Metaphysics and Ideologies in Science

Teresa CASTELÃO-LAWLESS[*]

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Abstract. What counts as scientific ideology for Canguilhem and Kuhn is functionally distinct. However, in this article I argue that metaphysical and other non-scientific beliefs brought about by scientists into their research traditions and that Kuhn sees as generating scientific change coincide closely with Canguilhem's conception of scientific ideology. Kuhn failed to describe clearly those ideological and metaphysical elements influencing the work of science. He chose to focus on psychological factors intrinsic to paradigms and present in paradigm shifts and in scientific revolutions and also in the internal mechanisms of science itself such as the discovery process. Canguilhem triangulated scientific ideologies with the traditional demarcation criterion between science and non-science and with the intertwining of practice, theory, and external (social) beliefs in scientific thought while distancing himself from the psychological dynamic in science characteristic in Kuhn's work. Their views are complementary.

Keywords: metaphysics; scientific ideologies; demarcation criterion in philosophy of science.

Canguilhem on Scientific Ideologies and Science

George Canguilhem's *Ideology and Rationality* is an example of Bachelardian scientific epistemology applied outside of physics and chemistry. In this work, Canguilhem analyzes the role that scientific ideologies play in the emergence and in the development of physiology, biology, biochemistry, genetics, medicine, etc. He addresses the gradual independence of those scientific disciplines from their hold on ideologies, their evolution toward rationality, and the influence that they (and their corresponding ideologies) exert on each other. The book is also a study on a special type of demarcation criterion in philosophy of science. The traditional, positivistic criterion of demarcation had been between science and non-science (which included ideology, metaphysics,

[*] Philosophy Department, LSH 215, Grand Valley State University Allendale, MI 49401–9403, USA. E-mail address: Castelat@gvsu.edu

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religion, and pseudo-science). Canguilhem's demarcation is that between non-science („false science", which includes religion, superstition, and magic), scientific ideologies (which are neither quite science nor quite non-science) and science. To him, a scientific ideology is in rupture with non-science. A mature science is also in discontinuity with the scientific ideology, with the social ideology, or with a neighboring science which provided it with its initial narratives and models, and also with a network of particular beliefs about objects of the world. Science is impossible without ideologies because they develop in the context of cultural *zeitgeists* that furnish them with their first expectations and with the first problems that their theoretical and experimental work is supposed to solve.

Canguilhem claims that the term „scientific ideology" should not be confused neither with Marxist ideology as it had been applied to economics and to politics, nor with Marx's „false consciousness" (Canguilhem, 32). This is because, to Marx, class ideology is supposed to disappear once history evolves into a classless society. But this does not happen in the case of scientific ideologies. First, a scientific ideology is not the same as the ideology of a scientist, as capitalist ideology had been the ideology of the capitalist (Canguilhem, 38). Second, ideologies are the historical precursors of science. They „(…) come to an end when the place it occupied is taken over by a discipline that operationally demonstrates the validity of its claim to scientific status." (Canguilhem, 33). In other words, science is verified scientific ideology. An example is Greek atomism which „claimed scientific status for their physics and psychology" (Canguilhem, 33). Third, when science emerges from an ideology, the place that it occupies in knowledge does not overlap exactly with the place occupied by the corresponding ideology. This means that there will always be a space for ideology side-by-side with science. Fourth, awareness of the distinction between scientific ideology and science only occurs retrospectively, from an outsider's standpoint. Worldviews provided by scientific ideologies are all-pervasive. They are intrinsic to science itself [2]. Scientists always think that they are doing science and that their knowledge is neutral in relation to their objects of observation, to their ideological biases, and to their society. Canguilhem argues that, often and unbeknownst to them, scientists transform a

[2] This view of Canguilhem is similar to Gaston Bachelard's and Michel Foucault's „systems of thought".

scientific ideology or a false science into a science or, on the contrary, they prevent a science from becoming more rationally grounded.[3] Because scientists are unaware of the non-neutrality of their scientific ways of thinking and knowing, they cannot detect like historians and philosophers do, the gradual separation between „perished history", and „sanctioned history" in the evolution of scientific knowledge.[4]

