that also seems bereft of religious concerns like Spinoza's. But one must venture further. I had to quickly convince myself that it was also impossible to underestimate the study of the structure of scientific thought.

The influence of scientific thought and the image of the world that it defines is absent in systems that are clearly based on science, such as those of Descartes and Leibniz, but it is also missing in doctrines – mystical doctrines – that are apparently aloof to every concern of this type. Thought, when it is formulated in a system, implies an image or, better, a conception of the world, one that it relates to. Boehme's mysticism is strictly incomprehensible without reference to the new Greek cosmology created by Copernicus.

These considerations have led me, or perhaps have led me back, to the study of scientific thought. I first immersed myself in the history of astronomy; my studies then led me to the field of the history of physics and mathematics. The most intimate relationship between *physica celestis* and *physica terrestris*, which emerged at the beginning of the modern age, is the origin of modern science.

The evolution of scientific thought, at least during the period I was studying it, also did not form a self-contained series but was, quite the contrary, very closely linked to that of trans-scientific, philosophical, metaphysical, religious ideas.

Copernican astronomy does not just contribute to a new more economical arrangement of "circles" but also to a new image of the world and a new sense of being: the sun, which has now been moved to the center of the world, reflects the renaissance of the metaphysics of light and elevates the earth to the

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level of the stars – *Terra est stella nobilis*, as Nicholas de Cusa put it. Kepler's work proceeds from a new conception of the cosmic order, it, too, based on Christian theology with the thought of Proclus which enabled the great astronomer to transcend the fixation on circularity which had dominated ancient and medieval thought (and even continued to in Copernicus). But it was also this very cosmological vision, which prompted him to reject Giordano Bruno's ingenious intuition, albeit one that was scientifically premature, being rejected and to constrict it to the bounds of a finite structure. One cannot really grasp the astronomer's or the mathematician's thought, if it is not seen as imbued by the philosopher's or theologian's thought.

Descartes' methodological revolution was also based on a new conception of knowledge. The intuition of divine infinity led Descartes to his great discovery of the positive character of the notion of the infinite that shapes his logic and his mathematics. Finally, the philosophical – and theological – idea of the *possible*, mediating between being and nothingness, enables Leibniz to go beyond the scruples that had stopped Pascal.

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The fruit of these studies, carried out alongside my teaching activities at the École Pratique des Hautes Études, was the publication, in 1933, of a study on Paracelsus and another one on Copernicus, followed in 1934, by an edition, with an introduction, translation and notes, of the first – cosmological – book titled *De revolutionibus orbium coelestium* and, in 1940, by *Études galiléennes*. In the latter work, I sought to analyze the scientific revolution of the 17th century, which was both the source and the result of a profound spiritual transformation that shattered not just the contents but also the very frameworks of our thought. The substitution of an infinite and homogenous universe by a finite and hierarchically structured cosmos of ancient and medieval thought implies and necessitates the reworking of the first principles of philosophical scientific reason as well as the revision of fundamental notions, i.e., that of motion, space, knowledge and being. It is because the discovery of three simple laws, the law of free fall demanded such efforts of three great minds that these efforts were not always crowned by success. Thus the notion of inertia, as evidently absurd as it was for antiquity and the Middle Ages and as plausible it is now, cannot be resolved [*dégagée*] in its entire rigidity even in Galileo's thought – something that was only achieved by Descartes.

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During the war I was busy with other tasks so that I could not dedicate as much time as I would have liked to theoretical works. Since 1945 I have undertaken a new series of studies, based on Kepler, on the emergence of the great Newtonian synthesis. These studies have formed the continuation of my work on Galileo's oeuvre.

The study of the philosophical and religious thought of the great protagonists of experimental mathematics, Newton's precursors and peers, and of Newton himself, has proven indispensable for the complete interpretation of this movement. Newton's philosophical conceptions concerning the role of mathematics and the exact measurement in the constitution of scientific knowledge were just as important for the success of his undertakings as his mathematical genius: it was not for lack of experimental skill but a consequence of the inadequacy of their philosophy of science – borrowed from Bacon – that Boyle and Hooke failed when faced with problems of optics and there are profound philosophical differences that nourished the opposition of Huygens and Leibniz to Newton.

