MAN OF SCIENCE, MAN OF FAITH: PIERRE DUHEM'S "PHYSIQUE DE CROYANT"

by Robert J. Deltete

Abstract. The essay "Physique de croyant" is an important statement of Pierre Duhem's position on the relation between his science and his religion. Duhem trod a difficult path, some might say an impossible one, in Republican France because he was both a physicist and a devout Catholic. In this essay, using "Physique de croyant" as a touchstone, I explore the way in which he tried to reconcile his conflicting allegiances. There are several strands in Duhem's strategy that need to be teased out. First, Duhem sought to defend his science against the charge that it was materialist and atheist. He did this with his claim, usually called the autonomy thesis, that physics and metaphysics are fundamentally different enterprises—that physics, properly conducted, has no metaphysical implications and requires no metaphysical support. This did not deny metaphysics its rightful territory. Second, Duhem used his segregationist position to defend the Roman Catholic Church against the assaults of the positivist scientism then in favor with the Republicans. Third, he also sought to protect his science against fellow Catholics who wanted to use it for polemical purposes. I develop and evaluate these lines of defense.

Keywords: Pierre Duhem; natural classification; Abel Rey

In a 1904 review of Pierre Duhem's philosophy of science, French doctoral student Abel Rey concluded an otherwise very favorable evaluation with the following remark:

> It has only been our intention here to examine the scientific philosophy of M Duhem, and not his scientific work. In order to find and express precisely that philosophy . . . it seems that we may propose this formula: In its tendencies toward a qualitative conception of the universe; in its mistrust of a complete *explanation* of the material universe in its own terms, as in the dream of mechanism; in

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its loathing, more affirmed than real, of an integral scientific skepticism, it is the scientific philosophy of a believer [la philosophie scientifique d'un croyant].[1] (Rey 1904, 444; emphasis added; quoted in Duhem 1905, 45; 1914, 414)

Given all of the compliments Rey paid Duhem in the rest of his review, this conclusion may not seem very important, but Duhem did not see it that way. He was stung—and alarmed. His reply was a long essay, "Physique de croyant," in two installments a year later, that crystallized his thinking of more than a decade on the relation between the science he practiced and the faith he lived.

Duhem conceded a sense in which his physics was the work of a believer. Indeed, he defiantly proclaimed it:

Of course, I believe with all my soul the truths that God has revealed to us and that He has taught through His Church. I have never concealed my faith, and I hope from the bottom of my heart that He in whom I have that faith will keep me from ever being ashamed of it. In this sense it is permissible to say that the physics I profess is the physics of a believer.[2] (1914, 415)

But this was not the sense that Duhem thought Rey intended. Duhem thought Rey was insinuating that he had been guided, more or less consciously, by his Christian beliefs in his critique of scientific theory, that these beliefs had inclined him to certain conclusions, and that his conclusions would therefore appear suspect to readers concerned with scientific rigor but opposed to spiritualistic philosophy or Catholic dogma.[3] In short, Duhem thought Rey was implying that one had to be a religious believer—*un croyant*—in order to accept both the principles and the consequences of the view of physical theory that he had proposed and defended. Duhem adamantly rejected that reading of his work. In what follows, I explain why and briefly comment on his position. It is a subtle and in many ways challenging one, and I cannot begin to do justice to it here; but I conclude that Duhem's "scientific philosophy" was much more the philosophy of a believer than he conceded to Rey and in a way that is compatible with what Rey wrote about him.

Carving Out a Position

I begin with the explanation. Duhem is difficult to approach. In part this is because he wrote so much, in so many fields, in his short life.[4] He made lasting contributions to physics, to the philosophy of science, and to the history of science—an almost unique achievement. But he is difficult to approach also because the environment in which he lived and wrote was so complex and unsettled—intellectually, politically, socially, and religiously. Duhem lived and worked in the French Third Republic, which he did not like and did not support, and that made him an outcast; he also was a Catholic at odds with most of the intellectually oriented Catholics of the time who were deeply suspicious of him. In consequence, Duhem walked

a tightrope. He spent most of his mature life trying to deal with conflicting claims to his allegiance by carving out an intellectual position that respected both his science and his faith. In spite of his best intentions, he rarely satisfied anyone.[5]

So what is the position Duhem sought to defend? It is best set out, in summary form, in the essay "Physique de croyant" ([1905] 1914), but it is presented more fully in *La théorie physique—son objet, sa structure* ([1906] 1914), which, as it turns out, was in process when Rey's essay was published.[6] He had expressed the main ideas more than a decade earlier in essays that have only recently gotten much attention.[7] The essential feature was a radical separation between physics (more generally, natural science) and metaphysics, including theology. (Call this the Separation Thesis.) A passage from an 1893 essay, "Physique et métaphysique," makes the point clearly:

> Physics is the study of *phenomena* having their basis in brute matter and of the laws relating them.
>
> Cosmology ["the part of metaphysics which treats of non-living matter and that, in consequence, corresponds to physics by nature of the things studied"] seeks to know the nature of brute matter, considered as the *cause* of phenomena, and as the *raison d'être* of *physical laws.*
>
> Between metaphysics and physics there is thus a distinction in kind. (Duhem 1893b, 57–58; emphasis added)

Physics and metaphysics are thus by nature distinct, each having its own goals and methods. A main reason, indicated in the last passage and made more explicit later, is that while metaphysics seeks to be causally explanatory, physics does not; it seeks only to describe and relate the phenomena—to represent them but not to explain them. Duhem had several reasons for sharply separating physics from metaphysics. One was to defend the autonomy of physics, its independence from metaphysics. A second was to protect metaphysics and theology from all of the anti-metaphysical and anti-theological diatribes of the Republican positivists. A third was (this will no doubt seem odd) to discourage fellow Roman Catholics from using the results of science to promote Christian apologetics.