In *Ideology and Rationality*, Canguilhem delimits the conceptual role of scientific ideology and therefore provides a first definition of the term. He asks: „Is the notion of scientific ideology relevant? Is the term a suitable one to designate and properly delimit the whole range of discursive structures claiming to be theories, the whole variety of more or less consistent representations of interphenomenal relations, and the whole spectrum of more or less permanent structures in terms of which men have interpreted their everyday experience? In short, is it a useful way of denoting those pseudosciences whose falsity is revealed solely by the fact that a genuine science has been established to refute their claim? (Canguilhem, 29). His answers to these questions are all in the affirmative. But he also warns that we must be careful with a tendency to connect scientific ideologies with pseudoscience alone. Ideologies are not necessarily pseudoscience, even though like pseudoscience, a scientific ideology will use scientific terminology in domains that have yet to be made scientific. The reason for such use is that „the existence of scientific ideologies implies the parallel and prior existence of scientific discourses" (Canguilhem, 32). It is therefore not surprising that ideologies will appropriate the terminologies of those sciences. They „run parallel" with each other, and the development of one implies the reformation of the other (Canguilhem, 57).

Scientific ideologies include all kinds of perceptions about nature that are not yet corroborated by evidence but which do have the function of guiding our thoughts about it. So, our belief that we can sharply separate „ideology" from „science" is mistaken, since ideologies grow concomitantly with science. Furthermore, epistemological ambiguities and

[3] Bachelard would call impediments to progress such as this „epistemological obstacles".

[4] These two categories are Bachelardian. „Perished history" of science means rejected science or non-science, such as the phlogiston theory. „Sanctioned history" of science is science which transcended history and became accepted as real science, such as Newtonian mechanics.

other conceptual blurs in the mind of the scientist are always present and are indeed inherent to knowledge building practices. The separation between scientific ideology and science cannot be made while knowledge is being constructed, but only when the first is supplanted by the second. For instance, „the seventeenth-century ideology of hereditary transmission" (Canguilhem, 35) was supplanted by the Mendelian theory of heredity, and „the nineteenth century scientific ideology of evolutionism emerged from generalizations of the principles of embryology and deduced from the law of conservation of energy." (Canguilhem, 36). But ideology never disappears from scientific contexts because they are part of the social worldview where sciences appear. In fact, the existence of scientific ideology and its intertwining with science a mixed blessing, for it is „both and obstruction to and a necessary precondition of progress" in knowledge." (Canguilhem, 32). As Bachelard would put it, they are epistemological obstacles to science but simultaneously their appearance in the act of knowing is a matter of functional necessity.

To Canguilhem, progress in scientific knowledge becomes visible only when scientific ideologies are falsified at a later time. And ideologies are only identified when science develops and becomes liberated from their hold (usually by collapsing into forms of knowledge that are in their turn also ideology-forming). This is what happened in the case of the theory of evolution. It „has changed since the time of Darwin, but Darwinism is an integral part of the history of the science of evolution. By contrast, evolutionist ideology is merely an inoperative residue in the history of the human sciences." (Canguilhem, 38). This claim also implies that scientific knowledge is created by particular historical and ideological circumstances, and that it is from them that their initial interpretative and explanatory models are derived. More examples of scientific ideologies include atomism, naturalism in medicine, materialism, certain disease theories, etc.

Other definitions of scientific ideology demarcate it further from both non-science and science. Here is a summary provided by Canguilhem himself:

a. Scientific ideologies are explanatory systems that stray beyond their own borrowed norms of scientificity.
b. In every domain scientific ideology precedes the institution of science. Similarly, every ideology is preceded by a science in an adjunct domain that falls obliquely within the ideology's field of view.

c. Scientific ideology is not to be confused with false science, magic, or religion. Like them, it derives its impetus from an unconscious need for direct access to the totality of being, but it is a belief that *squints* at an already instituted science whose prestige it recognizes and whose style it seeks to imitate." (Canguilhem, 38)

To Canguilhem, the difficulties that occur when we try to distinguish ideology from science come from the fact that ideologies are not perceived as ideologists by scientists themselves. They are only identified as ideologies when what was thought to be science is discovered to be instead a piece of pseudoscience, a badly-founded science, „inauthentic science," or knowledge aspiring to be science. However, they are never taken by Canguilhem as non-science or as false science. This is because he realized that they hold a crucial role in the epistemic development of science itself.

