The Legend of Philosophy's Striptease (Trends in Philosophy of Science)

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The title is meant to tease the reader and attract his/her curiosity, but the question behind the teasing is serious. The reader will gently excuse the unconventional gait of a chapter that originated as an invited lecture given in Paris, at the HOPOS 2006 June conference. Doing philosophy of science requires having been trained both in philosophy and in (at least some) science. That is already a challenge. Studying the history of philosophy of science (which is what "hopos" means) might require having been trained as a historian as well. As life is short, and no one is omniscient, philosophy of science and its history can only be the endeavour of a community of researchers. A common endeavour calls for, if not a plan, at least a common rationality. What follows is about doubts and hopes, and about the reasons we have for tolerating, and even loving, a variety of styles in the ways philosophy of science is practiced.

A rough survey of notorious works in philosophy of science will suggest (at least) three different styles. The argument goes through five points, with the subtitles: 1. Science and philosophy, 2. The legend, 3. Beyond the legend, 4. Styles in philosophy of science, 5. New questions, emerging styles?

1 Science and Philosophy

Is the relation between science and philosophy internal or external? Does science belong to philosophy, is philosophy inherent in science, are science and philosophy independent of each other? Let us here contrast two philosophers who were contemporaries, with very divergent views on the relation between science and philosophy.

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1.1 "Science Generates Philosophy" (Bachelard[1])

The French philosopher (and physicist) Gaston Bachelard would encourage young philosophy students to read scientific publications, to get to know researchers in science, to go to the laboratory and see them work, or even to do laboratory work themselves. He called the plunging into science at work an experience of "meeting double transcendance", that is, an experience of exposing oneself to be sanctioned both by hard facts, and by the criticism of other members of the group. He was convinced of two things. First, numerous philosophical questions emerge from science itself, and those are real questions, that is, questions about how the world really is. Second, philosophers should risk conjectures that are vulnerable to refutation or correction by scientific results, rather than taking refuge in unfalsifiable "intuitions". Bachelard indeed thought that "*science does not get the philosophy it deserves*"[2], because philosophers tend to indulge in autistic speculation, while scientists too often satisfy themselves with primitive metaphysical beliefs. The philosophy science deserves would be a "discursive metaphysics open to rectification"[3].

1.2 "Science Does not Think" (Heidegger)

The German philosopher Martin Heidegger is well aware of the provocative tone of his claim when, in a series of lectures that were given during the Winter semester of the academic year 1951–1952, he declares:

> Science does not think, and cannot think; indeed, that is what constitutes its chance, that which secures its own way of proceeding. Science does not think. A shocking assertion. Let it be shocking, even if we complete it with another assertion: that science is always somehow related – in its peculiar way – to thinking.[4]

This does not merely assert that practicing scientists do not have time for leisurely philosophizing. What Heidegger means is that there is a gap, a fracture between science and philosophy. It is common knowledge that he ascribes the fracture to the technological drift of contemporary science: when you want results, you cannot think. (Then, only in the old times, when science meant contemplation, when it aimed at pure, disinterested knowledge, only then, perhaps philosophy and science were one and the same?) But there is more to Heidegger's charge against the quest for power. The leitmotiv of the 1951–1952 course is: "up until now, Man has done too much, and thought too little" *(ibid)*. Acting keeps mankind from thinking. What's thinking? Meditating. A solitary journey. Note that Heidegger adds that even philosophers may publish a lot and think very little. At any rate, an activist science is foreign to philosophical thinking.

Heidegger's way (science is technoscience, and technoscience is unrelated to serious philosophy) may be safer than Bachelard's (scientific investigation is philo-

sophical by its nature). The poet and essayist Paul Valéry, who enjoyed the company of scientists and philosophers, lucidly warned them:

> In our times metaphysics was seen to be caught by surprise in the variations of science, and eventually bullied in the most hilarious manner. That's why I'd happen to think that, if I were a philosopher, I would endeavour to make my philosophical reflection independent of any knowledge that new experience might shatter.[5]

2 The Tale of Philosophy's Striptease

In the late 20th Century many a philosopher feared that philosophy was about to disappear, at least from university education. Philosophy is in danger, they said, it needs to be rescued. Or they would tell, as did Stephen Toulmin with a touch of humour, "how medicine saved the life of ethics"[6], and did not save the life of epistemology… Where did the threat come from?

2.1 Philosophy and the Breeding of Science

The story goes like this. Note that it should not be mistaken as history. It is a tale. Once upon a time philosophy included all sciences, and the technologies derived from science, and the wisdom that goes with such endeavours. A well-known representation of such a concept of philosophy is Descartes' tree of knowledge:

> The whole of philosophy is like a tree, the roots of which is metaphysics, the trunk is physics, and the branches issued from the trunk are all other sciences, which come down to principally three, namely mechanics, medicine and ethics; I mean, the highest and most perfect ethics, based on full knowledge of all other sciences, thus being the ultimate degree of wisdom.[7]

The tree eventually lost its branches. Sciences fell off philosophy and became autonomous. First, the sciences of nature, in the course of the 17th and 18th centuries: physics, chemistry, biology, with Boyle, Newton, Lavoisier, Lamarck, etc. Then, the noosciences, or sciences of culture, in the course of the 19th century: psychology, and the social sciences. Philosophy was then faced with a trilemma: either rehearse its own history and lament over its being stripped of all the good sciences it carried, or claim to be one of the sciences, or take refuge in literature and poetry – which was Paul Valéry's option, when he said that a piece of philosophy isn't any more serious than a piece of music.[8]

The legend may have been borne as a misunderstanding of W. Dilthey's reflection on the emergence of human sciences as historical sciences. We will come back to Dilthey later. At this point, let us ask a question. What happens after the tree has lost its branches, that is, after philosophy has been delivered of all the sciences? What is left?