I addressed several aspects of these studies in my courses at the University of Chicago, at conferences at the University of Strasbourg and at the University of Brussels, at Yale and Harvard as well as in talks that I gave at the Congress of the History and Philosophy of Science (Paris, 1949) and at the International Congress of the History of Science (Amsterdam, 1950). In my lectures at the 5th section of the École Pratique des Hautes Études, I examined similar problems: the transition from a "world of approximation" to a "world of precision", the elaboration of the notion of and techniques of precise measurement, the creation of scientific instruments that have made possible the move from qualitative experimentation to the quantitative experimentation of classic science, that is, the origins of infinitesimal calculus.

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The history of scientific thought, as I understand it and have strived to practice myself, seeks to grasp the trajectory of this way of thinking in its creative thrust. To this end, it is essential to place again the works studied here in their intellectual and spiritual context, to interpret them in relation to the mental habits, preferences and aversions of their authors. One must resist the temptation – one that so many historians of science have succumbed to – to make accessible the often obscure, awkward and even confused ideas of Antiquity – by translating them into a modern language that clarifies them while at the same time distorting them. Nothing, by contrast, is more instructive than the study of the demonstration of one and the same theorem by Archimedes, Cavalieri, Roberval and Barrow.

It is also essential to integrate in the history of scientific thought the way in which it understands itself and positions itself in relation to both what preceded and accompanied it. One should not underestimate the interest of polemics by, say, Guldin or Tacquet vis-à-vis Cavalieri and Torricelli. There would be the danger of failing to closely examine the way in which Wallis, Newton, Leibniz envisaged the history of their own discoveries or to neglect the philosophical discussions that they unleashed.

Finally, the errors and failures should be studied with just as much care as the successes. The errors of a Descartes and of a Galileo, the failures of a Boyle and of a Hooke are not only instructive, they also reveal the difficulties that had to be overcome, the obstacles that had to be surmounted.

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Having experienced two or three profound crises ourselves with regard to our way of the thinking – the "foundational crisis" and the eclipse of mathematical absolutes, the relativist revolution, the quantum revolution – having been subject to the destruction of our old ideas and having made the effort to adapt to new ideas, we are in a better position than our predecessors to understand the crises and polemics of bygone eras.

I think that our era is particularly amenable to studies of this type and to a teaching that would focus on them under the title of the *History of Scientific Thought*. We no longer live in the world of Newtonian ideas nor in one of Maxwellian ideas and we are thus capable of viewing them both from within and from without, of analyzing their structures and perceiving the causes of their shortcomings, just as we are better able to understand them and the meaning of the medieval speculations on the composition of the continuum and the "latitude of forms" and the evolution of the structure of mathematical and physical thought in the course of the last century in its attempt to create new forms of reasoning and its critical return to the intuitive, logical, axiomatic underpinnings of its validity.

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My intention is also not to limit myself to the study of only the 17th century: the history of this great period must shed light on the most recent periods and the subjects that I have treated should be characterized, but not exhaustively, by the following themes:

The Newtonian system; the heyday and philosophical interpretation of Newtonianism (up to Kant, and via Kant).

The Maxwellian synthesis and the history of field theory.

The origins and the philosophical underpinnings of the calculus of probabilities.

The notion of infinity and the problems of mathematical foundations.

The philosophical roots of modern science and recent interpretations of scientific knowledge (positivism, neo-Kantianism, formalism, neo-realism, Platonism).

I believe that by applying the method I have just outlined, these studies will shed a bright light on the structure of the great philosophical systems of the 18th and 19th century which are defined in relation to scientific knowledge, be it to integrate it, be it transcend it; these will allow us to reach a better understanding of the philosophical-scientific revolution of our time.

Illustrated by Tannery, Duhem, Hannequin and Brunschvicg, Meyerson and Pierre Boutroux, the study of scientific thought and of its history has long been one of the most valuable traditions of the French school of philosophy. It is this tradition which, within the limits of my capacities, I would like to contribute to reviving. If a chair in the History of Scientific Thought were created, or rather re-created, at the Collège de France, this would make it possible to unite the scattered and dispersed efforts of researchers who are isolated today. At the same time, it would offer men of science, philosophers and historians a means to bring together their respective points of view and an opportunity for collaboration that is necessary not only for the progress of their individual disciplines, but also for safeguarding humanist values.

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