As we will see, in *The Structure of Scientific Revolutions*, Kuhn tends to be vague as to where ideologies and metaphysics of nature come from. He acknowledges that a paradigm can start by appropriating a prevalent metaphysics from society, and also that each school of thought (the pre-paradigm stage) has its own metaphysics of nature or ideology. But he never specifies exactly how or why this happens except that it occurs when there is the need to explain a set of phenomena in the absence of a common core of beliefs to help direct research. Furthermore, he is careful to point out that his model of science is limited in its applications. First, it does not include the influence of social forces in the development of science, or in paradigm shifts and revolutions.[5] Second, he does not think that the model should be applied to the understanding of the evolution of mathematics or that of combined disciplines such as biochemistry, the latter of which „arose by division and recombination of specialties."(Kuhn, 15) On the contrary, in *Ideology and Rationality* Canguilhem is very specific about the role of social elements at the root of scientific ideologies, and he dwells extensively on the evolution of patterns of 'composite' sciences such as anatomo-pathology; medical statistics, biochemistry; and microbiology. Furthermore, he explains that

[5] The historiography of *The Structure of Scientific Revolutions* is internalistic. This does not mean that Kuhn is always an internalist historian of science. He recognizes that social elements are important to understand the development of science but indicates that he will not address them in the book. On the other hand, his *The Copernican Revolution* (1957) is a good example of externalist historiography of science.

particular sciences can become scientific ideologies when their standards of assertability extend to emerging scientific fields or when they become independent from their ideological and social roots. This happens when an epistemological break with an ideology occurs or a new epistemological domain begins. Also, sciences can have a direct or an indirect role in the formation of other ideologies and other scientific fields. The invention of chemotherapy, for instance, was the indirect result of cellular biology and the direct result of bacteriology.

The influence of Aristotelian ontology and teleology on embryology and animal biology exemplifies to Canguilhem the influence exerted by ideological principles that are external to science itself. He also shows that particular ideologies such as mechanism have had an important heuristic value that went beyond the one originally ascribed to it by physicists in the seventeenth century. On the other hand, ideologies can equally well constitute „epistemological obstacles" to the advancement of science. Examples of the former include the relation between medical theory and therapeutics via chemotherapy, the relation between heliocentric cosmology and Darwinism; or the relation between the ideology of heredity and the science of heredity. An example of the latter is the obstacle that a particular conception of biology had on the elaboration of the concept of physical regulation. Finally, he identifies extra-scientific reasons which have led groups of scientists from different countries to accept or reject particular sciences and scientific ideologies on purely preferential, philosophical grounds. The contention between French vitalists and German romantics is an example among many others.

The speculations of Canguilhem regarding the transfer of social class stereotypes into scientific judgments are particularly insightful as they give some consistency to Kuhn's later speculation about the social roots of scientific metaphysics of nature. Canguilhem argues, for instance, that Claude Bernard's methodological discourse in medicine is composed of two inseparable concepts: theory and progress. He then goes on to say: „Add to this the two concepts of determinism and action – knowledge of the one being essential for success of the other – and you have the four components of a medical ideology that clearly mirrored the progressive ideology of mid-nineteenth-century European industrial society." (Canguilhem, 61). The medicine of Bernard is, therefore, „a definitive model of what medicine in an industrial society ought to be" (Canguilhem, 62). The same thing happened with chemotherapy. It could

have not existed „without a certain level of scientific and industrial society" (Canguilhem, 68).