2.2 What is "Pure" Philosophy, in the Nude?

Obviously the roots of the tree are still there. Shouldn't philosophers be busy enough with *metaphysics*, considering (as Kant said, quoting a latin poet) that "nothing is over as long as something remains to be done"[9] ? But whoever has read the *Critique of Pure Reason* (1781, 1787) to the end has been persuaded that metaphysical constructions are hopeless. Even though Kant calls metaphysics a "*fundamental science*", he maintains that the scope of metaphysics has to be strictly limited, following a serious analysis of the limits of human knowledge. Metaphysical schemes are without substantive import. They may have, at the most, heuristic or speculative value, but they do not tell us anything about the real world.

Indeed, Immanuel Kant had been captivated by *prima philosophia*'s appeal. This he confessed in *Dreams of Spirit-Seer* (1766):

> My fate was to fall in love with metaphysics, although I could hardly pride myself on having been granted her favors.[10]

Such a seductive metaphysics was like Swedenborg's chimeras, or at best Plato's world of Ideas, an enchanting world, a dream! A rational critical attitude required to chase away the dream and face the facts.

2.3 Interpreting the Tale: Edmund Husserl vs. Bertrand Russell

Quite a few philosophers in the early 20th century apparently accepted the story of philosophy being robbed and deprived of scientific disciplines that had originated from her. Husserl deplores the fact, Russell is delighted.

According to Edmund Husserl, the scientific *impulse* – the want for good knowledge, for clear, sure, valid, apodictic knowledge – lay within philosophy. The "vital task" of philosophers is to build a sound and universal science, based on rock-firm ground, totalizing all truths about the world. Unfortunately, as explained in *Philosophy as rigorous science*, while striving to be scientific, philosophy merely succeeded in giving birth to independent sciences:

> The only ripe fruit of such efforts has been to establish in their independence the rigorous sciences of nature and mind, as well as the new branches of pure mathematics.[11]

What happened was that, as they started accumulating a body of knowledge, the sciences underwent a process of *naturalization*: first the sciences of nature, then even the sciences of consciousness, became *positive*. They got engulfed in the object, and lost track of the founding subject giving birth to the data. The sciences of nature are rigorous in that they are critical of their experimental procedures, but they do not criticize their foundations. It sounds as if this setback were, to some extent, philosophy's fault. However, once naturalized, the sciences are incomplete and not truly autonomous. The objective is to bring them back into philosophy's womb. The tree of knowledge must be reassembled:

> There is only one philosophy, only one true and genuine science, within which the particular genuine sciences precisely are non-autonomous members.[12]

Unlike Husserl, Bertrand Russell finds philosophy's striptease most enjoyable. He welcomes philosophy getting denuded of her belongings because he does not believe in the foundational role of philosophical reflection. Philosophy is idle chat, vacuous talk. We need the precise tools of mathematical logic to clarify philosophical problems, and eventually solve them, or else discard them as insolvable, or pointless. All philosophical claims have to be systematically reexamined, and as a result of stringent analysis, philosophy ends up as empty as a puppet:

> I believe the only difference between science and philosophy is, that science is what you more or less know and philosophy is what you do not know … Therefore every advance in knowledge robs philosophy of some problems which formerly it had, and if there is any truth, if there is any value in the kind of procedure of mathematical logic, it will follow that a number of problems which had belonged to philosophy will have ceased to belong to philosophy and will belong to science.[13]

This was written during Russell's "Wittgensteinian' epoch (as admitted by Russell himself, in *The Monist*, 1918). The reader is reminded of assertions found in the *Tractatus Logico-Philosophicus*.[14]

3 Beyond the Legend

Science does not belong to philosophy: let us admit it. The claim that it does is, at least to some extent, a delusion. From that it does not follow that science is foreign to philosophy. The programme of modern empirical science, as designed by Francis Bacon, talked of "natural history" (or the investigation of facts in the universe) as a platform wich would "serve for a foundation to build philosophy upon"[15], and his "natural philosophy", which in the *Advancement of Learning* (1605) he calls "metaphysic", states the laws ("axioms") of nature drawn from experience by the inductive method. From that perspective, natural philosophy belongs to science, or perhaps philosophy is an extension of science. Let us now ask: how did philosophy *of* science emerge as a discipline?

3.1 From Natural Philosophy to Philosophy of Science

Although Bacon wants the laws of nature to be derived from scientific observation and experiment (as opposed to deducing them from "brain-created" general principles), he takes for granted that there are universal laws of nature, because nature is the well-ordered creation of God; even if "we will have it that all things are as in our folly we think they should be, not as seems fittest to the Divine wisdom, or as they are found to be in fact", he warns that "we cannot command nature except by obeying her"[16]. Most of the early natural philosophers, including Newton,[17] share this assumption.

In the course of the 19th century, however, the transition from natural theology to natural philosophy places Nature and its dark spontaneity as an alternative to God. Different regions of nature may then have their specific regularities, or Nature may vary. "Any science must have its own philosophy", Lamarck writes,[18] speaking of zoology. Doing natural philosophy in general, *i.e*. philosophy of Nature, in the manner of John Herschel,[19] and relying on inductive methods, takes a bet on Nature's consistency. Auguste Comte admits that his "positive philosophy" is much like what is called "natural philosophy" in England, but his *Course*[20] is segmented according to a hierarchy of natural sciences, from physics to sociology (from more general and simpler, to more particular and complex), with a view to evidence both the transitions between disciplines and the proper "scientific genius" of each science.[21] Charles Darwin admired Paley's *Natural Theology*,[22] but there is a vast distance from the harmonious world of Paley to a Darwinian order.

The diversity of sciences calls for philosophical questioning. William Whewell in 1840 publishes his *Philosophy* (singular) *of the Inductive Sciences* (plural).[23] Whewell does not have a system of the sciences, as Comte does; he considers several kinds of sciences, each with their core concepts or Ideas, including sciences (such as geology) in which the present state of things is explained by past events, a type of research he qualifies as "aetiological history". The phrase "philosophy of the sciences" is commonplace around the middle of the 19th century. It is replaced by "philosophy of science" at the end of the 19th century, at the expense of philosophy becoming what Pearson[24] terms "the grammar of science". Although Pearson takes his examples from physics, on account of the unity of its "grammar" the unity of science is postulated for all "branches of knowledge". To sum up: the 19th century takes us from the unity of nature to the unity of science, and from philosophy of nature to philosophy of science. Meanwhile there is considerable diversification of the sciences, due to the more and more irreducible diversity of objects studied.

3.2 Antoine-Augustin Cournot and the Non-Scientific Status of History

Antoine Augustin Cournot agrees with the distinction (coming from F. Bacon, slightly modified by d'Alembert in the *Encyclopaedia*[25]) between two types of knowledge: historical, and theoretical.[26] Indeed, some aspects of historical research may be considered scientific, but other aspects are irreducibly unscientific. The scientific part of the work consists in establishing the facts and their chronology. The narrative part, namely the reconstruction of the course of events, involves speculative choices (drawing up causal links, distinguishing between chance events and rational links within clusters of events); the uncertainty of such choices cannot be eliminated, the probability of their being right is "philosophical probability", and "philosophy of history" resides in the speculation they involve.

Scientific knowledge proper is theoretical: formulate general hypotheses or theories, and submit them to the "criterion of experiment", or demonstration, is its

motto. Scientific theorizing, however, may go beyond what can decisively be settled by way of experiment. The speculative attempt at going beyond the facts already known and looking for hidden regularities, or at "capturing analogies and searching for the reasons of things", is risky, for it amounts to "wandering from those facts which can be rigorously controlled"[27]. Cournot uses the terms "philosophy of the sciences" to mean: "philosophical speculation inherent in scientific work". He reckons that there is in mathematics, physics, biology, economics,

> a part of philosophical speculation, from which science cannot refrain, or, should it cut off from it – assuming that were possible – it would be at the expense of its own dignity.[28]

In either case (be it history, or science) the speculative part of the research is deemed philosophical, although it is a philosophy from inside science, and possibly made by scientists. Cournot himself, a mathematician by training, and the discoverer of a grand theorem in mathematical economics (the Cournot–Nash equilibrium), considered philosophical speculation a natural continuation of scientific investigation.

3.3 W. Dilthey and the "Essence" of Philosophy

Wilhelm Dilthey ambitioned to establish the noosciences, or sciences of the mind and culture (*Geisteswissenschaften*) as an autonomous group of sciences, distinct from the sciences of nature (*Naturwissenschaften*). He was aware of German philosophers, from Schelling to Hegel and Schopenhauer, trying persistently (against Kant) to provide a metaphysical foundation for the sciences:

> So the possibilities of the metaphysical method were tried in Germany, one after the other, and always with the same negative result.[29]

Dilthey rejects both Kantian transcendantalism and postkantian foundationalism. He does not like J.S. Mill's naturalistic solution either. In the *System of Logic*, Mill claims that the "backward state" of what he names the "moral sciences" should be remedied by applying to them the methodology of physical science. Dilthey wants the specificity of moral science to be preserved. In his *Introduction to the Human Sciences*,[30] he argues that individualizing those sciences does not require to rely on such old metaphysical distinctions as that of material *vs*. spiritual substances. It is enough to refer to the distinction between our experience of the external world, and our inner experience, and characterize for the two types of experience the appropriate scientific approach: explain phenomena in terms of cause and effect relations in the former case, possibly explain *and* especially understand in the latter case.

In fact, Dilthey analyzes at great length[31] the ways in which modern sciences, starting with physical sciences, had to get emancipated from *prima philosophia*, or the metaphysics of substantial forms. That may be one of the sources of the legend of philosophy being deprived of the sciences. If so, the legend was based on a misinterpretation. Dilthey does not mean to say that modern sciences are in no relation to philosophy, he means to say that they are *not rooted* in philosophy. Human sciences

have their roots in human (real) history. They do not need metaphysical principles for a start, they need a methodology.

Philosophy is not the foundation of human science: it is its achievement, its "ultimate result". Science culminates in philosophy:

> The set of mind sciences combined all historical research under the viewpoint of universal history, rooted those sciences in history, and gathered together philology, criticism, historiography, comparative history and history of evolution. That way history turned into philosophy.[32]

4 Styles in Philosophy of Science

Thomas Kuhn was interested in analysing the "essential tension"[33] within scientific research between "divergent thinking" and "convergent thinking". This section will deal with the tension within philosophy of science induced by various (historically attested) ways of viewing the relation between philosophy of science. Schematically, divergent interpretations given to the "tale" yield several ways of conceiving the tasks of a philosophy of science.

Assume science has severed its links with philosophy (science "does not think"). "Pure" philosophy stands by herself. It may ignore science. It also may, from outside, take science as an object for study, among other objects. As there is a sociology and a psychology of science, there will be a grammar of science (if philosophy's expertise is grammar).

Now assume that science has rejected metaphysical preconceptions and kept its philosophical momentum (science "thinks"). There remains a special link between philosophy and science, a secret complicity, no matter how critical the partners get of each other. What do they share? It may be a common desire for truth. How do they differ? One may hypothesize that science works at conquering new pieces of knowledge, and philosophy retrospectively studies how science did the work (philosophy accompanies science, as history and methodology of science); then philosophy and science complement one another. One may also hypothesize that theoretical speculation, prospective thinking, from inside science, is tentatively philosophical.

Let us briefly examine the three styles just sketched.

4.1 Formal Philosophy of Science

Famous textbooks illustrate what Susan Haack calls the "linguistic-conceptual-analytical style" which was dominant within the English-speaking philosophical community during the 20th century. Arthur Pap's *Introduction to the Philosophy of Science* is a superb example; it also has the merit of warning that there exist other styles.