Despite some historiographical similarities between the epistemological models of science of Canguilhem and Kuhn, the former is careful to point out that historical contexts do not entail that medicine or the sciences are merely 'socially constructed'. It is easier to infer relativism from a Kuhnian approach to science. In *The Structure of Scientific Revolutions*, Kuhn claims that progress in science exists inside of paradigms only, and results from the accumulation of elements and their articulation by scientists doing 'normal science'. A scientific revolution, on the other hand, does not imply that science progresses (in traditional sense) as much as that it represents a radical shift in rationally and empirically incommensurable scientific world views. Canguilhem builds the epistemological path from ideology to science and calls it the „conquest of rationality." One cannot have, he says, two types of chemistry with „opposing premises," one for physicians and another for pharmacologists. One could then say that, while scientific ideologies are socially constructed, the sciences are ideologies which transcend their cultural contingency by way of their consistency, experimental confirmation, critical rationalism, and „methodological exigency." It remains that „the characterization of a certain set of observations and deductions as an ideology came after the disqualification of its claim to be a science; this was accomplished by the development of a new discourse, which circumscribed its field of validity and proved itself through the consistency of its results." (Canguilhem, 36). For Kuhn, on the other hand, a paradigm shift is not an evolution towards increased rationality, but a qualitative change in the way scientists look rationally and critically at the same things or at different things according to shifts in paradigm commitments.

Canguilhem's epistemological strategy solves an important difficulty in Kuhn's approach to science. Kuhn accepts that scientists in current paradigms take previous paradigms as instances of error which were falsified by a new approach. But, historically speaking, he claims there are no substantial structural differences between paradigms. In fact, they all share the same elements: an ontology, a metaphysics, a methodology, a research tradition, tacit rules, instrumental, experimental and ideological commitments, anomalies, etc. Only incommensurability makes one think of Aristotelian theory of motion as non-science. In fact, it is as valuable a science as Galilean or Newtonian theories of motion were sciences. They

all fulfilled within the context of their time a similar explanatory role. They were coherent, predictive, and they implied all sorts of metaphysical, observational, and instrumental commitments.

In the model of science offered by Canguilhem, the dichotomy between the perceptions of science by scientists and that of historians is dissolved, since the ideal of scientific progress remains unchallenged in both reference frames. According to Canguilhem, both scientists and historians accept without a doubt that what had been taken in the past as science is now identified as a scientific ideology. These ideologies will be seen as the intellectual antecedents of science itself, always located in rarefied field between desire to know and methodology, between assumption and verification.

Kuhn on Ideology in Scientific Paradigms

The uses that Canguilhem and Kuhn make of „ideology" have little in common. Kuhn developed what he called his „generally structuralist leanings" regarding science with the help from revolutions of incommensurable paradigms and from a deconstruction of scientists' shared commitments *vis-à- vis* belief systems. Furthermore, while Canguithem tries to dissect the hold that ideologies have on the legitimation of scientific theories, Kuhn devotes his attention to the structure of science itself and to shifts of scientific world views, which always incorporate metaphysics.

Kuhn does not use the term „scientific ideology." But he uses the term „ideology" once in *The Structure of Scientific Revolutions*. While referring to scientists' education, he argues that „the deprecation of historical fact is deeply, and probably functionally, ingrained in the ideology of the scientific profession, the same profession that places the highest of all values upon factual details of other sorts" (Kuhn, 137). Here, „ideology" is taken negatively as a cause of scientists' disinterest in the past of their fields of expertise, and positively as a restriction imposed from within science itself by a need to focus on present factual pursuits. Kuhn never mentions „ideology" in the Postcript to *Structure* or in another book on the socio-historical philosophy of scientific change with which Canguilhem was apparently familiar, i.e., *The Copernican Revolution* (1957).

Interestingly enough, Kuhn does appeal to the role of ideology in science in less well-known texts which were published between 1965 and 1969,

and again in 1990. There, Kuhn responds at length to criticisms of his model of science put forth by Karl Popper, Imre Lakatos, Paul Feyerabend and Stephen Toulmin. In the case of the 1960s essays, the attacks by his critics are mostly directed toward Kuhn's model in *The Structure of Scientific Revolutions* .In the 1990 essay, Kuhn adds new insights to the model as well as amends original positions in light of both those criticisms and the intellectual developments he had already initiated at the time of the Postcript to *Structure*. He also uses that essay to address the possibility of cognitive evaluation (assessment of objectivity) despite incommensurability of world views, and to attack what he considered to be the extreme postmodernist view of science that he saw emerging from another instance of misinterpretation of his work.