> The philosophy of science is here conceived as indistinguishable from analytic philosophy except that the analysis is restricted to concepts and problems that are especially rel-

> evant to science. It should be distinguished from a different conception of the philosophy of science as a speculative synthesis of the fruits of scientific research. … Logic courses overlap a great deal with philosophy of science-in-general.… Epistemology can hardly be distinguished from philosophy of science-in-general, provided its problems are problems of logical justification of beliefs and not (psychological) problems of genetic explanation of beliefs ….[34]

Philosophy here stands by itself as an "analytic" discipline, the tools of which are essentially logic and grammar. Science is identified with its linguistic productions, namely scientific publications. When a philosopher is interested in a piece of science, his/her task is to detect the primary notions, check that other notions are properly defined in terms of the primary ones, look for the axioms of the theory (or axiomatize the theory), make sure that the set of axioms is consistent and eventually that the axioms are independent of each other, interpret the axioms and build models, verify that the author's conclusions are properly derived from the axioms, or pinpoint the flaws in the argument…. In short, philosophical expertise is with language, the tool for language analysis is logic, philosophy identifies with logic. Logical treatment has to do with the structure of knowledge, not with its contents (supposedly the form does not add anything substantial to the contents). In that context, philosophy is not a source of knowledge. The philosopher is a sort of constable, a public officer in charge of restoring or maintaining law and order. Genuine philosophical problems are problems of logic.

Bertrand Russell anticipated such a conception of philosophy, when he bluntly declared that logic is "the essence of philosophy":

> Every philosophical problem, when it is subjected to the necessary analysis and purification, is found either to be not really philosophical at all, or else to be, in the sense in which we are using the word, logical.[35]

In other words, philosophy is either nothing, or a science; and philosophy of science must be science of science. Rudolf Carnap, Hans Reichenbach,[36] symbolize the migration of "scientific philosophy" from Berlin and Vienna to the United States before World War II.

An inquiry into the relationship between formal methods and philosophical investigations was carried out in 2005 by editors of the *Synthese* journal.[37] A bunch of living philosophers, who had been trained in that style of philosophy, were asked why they were initially drawn to formal methods, and what role formal methods had played in their philosophical work. The outcome helps to understand what was achieved along those lines. Most philosophers trained in logic and mathematics did get results; for example, Adolf Grünbaum praises the "axiomatic rigor" by which he could demonstrate that a number of Euclid's "theorems" did not follow from their premises, unless additional postulates were made explicit. There are, however, reservations about an exclusive use of formal methods in philosophy of science. Sven Ove Hansson mentions the "dangers of oversimplification", Timothy Williamson resented the "abuse of formalization" in the manner in which Davidson's programme was taught at Oxford, Jaakko Hintikka warns us that there is inseparability of form and substance and that it makes no sense to develop a formalism without worrying about its substantive purpose, Susan Haack learned formalism and turned to pragmatism:

> Pragmatism opened my eyes to a conception of philosophy broader and more flexible than, as Tony Quinton [1983] puts it, the "lexicographical needlework' of pure linguistic analysis.[38]

The concerns expressed by formal philosophers of science are foundational and critical, rather than constructive. They mean to dissect, clarify, justify, make sure that science proceeds on firm ground. Clark N. Glymour observes that philosophers are oversensitive to incoherence and tend to obstinately go back to first premises, while scientists tend to go ahead and be insensitive to contradiction. Moreover, formal analysis is (like mathematical truth) timeless and non-historical. Patrick Suppes had already pointed out "a tension between those who advocate historical methods as the primary approach in the philosophy of science and those who advocate formal methods"[39]. Suppes himself is very tolerant of such a diversity of approaches: "This tension in itself is a good thing. It generates both a proper spirit of criticism and a proper sense of perspective"[40]. Now what is, according to Suppes, the specific contribution of formal philosophy of science?

> For me … the best way to think about formal methods in philosophy is in providing a foundation for mathematics or for the sciences. I include in the sciences the problem of clarifying the foundations of probability.[41]

Ruth Barcan Marcus thinks of logicians interested in other sciences as essentially contributing their critical mind:

> Philosophers who are not ignorant of work in other disciplines … have also proved to be incisive critics. There has been and could be fruitful collaboration as in linguistics, law and cognitive science.[42]

Finally, Gabriel Sandu remembers that the Finnish philosopher Georg Henrik von Wright, a formal philosopher himself, anticipated a change of style at the turn of the 21st century:

> In this very department [Helsinki], shortly before his death, von Wright predicted that this century will not be that of logic, as the preceding one, but that of speculative philosophy.[43]

As a matter of fact, formal methods are alive and well, not only in English speaking countries, but also on the European continent, possibly with a preference for applications to the general theory of knowledge, rather than for the study of particular sciences. An example is a recent doctoral dissertation on "Propositional attitudes and epistemic paradoxes"[44].

4.2 History and Philosophy of Science, and Historical Epistemology

The historical epistemology (or HPS) approach is rooted in a strong tradition on the European continent, from Comte and Cournot to Duhem, Koyré and Canguilhem. It occasionally migrated to the other side of the ocean. Its concerns are with the genealogy of scientific discoveries, the building of scientific concepts and theo-

ries, the methodologies of establishing scientific facts and/or justifying scientific assertions, the modes of scientific explanation, etc. It counts many famous works, of which we may mention just a few: Ernst Mach's *Science of Mechanics* (1883),[45] Leon Brunschvicg's *Stages of Mathematical Philosophy* (1912),[46] Emile Meyerson's *Explanation in Science* (1921),[47] Pierre Duhem's majestuous *History of Cosmological Doctrines* (1913-1959),[48] Ludwik Fleck's *Genesis and Development of a Scientific Fact* (1935),[49] Gaston Bachelard's *Formation of the Scientific Mind* (1938),[50] Georges Canguilhem's *Formation of the Concept of Reflex* (1955),[51] Alexandre Koyré's *Astronomical Revolution* (1961),[52] Ernst Mayr's *Growth of Biological Thought* (1982),[53] Lorenz Krüger's (et al.) *Probabilistic Revolution* (1987),[54] etc. All of these works combine (internal) history of science and a philosophical investigation into what genuine scientific knowledge and research is and should be. For example, Mach warns that his critical-and-historical approach is "antimetaphysical"; Meyerson finds (chemical) science to be "essentially ontological", that is, he dismisses radical positivism; Mayr argues for life science requiring an epistemological paradigm different from that of physics.

Thomas Kuhn, who was drawn "from physics and philosophy to history", insists that the history and the philosophy of science are and should remain "separate and distinct disciplines"[55]. Georges Canguilhem quotes Dijksterhuis saying that the history of science is "not only the memory of science, but also its epistemological laboratory"[56]. In fact, Canguilhem says, "epistemology has always been historical", even in Kant's second preface to the *Critique of Pure Reason*.[57] There can't be proper epistemological study without historical contextualisation. Conversely, the choice of interesting historical matter may rely on epistemological judgement:

> There are in fact two versions of the history of science: the history of obsolete knowledge and the history of sanctioned knowledge, by which I mean knowledge that played an active role in the making of subsequent science. Without epistemology it is impossible to distinguish between the two. Gaston Bachelard was the first to make this distinction.[58]

The distance between "history of obsolete knowledge" and "history of sanctioned knowledge" is illustrated by two doctoral dissertations, both recently defended. One is a careful study of the medical conceptions of migraine in the 19th century;[59] it describes a succession of intellectual fashions, culturally fascinating, scientifically eccentric, and the patients went on living with their headaches. The other analyses how the concept of neuron emerged during the 20th century,[60] from a research on the nervous system previously directed at the neural fibre; it shows that a multiplicity of new technologies and new experimental strategies coming from various disciplines converged to constitute neurophysiology as the science of neural cells and neural networks; this study gives a clear sense of a gain in knowledge in the midst of multiple erring ways.

Often debated within the historical-epistemological tradition is the question, whether there is continuity or discontinuity in the evolution of science. Ernst Mach tells how the laws of mechanics were progressively discovered through human (biological) experience of motion; he suggests that there is continuity from experience to science, advocates description as demonstration, and claims that historical knowledge is necessary for proper understanding of current science. He comments:

> That which for Husserl is a humiliation for scientific thinking, namely its continuity with common ("blind"?) thinking, that I see as an element of grandeur, for that is how science is rooted in the depths of human life and has a deep impact on it.[61]

Bachelard, on the contrary, as soon as 1938,[62] popularized the notions of epistemological *obstacle* and epistemological *rupture*, to emphasize the discontinuity between common and scientific ways of thinking.

Cournot (around 1870) initiated the technical use, in history of science, of the concept of *scientific revolution*.[63] Cournot is not a radical discontinuist, although he admits of deep reorganizations of knowledge, such as the introduction of quantitative chemistry by Lavoisier, which deserve the qualification of "revolutionary". Scientific revolutions reemerged in the 20th century, together with scientific paradigms. The notion of *paradigm* was launched by Kuhn, with reference to Fleck's notion of *Denkstil*. It was soon followed by Foucault's notion of *épistémè*.[64] The kind of history of science using such concepts may be viewed as a discontinuist variety of historical epistemology, with philosophical assumptions taken from structuralism (Gestalt theory) – the paradigm being a conceptual structure, incommensurability being discontinuity between structures. The group of scholars who gathered in Bielefeld during the academic year 1982-83 to study the rise of probability in the sciences did raise the question: was the rise of probability revolutionary? Bernard Cohen gives four criteria to decide when a scientific revolution has occurred. Lorenz Krüger opts for a "slow rise of probabilism". Ian Hacking concludes that, even though one cannot talk about a probabilistic revolution in the scholarly sense, yet "the taming of chance and the erosion of determinism constitute one of the most revolutionary changes in the history of the human mind".[65]

Hacking defines himself as practicing another variety of historical epistemology, wich borrows both from the analytic and the continental styles. The guide line is to combine the "Lockean imperative to investigate the origin of ideas" with Michel Foucault's "history of the present". As a consequence, historical enquiries

> are not done out of curiosity about the past. They are intended to show something about our present reality, our present reasoning, our present modes of research.[66]

Together with historian Lorraine Daston, in the Fall of 1993, Hacking had a workshop in Toronto on the topic of "historical epistemology". The working paper written in preparation of the event enumerates what Hacking's brand of historical (meta?)-epistemology is not: "(a) not studies of theory change … (b) not social studies of science … (c) not cognition, not biological … (d) not overarching pictures of civilization … (e) not deconstruction … (f) not archaeology, not genealogy … (g) not science in action"[67]. This quotation helps to point out the large variety of substyles flourishing during the late 20th century, within what is commonly designated as HPS. It may be fun for the reader to try and guess who lies behind each designation.[68]

4.3 Philosophy of Nature/Philosophical Anthropology

At the end of his life, Christiaan Huygens wrote a philosophical treatise, entitled *Cosmotheôros*, in which, on the basis of recent astronomical discoveries, he con-

jectures how the universe may really be. Far from being spherical and limited, it is immensely vast. It contains a great many other suns than our sun, with other planets moving round them, and those planets might be habitable:

> So that what we allowed the planets, upon the account of our enjoying it, we must likewise grant to all those planets that surround that prodigious number of suns. They must have their plants and animals, nay and their rational creatures too, and those as great admirers, and as diligent observers of the heavens as ourselves ….[69]

Huygens' *Cosmotherôs* is an early piece of modern natural philosophy, just like Freud's *Civilization and its Discontents*[70] is an early contemporary piece of philosophical anthropology, a conjectural essay on the uncertain outcome of the conflict (evidenced by psychoanalytic research and the social sciences) between human native agressivity and its cultural domestication.

Natural philosophy is speculative philosophy, grounded in scientific knowledge and data, going beyond just what those known data allow to assert, with a view to seizing a unity or rationale in the ways nature is constituted. Such a speculation remains, at least for a part, vulnerable to refutation or correction by the findings of further scientific investigations. The enterprise is risky, to the extent that it is both tentatively metaphysical, and fallible. The French philosopher Jean Largeault finely analysed the metaphysical patterns between which natural philosophy tends to oscillate: form *vs*. matter, mechanism *vs*. dynamism, determinism *vs*. contingency, continuity *vs*. individuation, etc.