To positivists and their intellectual descendants, science becomes increasingly better at representing (or „approximating") reality by getting rid of the extra-scientific elements with which it is easily infected. Therefore, over time science becomes more rational and more objective (epistemologically this would be akin to the „correspondence theory of truth). The picture of scientific practice offered by Kuhn, which includes the theory-ladeness of experimentation, the incommensurability thesis, and the techniques of mass persuasion required for paradigm shifts, seems to destroy those ideals which had been inherited from the Enlightenment and which continued to be part of positivistic accounts throughout the nineteenth and the twentieth centuries. To them, and this was part of the positivists' criticism of Kuhn, to accept that science was as prone to error, uncertainty; personal accident, ideology, and power struggles appeared to imply that the production of scientific knowledge resulted exclusively from irrationality, subjectivism, relativism, arbitrariness, and constructivism. This becomes the second context in which Kuhn refers to „ideology." It is also where Kuhn's conception of ideology in science emerges both as a sketchy outline of Canguilhem's and as functionally separate from it.

It is not my purpose here to describe Kuhn's defense against the above charges. But I do find it arresting his appeal to ideology in order to address objections to his model and, concomitantly, to build a strong case for the epistemic success of science despite the near untranslatability of scientific frameworks. In view of claims made by Canguilhem that ideology is not non-science but is indispensable to the emergence of science itself, arguments for objective standards of theory choice also become relevant to Canguilhem's brand of scientific change. In order to

deal with these issues, I think it appropriate to focus on Kuhn's qualifications of „ideology" in the post-*Structure* essays. I also show that Kuhn's „ideology," contrary to Canguilhem's „scientific ideology", does not stand as a distinct epistemological category.

The list of uses of „ideology" in science offered by Kuhn is the following:

In the1965-1969 essays:

1. „…train [people] in some science and in the specialties relevant to the choice at hand; imbue them with the value system, the ideology current in their discipline […] and finally let them make their choice." (Kuhn in Conant and Haugeland, 131).
2. „[Our] common use of explanatory principles […] [is] ultimately sociological or ideological in structure." (Conant and Haugeland, 131).
3. „Judgments of value (...) [are] imperatives which commit scientists to making certain sorts of decisions […]" and „specify ideological commitments which scientists must share if their enterprise is to, succeed." (Kuhn in Conant and Haugeland 133).
4. „The effects of a shared ideology are less uniform [that of shared algorithms]" because „group behavior will be affected decisively by the shared commitments, but individual choice will be a function also of personality; education, and the prior pattern of professional research" (Kuhn in Conant and Haugeland, 134).
5. „All scientists must be taught- it is a vital element in their ideology - to be alert and responsible to theory breakdown" (Kuhn in Conant and Haugeland, 142).

In a 1990's essay:

6. „What has emerged for me as essential is not so much the details of historical cases as the perspective or the ideology that attention to historical cases brings with it. […] Beliefs are already in place. […] For the historian, no Archimedian platform is available for the pursuit of science other than the historically situated one already in place." (Kuhn in Conant and Haugeland, 95).

It is clear from the above list that Kuhn defines „ideology" in two different ways: a) as a perspective („explanatory principle") in science studies, namely historical sociology of science; and b) as the web of commitments, beliefs, and values that scientists share as a group, and

which they „must be" taught in the course of their education in a discipline so that they accept it during their professional initiation and throughout their research practices. The use that Kuhn makes of „ideology" in *The Structure of Scientific Revolutions* belongs to b).

The first type of definition is analogous to Canguilhem's position, even taking into account that Kuhn renounced the identification of his work with sociological studies of science. Just as Kuhn, Canguilhem believes that history of science must incorporate the study of ideologies and how they have shaped scientific interpretations of reality. To both Kuhn and Canguilhem, history also reveals total or partial „epistemological ruptures" between past and present science. Because of this intellectual insight, both agree that historians must look into past scientific practices on their own terms, that is, in relation to the context of discovery in which they have occurred and in which they were legitimized. Kuhn, for instance, claims that recent historians are right when they ask „not about the relation of Galilean views to those of modern science, but rather about the relationship between his views and those of his group" (Kuhn, 3).