> I wanted to approach the enigma of forms, which let themselves be perceived in the physical world, which mathematicians discover through direct or abstract intuition, while their union with matter, or in Lautman's words their incarnation, remains incomprehensible.[71]

Some philosophers, like Bergson, have ambitioned to develop a *positive metaphysics*, the intuitions of which would be empirically controllable. Bergson, however, denies to metaphysics the role of an "hypothetical extension of science"[72]; he wants for his metaphysics a separate access to experience. In fact, even though Bergson's book on *Creative Evolution* (1907) might qualify as *philosophy of nature*, most philosophy of nature is the work of scientists trying to synthesize by building bridges between several scientific domains, or to anticipate the directions of further scientific research. August Weismann held the chair of zoology at the university of Freiburg. Towards the end of the 19th century he speculated that unicellular organisms are potentially immortal, and that the division of labor between somatic and germ cells in multicellular organisms (a product of natural selection) ends up in the mortality of the soma; he postulated a continuity of the germ plast, which implied that acquired characters could not be inherited; his *Essays upon Heredity*[73] are very "philosophical" in character, yet many of his intuitions were eventually confirmed by cytological investigations.

Natural philosophy flourished in the early 19th century. Engulfed under the wave of positivism, it then became marginal, until it reappeared in the 20th century as an urge for philosophy from inside science. Erwin Schrödinger, in the Preface of his *What Is Life?*, confesses having inherited a "longing for unified, embracing knowledge", an excuse for the physicist to imagine a molecular picture of the "hereditary code-script" by which living beings reproduce themselves. When Conrad H. Waddington, in 1960, was invited to give a series of lectures in biology at the University

College of the West Indies, in Kingston, his first lecture was on "the natural philosophy of life", in which he explains that biological research has both a "craftsman aspect", implying an "effort to control the world", and a speculative aspect, expressing a "wish to understand the world", which precisely he calls *natural philosophy*. Waddington was an early promoter of systems biology. He pays homage to the mathematician and physicist Alfred N. Whitehead for having "dehorned" the main dilemma of theoretical biologists: should biology concentrate on the constituents or on the architecture of living beings? In other words, is the organism reducible to the sum of its parts, or is the investigation of architecture another avenue for discovering more about the constituents? Waddington holds that, in a sense, "the architecture is more important than the constituents"[74]. Whitehead himself reckons "that the world in unfathomable in its complexity, and that anything you put together … ought to be open to criticism if it is any good at all". He calls his philosophical endeavour an *Essay in Cosmology*, "cosmology" is his word for "philosophy of nature", and he defines it as speculative philosophy:

> Speculative philosophy is the endeavour to frame a coherent, logical, necessary system of general ideas in terms of which every element of our experience can be interpreted.[75]

Scientific philosophy, or philosophy of science? Jacques Monod in his *Chance and Necessity*[76] takes it for granted that there is a philosophy inherent in modern biology (philosophy within science), which merely has to be made explicit; for example: "all living beings are at the same time fossils", carrying within the most minute part of their structure the marks of their common ancestry. The mathematician René Thom assumes that dynamic living phenomena, such as the development of embryos, or in general morphogenetic processes, obey mathematical constraints, which may be modeled using the (qualitative) tools of topology; the philosophical import of his quest for such "archetypes", according to Thom, is to offer a strictly monist conception of living beings, "dissolving the mind and body antinomy into a unique geometrical entity"[77]. Trained in physics and astronomy, Eric Chaisson suggests a general scheme of universal evolution, apt to synthesize astrophysics and bio-chemistry, and to "reconcile the theoretical destructiveness of thermodynamics with the observed constructiveness of cosmic evolution". His ambition is much like that of Whitehead:

> Cosmic evolution is a search for principles that subsume, and even transcend, Darwinian selection – a unifying law, an underlying pattern, or an ungoing process perhaps, that creates, orders, and maintains all structure in the Universe, in short a search for a principle of cosmic selection.[78]

Of philosophical anthropology, as it developed in Europe approximately between 1920 and 1960, one may also ask whether it is a philosophical way of doing science, or a scientific style of philosophizing. The central idea, shared by von Uexküll, Buytendijk, von Weizsäcker and others, is that in doing research on living beings, including humans, one is dealing with other subjects, and not merely with objects for study. Von Weizsäcker in 1939 offers a conjecture that is intended to guide the research in such sciences; he calls it *Gestaltkreis* (cycle of structure). It is a general scheme of the unity of receptivity and movement: perception calls for action and

action calls for perception, the passive and the active revert to each other. In the second edition of his book *The Gestaltkreis*, von Weizsäcker notes that what he meant to say has since been brillantly expressed by a French philosopher named Sartre (with his duality *en soi*/*pour soi*). Sartre had probably read or heard of the German book (he does not mention it). Von Weizsäcker was both a physician trained in neurology and internal medicine, and a researcher with a laboratory besides his clinic at the University of Heidelberg. His clinical practice was innovative, he introduced psychosomatic techniques, he had a theory of the patient both enduring (passively) and managing (actively) her disease. Finally, he developed a general philosophy of what it is to be human, that he calls a theory of the *split person*: "a human being is a thing (to be) *linked with* a subject (to feel, to be moved)"[79]. That is undoubtedly speculative philosophy based on neuroscience and clinical experience.

At a meeting of the French Philosophical Association, in 1928, there was a controversy between Gabriel Marcel and Léon Brunschvicg. The disputed question was: Why not write novels, rather than speculating on the basis of scientific data? Marcel's opinion was that the rich fantasy of literary imagination is far more exciting than speculation restricted to what would be compatible with science. Brunschvicg answered:

> L.B. What is richer in concrete reality: the universe of imagination or the universe of scientific intelligence? Descartes and Spinoza raised the question. Their answer is straightforward: the universe of imagination is fragmented and its gaps allow for miracles, whereas mysteries fade away as the study of cosmic movements within the double vastness of space and time reveals the unity and solidarity of the real world.[80]

To be sure, writing a doctoral dissertation in the natural philosophy style requires a strong scientific background, and philosophical boldness, but some candidates have recently met the challenge. An experienced physicist defended a thesis in which he proposed a readjustement of Whitehead's cosmologic scheme on the basis of new developments in quantum mechanics.[81] A medical doctor and pediatric surgeon developed a philosophy of pain, strongly rooted in, and very critical of, current (pseudo?) science and practice implying an ontological dualism of psychic and physical pain.[82] In the latter case, the philosophical questioning evidently came from inside clinical science and practice.

5 New Questions, Emerging Styles?

While standard styles are still operational, at least in France, as evidenced by the topics chosen by doctoral students for their dissertations, quite a few samples of mixed styles have surfaced, and new questions are springing up from science itself. Patrick Suppes declared in 1979:

> The tyranny of any single approach or any single method, whether formal or historical, should be vanquished by a democracy of methods that will coalesce and separate in a continually changing pattern as old problems fade away and new ones arise.[83]

That is pretty much what we observe today: a plurality of methods, mixed styles and some new problems.

5.1 "We Need a Philosopher"

A survey of doctoral dissertation topics in France shows that philosophy of science dissertations are a small minority (5%) among philosophy PhDs: the overall majority is history of philosophy. But in the HPS area philosophy has at times been *called for*. Finding that there is a social demand for philosophy of science is gratifying.

Every other year the United Nations publish a *World Population Prospective*. It has become common knowledge that all countries in the world will sooner or later have to face the problem of their population's aging. The French government in 2007 asked a group of experts to devise an "Alzheimer plan". Experts were researchers in neuroscience, and in social science, clinicians, nurses and social workers, economists, hospital managers. They went around asking: "we want a philosopher". A philosopher expert in Alzheimer's disease? There was one. A doctoral student was in the process of defending his dissertation on "Philosophical problems raised by Alzheimer's disease (history of science, epistemology, ethics)"[84]. He was most welcome and helpful in the group. Why had he chosen such an exotic research topic? He happened to know a geriatrist and a biologist working in the field, both had expressed perplexities: how could a variety of senile dementia have virtually become the whole of dementia, what sense did it make to investigate animal models of human dementia, how to respect the autonomy of a person who, as dementia progresses, is losing her autonomy? Those were philosophical questions, issued from a bio-medical milieu, taken up and worked out by a philosopher.

New problems have indeed arised in and about science. Firstly, scientific research is more and more technological, nay industrial, and scientists have developed an awareness (eventually a fear) of their *creative power*. Secondly, the growing and crucial dependence of nations on science and technology for access to basic commodities (water, health, energy) goes with a social control of scientific research (*via* funding or legislation), and a questioning (nay distrust) of scientific expertise, which has deeply modified what used to be called *freedom of research*, and has led to the development of an expertise in the evaluation of research projects, prior to the research being conducted. Thirdly, scientific *rationality* is more and more collective in character, a puzzle for philosophers.

5.2 Science is Creative

Philosophers of science tend to take for granted that science produces statements about the world *as it is*: hypotheses, theories, scholarly papers published in professional journals. It may be the case that "true" statements in physics and astrophysics aim at describing the real world as we observe it. But as soon as 1860, when Berthelot launched "synthetic chemistry", it became clear that chemistry does more than that. Chemistry, said Berthelot, is not only about analysing the natural properties of simple or compound bodies made by nature (as Lavoisier said), it is also about

synthesizing new compounds that nature did not actualize: "Chemistry creates its object of study. Such a creative power is analogous to the power of art; it essentially distinguishes chemistry from natural & historical sciences"[85]. Thus chemical science investigates not only *existing* substances, but also *possible* substances. Chemists do not produce statements only, they enrich the world with new *beings*. Their creativity interacts with nature's spontaneous creativity.

There is ample evidence to show that biology for half a century now has followed the same path, revealing possibilities that were implicit in nature. The phrase "synthetic biology"[86] was introduced in 1980 to mean the use of recombinant DNA technology to produce genetically engineered bacteria. More recently it refers to efforts at *redesigning life*, that is, isolating interchangeable modules in living systems and reassembling them in non-natural ways, with a view to clarify aspects of their functioning which are not easily accessible by mere analysis. Claude Debru parallels the "tinkering around" of human biotechnology and that of natural evolution: researchers take advantage of possibilities that are inherent in nature, they exploit and combine them, they go by trial and error, as does natural evolution; eventually also they freeze at the perspective that they might have triggered off a disaster. Debru's confidence in natural trends has a Leibnizian flavor:

> Common judgement considers some technological innovations as extraordinary. It has not yet been accustomed to perceive their conditions of possibility, inherent in the mechanisms and phenomena of biological evolution. Possibilities spontaneously tend to actualize because they are partially actualized already.[87]

In brief: modern biology creates new beings, new entities which did not previously exist, and which come to inhabit our world, such as genetically modified rice or maize, transgenic tomatoes, chimerical mice. The acceptability of creating, for the purpose of research, hybrid embryos (*e.g*. human sperm, mouse oocyte) or cybrid embryos (transfer of a human nucleus into an enucleated animal oocyte), was hotly debated in England in 2007. The possibility of deriving gametes (sperm and oocytes) from embryonic stem cells, and from those gametes to build "artificial embryos" successfully developing (at least) up to the blastocyst stage, has been established for mice; a similar breakthrough is likely to be achieved sooner or later for human gametes. Our ways of making babies, our conception of parenthood, are being shattered. The problems inherent in such advances cannot escape philosophers of life science. Might they claim that those are mere ethical or political problems, while philosophy of science is essentially theoretical? There is no golden standard keeping philosophy of science from being practical, or testifying to a higher dignity of theoretical philosophy over practical philosophy. Can it be argued that practical problems are the business of philosophers of technology, while philosophers of science should inquire into knowledge processes? Gilbert Hottois has convincingly argued that the acquisition of knowledge nowadays is highly technological, that there is no "pure" scientific knowledge (even in mathematics) completely isolated from techno-science, and that there is in our technoscience a "technopoiesis", or even a "technopoetry"[88], well worth the philosopher's attention.