But it is the second type of usage that is more interesting, because a look at the conception that Kuhn has of „ideology" in science seems to resemble a weak version of Canguilhem's „scientific ideology" This is hardly the case. To Kuhn, ideologies are necessary components of science itself, even when it has matured into a paradigm. They are part of a shared background of assumptions which guide scientists in their research and their assumptions about the physical world. They help them assess their practices and thus build consensus over theory choice. Ideologies are, therefore, essential to the coherence of justified true belief. To Canguilhem, scientific ideologies are also providers of background assumptions: But, contrary to Kuhn's explanation, they are just appropriating the epistemologically ambiguous space to be later occupied by a science. Ideologies are not to Canguilhem, as they are to Kuhn, embodiments of values expressing consensus in the scientific community and reached from collective psychology This distinction does not imply, however, that Kuhn failed to reflect on issues considered of the utmost importance to Canguilhem and that he analyzed with the help of the concept of „scientific ideology".

Kuhn's Metaphysics and Canguilhem's Ideology

What Canguilhem calls, in *Ideology and rationality*, „scientific ideology" is what Kuhn calls, in *The Structure of Scientific Revolutions* and in its Postcript, „metaphysical" expectations and commitments to beliefs about nature. In his book, Kuhn ascribes different roles to „metaphysics". Metaphysics are: 1) intrinsic to paradigms where they help guide scientific research; 2) a basic component of those competing „schools of thought", which antecede the emergence of a first paradigm; 3) present in times of „extraordinary science" when a paradigm enters into crisis; and 4) part of the „disciplinary matrix" of a scientific field.

It is easy to see that the role of metaphysics in definitions 1), 2) and 3) resemble the functions that Canguilhem ascribes to scientific ideologies. While talking about schools of thought, Kuhn argues that „each of the corresponding schools derived strength from its relation to a particular metaphysics," and also that „no natural history can be interpreted in the absence of at least some implicit body of intertwined theoretical or methodological belief that permits selection, evaluation, and criticism" (Kuhn, 12). If that body of beliefs is not already implicit in the collection of facts - in which case more than „mere facts" are at hand - it must be externally supplied, perhaps by a current metaphysic, by another science, or by personal and historical accident (Kuhn, 16 -17). Canguilhem says about scientific ideologies what Kuhn says here about metaphysics: they are not science yet, they occupy the place of what later becomes science, and they provide, at least for a while, knowledge of a special type. It can be a science or an ideology, but not a non-science. It still must be present for science itself to emerge and to develop its explanatory models.

Like Canguilhem's ideologies, metaphysical commitments for Kuhn can be elements of a science which were transferred into a new epistemological domain. Kuhn admits, for instance, that „gradual assimilation of Newton's gravitational theory led chemists to insist that gain in weight must mean gain in quantity of water" (Kuhn, 71). Later, he also says „the seventeenth century's commitment to mechanico-corpuscular explanation proved immensely fruitful for a. different number of sciences, ridding them of problems that had defied „generally-accepted" solution and suggesting others to replace them" (Kuhn, 104). Similarly, Canguilhem wrote that botanists in the seventeenth-century did research in vegetable physiology with the help

from models of contemporary models of animal physiology. Both Canguilhem and Kuhn regard such transfers of information as typical of the process of normal knowledge production. They contribute to what Kuhn called the „essential tension" between alternative explanations without which normal science and radical developments or revolutions in science could not occur.

Just as in the case of Canguilhem's scientific ideologies, Kunh's metaphysics become visible when a paradigm enters into crisis. In the context of „extraordinary science," those tacit „rules that have guided particular normal - scientific [traditions]" are loosened (Kuhn, 46). This is when scientists' discussions, imbued with metaphysics or „debates over fundamentals," become more philosophical than scientific (Kuhn, 88 and 91). Also, Kuhn remarks that an effect of crisis is that „the research it guided resembled that conducted under the competing schools of the pre-paradigm period" (Kuhn, 72). Here we are back to Canguilhem's conception of scientific ideology as initiator of scientific narratives.

In the Postcript to *The Structure of Scientific Revolutions*, Kuhn substitutes the term „paradigm" for that of „disciplinary matrix." In a disciplinary matrix, metaphysical beliefs play an important role in science, one which is again analogous to Canguilhem's scientific ideologies. Components of a disciplinary matrix include: „symbolic generalizations," „metaphysical parts," and „values". Metaphysical parts are „shared commitments to such beliefs as: heat is the kinetic energy of the constituent parts of bodies; all perceptible phenomena are due to the interaction of qualitatively neutral atoms in the void, or, alternatively, to matter and force, or to fields [...] such commitments as particular beliefs in particular models all models […] have similar functions. Among other things they supply the group with preferred or permissible analogies and metaphors." (Kuhn, 182-4). Canguilhem also thinks that metaphors and analogies are important frames for the construction of (pseudo) scientific narratives.

Just as Kuhn, Canguilhem takes ideologies as embodiments of belief about the natural world and about science, and argues that both types of belief have a strong effect on how research is undertaken by scientists. But the analogy stops here. For, as we have seen, what Canguilhem identifies as scientific ideologies, like „mechanism" or „atomism" are taken by Kuhn as metaphysics of nature. Furthermore, Kuhn argues that

ideological commitments (and, in some cases, metaphysical ones) are intrinsic to scientists' value systems. Through education, they become part of the psychological make-up of scientists which then interpret and apply them, and where individual applicability generates important intellectual tensions that are fruitful for the production of knowledge. Values are heuristic devices without which scientific judgments over theory choice cannot be made. Examples of these values include fertility, clarity; accuracy, and „judgments of simplicity; consistency, plausibility" (Kuhn, 185). To Canguilhem, ideologies are heuristic tools but only until something better, i.e., more rationally grounded, comes along. Also, they are to him complete world views rather than networks of values. Kuhn's ideologies, i.e., beliefs held by scientists about criteria for theory choice, cannot stand independently from scientific paradigms as scientific ideologies do in relation to Canguilhem's good science.

Conclusion

To Canguilhem, ideologies are in-between science and philosophy but intertwined with science; they are outside of science (because they are pseudo-science) but exert pressure on it from both within and without. Nevertheless, they constitute a fundamental influence in how scientists learn to think scientifically. Ideologies are initiators of scientific knowledge and can be instruments of scientific change. Contrary to Kuhn's ideologies, they tend to disappear from the domains upon which they have exerted their influence once a scientific field reaches its maturity; i.e. when it conquers its own methodological and rational standards of critical objectivity. But to Kuhn, rationality is only one scientific value among many, not that for which science ultimately aims. In this case, ideology and metaphysics are omnipresent in the scientific process itself and therefore in every paradigm's research tradition. One does not get rid of ideology or of metaphysics just because a domain became scientific. But to Canguilhem, one has to rectify an ideology in order to make knowledge become science.

In spite of a resemblance between one's „ideology" and another's „metaphysics," Canguilhem's and Kuhn's conceptions of ideology remain distinct in respect to their socio-psycho-logical foundations, their epistemological location, their function, and their permanence in the evolution of scientific knowledge. It is possible, however, to see their models complementing each other. Specifically, Canguilhem completes

Kuhn's speculation on the sociological roots of metaphysics of nature while preserving a neo-positivistic sense of scientific progress that Kuhn's model did not succeed in asserting unequivocally. Canguilhem explains how the sciences feed off of each other and develop in unexpected ways, and how science is culturally contingent but prone to transcend relativism toward universality of standards. He also gives a dynamic picture of how several sciences relate to each other and to ideologies at different stages in their parallel but asymmetrical evolutions. This is more realistic than Kuhn's one-paradigm-at-a-time construct.

Kuhn, on the other hand, shows that what Canguilhem sees as definitive science may still be prone to radical conceptual changes, albeit, and quite problematically, without loss of scientific status. He also addresses important issues which are ignored by Canguilhem, such as how scientists reach consensus regarding what counts as „rational" science, how individual creativity and other personal accidents foster tensions between incommensurable scientific standpoints that are crucial to science's evolution toward objectivity, and how belief systems within science are not signs of ideological infection to be shed over time. Their models are complementary.

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