If scientific research is indeed creative, philosophers of science have a right, perhaps a duty, to examine the possibilities opened by science, discriminate between

these possibilities those that they would or would not wish to see actualized, justify their choices. Especially when it comes to human genetics and anthropotechnology, there is space for history of discoveries, speculation on their potential impact on our image of humanity, careful study of the intertwining of methodological and ethical requirements in research strategies, etc. Recent doctoral dissertations in France illustrate a renewal of interests and a diversity of mixed styles. There was an essay on the technological remodeling of the human body (exploration of actual possibilities, criteria for judgement): "From biomedicine to anthropogeny. Epistemological and ethical reflection"[89]; a questioning of the notion of *genetic fate*, in the context of prenatal or preimplantation diagnosis of hereditary diseases: "Free choice and individual fate. Concepts and problems within predictive medicine"[90]; an incisive analysis of the impact of risky transplantation techniques: "What is at stake in liver transplantations with living donors"[91].

5.3 Freedom of Research vs. Human Dignity

It is disquieting to observe that in Europe it has been, so far, impossible to get a consensus on which type of research should, or should not, be permitted in life sciences. Indeed, there have been examples of a world consensus on the prohibition of research on weapons of mass destruction (*e.g*. biological), of which it is well known that it was secretly disobeyed. The point here lies elsewhere. In France the use of the technique of somatic cell nuclear transfer has been prohibited by law, and the researchers who would use it would be heavily punished. Ireland and Italy are on the same line. In the United Kingdom the Human Fertilization and Embryology Authority has given explicit permission to some research groups to use that technique. Sweden and Belgium would be inclined to go the British way. What is at stake? Human dignity. Do we have different conceptions of human dignity, or a different appreciation of the technique? Such a question is of interest to philosophers of science.

The *Universal Declaration on the Human Genome and Human Rights* (UNESCO, 1997) states that reproductive cloning of human beings is "contrary to human dignity" (Art. 11), and should not be permitted. It does not say that the technique of nuclear transfer is objectionable in itself. It also says that "States should take appropriate steps to foster the intellectual and material conditions favourable to freedom in the conduct of research …" (Art. 14). On the other hand, it is specified that "in the case of research, protocols shall … be submitted for prior review" (Art. 5). Authorities in charge of scrutinizing the research protocols will therefore have the responsibility of deciding whether the research is compatible with "respect for the human rights, fundamental freedom and human dignity …" (Art. 10).

A doctoral student had the opportunity to observe such an authority at work. It is a committee in charge of examining research protocols in epidemiology, the advice of which conditioned the granting of a permission to use, for the purpose of the research, nominative lists of sensitive data about people's health. The commit-

tee's basic assumption was that using the data to serve a bad protocol would be an insult to the dignity of the subjects. As a consequence, the scientific quality of the protocols had to be evaluated. And the members of the committee had developed an expertise at discriminating reliable protocols from poor ones:

> How to identify a phony research protocol which complies only apparently with scientific requirements? What are the exact criteria allowing to distinguish good science from trash science? Is there a consensus on what a bias would be, which compromises the credibility of a research protocol? Such questions do not arise when one writes the history of mature science, of scientific endeavours having survived a multiplicity of selection procedures.[92]

The doctoral dissertation is about demarcation between science and pseudo-science in that context. It identifies three kinds of demarcation criteria (epistemic, non-epistemic, peri-epistemic), and shows how the *ethos* of epidemiological research defines itself. What is new here is that the (complex) criteria are extracted from an empirical observation of epidemiologists at work, instead of being conceived a priori.

5.4 The Collective Character of Scientific Rationality

Ludwik Fleck pointed to the "style of thought" inside science, and to the dependence of individual scientists on a "thought collective"[93]. This was interpreted by Kuhn as prefiguring the notion of "paradigm". Perhaps there is more to it than that. No individual researcher today can assimilate the whole of science, even within her own domain of research. Within large research projects, each individual contributes her particular expertise, and *trusts* her partners for their expertise. At the individual level, scientific knowledge is in fact a mixture of knowledge, belief and trust. The overall rationality of an enterprise such as the Human Genome Project is dependent on the collective functioning of a group. Detailed studies are needed, at the crossroads between sociology of organizations, logic and psychology of human interactions, and collective ethics, of the ways various expertises adjust. In our "philosophy of science" book we had a chapter on "the intersubjective construction of scientific objectivity"[94]. In his essay on the evolution of reason Bertrand Saint-Sernin[95] analyses the social conditions, the epistemological basis and the anthropological foundations of the new rationalism.

The scientific community is fragmented: each field scrutinizes one sector, from one perspective, with its own methods; but the scientific community has learned how to work collectively, and pays attention to junctions between domains, making it possible to eventually reassemble pieces of knowledge with a view to maintain a coherent representation of the natural world. The community of philosophers of science is also fragmented; the coherence of its rationality may depend on its capacity to bring individuals to complement each other within collective research projects. Alasdair McIntyre once wrote:

> The building of a representation of nature is, in the modern world, a task analogous to the building of a cathedral in the medieval world or the founding and construction of a city in

the ancient world, tasks which might also turn out to be interminable. To be objective, then, is to understand oneself as part of a community and one's work as part of a project and part of a history.[96]

Endnotes

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2 Bachelard, 1953, Intr. "Phénoménologie et matérialité", § VIII: "la science n'a pas la philosophie qu'elle mérite".
3 Bachelard, *Ibid*.
4 Martin Heidegger, 1954, I, 1.
5 Paul Valéry, 1929, "Léonard et les philosophes": "Notre époque a vu la métaphysique surprise par les variations de la science de la manière la plus brusque, et parfois la plus comique. C'est pourquoi il m'est arrivé de penser que si j'étais philosophe, je m'attacherais à rendre ma pensée philosophique indépendante de toutes connaissances qu'une expérience nouvelle peut ruiner".
6 Stephen Toulmin, 1982, pp. 736–750.
7 René Descartes, 1644–1647, Preface: "Ainsi toute la philosophie est comme un arbre, dont les racines sont la métaphysique, le tronc est la physique, et les branches qui sortent de ce tronc sont toutes les autres sciences, qui se réduisent à trois principales, à savoir la médecine, la mécanique et la morale; j'entends la plus haute et la plus parfaite morale, qui, présupposant une entière connaissance des autres sciences, est le dernier degré de la sagesse". p. 14.
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28 Cournot, 1851, chap. XXI, § 329.
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36 Hans Reichenbach, *The Rise of Scientific Philosophy*, 1951.
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