Let me amplify, briefly, each of these reasons. Duhem sought to defend *his* physics, as an autonomous discipline, from the encroachment of metaphysics, which he thought historically had inhibited its fruitful development. He did this most famously in Part I of *La théorie physique*. There he wrote: "A physical theory is not an explanation. It is a system of mathematical propositions [he is clearly thinking only of physics], deduced from a small number of principles, whose aim is to represent as simply, completely, and exactly as possible a set of experimental laws" ([1906] 1914, 24). This approach was positive but not positivist.[8] Indeed, Duhem denied that he was a positivist—someone for whom there is no rationally defensible method apart from that employed in the exact sciences, the positive

ones, so that what is inaccessible to this method is ipso facto unknowable. On the contrary, he thought that, as he put it in the early essay cited above, "The knowledge which metaphysics gives us of things is far more intimate, more profound, than that which is furnished by physics; it thus surpasses the latter in excellence" (1893b, 58).

In separating science from metaphysics, therefore, Duhem was not trying to demarcate sense from nonsense in the manner of earlier and later positivists. He thought that metaphysics, including theology, was a genuine form of knowledge with its own object and method. So he sought to protect it from the positivists. At the same time, he did not embrace the approach of most fellow Roman Catholic intellectuals who were responding to the encyclical *Aterni Patris* of Pope Leo XIII in 1879, which urged the works of Thomas Aquinas as a cure to contemporary scientism and atheism. Duhem did not respect most of the proponents of neo-Thomism and tried to distance himself from them. Some only tried to show that scholastic philosophy could be reconciled with contemporary science; others, however, argued that it had given rise to modern science, and some even asserted that science should be constrained by scholastic wisdom. Always fiercely independent, Duhem bristled.

"Physique de Croyant"

How is this position presented in "Physique de Croyant"? Recall that Duhem began by declaring that he was a believer in the teachings of the Roman Catholic Church, but he interpreted Rey to mean that one had to be a Catholic in order to accept his (Duhem's) physics ([1905] 1914, 414). Duhem denied that. He repeated that his discipline was autonomous, that it had its own goals and methods (pp. 414–15). Indeed, he reiterated his dual claim that his system of physics was "positive" in both its origins and its conclusions (pp. 416–22, 422–28), so it can be (should be) "as much the physics of an unbeliever as a believer" (pp. 427, 441). But he then went to work on the positivists (pp. 428–35), arguing that his view of physics "sweeps aside the supposed objections of physical science to spiritualistic metaphysics and to the Catholic faith" (p. 428). He also went to work on fellow Catholics, arguing that his system of physics carried "no metaphysical or apologetic import" (pp. 435–40). Thus the conclusion to the first five parts of his essay:

> We therefore propose a theoretical physics that is neither the theory of a believer nor that of an unbeliever, but merely and simply the position of a physicist; [while it is] admirably suited to classify the laws studied by the experimenter, it cannot oppose any assertion of metaphysics or of religious dogma, and is equally incapable of lending any support to any such assertion. (p. 441)

Note the two-sided balancing act. This looks like a position that has Duhem arguing that science and metaphysics do not conflict, but only

because they do not meet. He can therefore defend both his physics and his religion by keeping them in separate compartments. This is what the Separation Thesis should tell him to do. But this is not what Duhem does. In the last four parts of his essay, he instead argues that "physical theory has as its limiting form a natural classification" (pp. 445–53), that "between cosmology [the part of metaphysics that concerns inanimate nature] and physical theory there is an analogy" (pp. 452–53), and that the most propitious analogy, for which history had prepared the way, was an analogy between a generalized thermodynamics and Aristotelian metaphysics "shorn of its fossilized elements" (pp. 462–72).

Having worked hard to separate physics from metaphysics, Duhem then worked just as hard to bring them back together via the idea of natural classification (NC). I will not explain here what an NC would consist in except to note two things: first, it would be a physical theory that "reflects" or "mirrors" the underlying ontological order, and, second, the relation would be one of analogy, not identity.[9] Nor will I explain why Duhem thought that a generalized thermodynamics, or energetics, is the most propitious analogy to a generally Aristotelian metaphysics, because that would take me too far afield (but see Deltete and Brenner 2004). Instead, I want to ask why Duhem thought physical theory was approaching an NC at all. When he first introduced the idea of NC in the early 1890s, it was little more than a vague hope based on an appeal to eighteenth- and nineteenth-century debates on proper biological classification (Duhem 1893c, 357–58, 377–78). By the time he composed *La théorie* a decade later, he had formulated several arguments in its favor.

To set the stage for them, recall his definition of theory (above). This is in the interest of intellectual economy. Also in that interest is his claim that "Theory is not only an economical representation of experimental laws; it is also a *classification* of them" ([1906] 1914, 30), although Duhem seems to have thought that this goes beyond what positive method can justify (p. 287). He argues that such classification is not artificial but, rightly pursued, approaches NC: "[It is] the aim of physical theory to become a *natural classification*, [that is,] to establish among the diverse experimental laws a logical co-ordination that is an image and a reflection of the true order according to which the realities that escape us are organized" (p. 41; emphasis added). But that claim, which Duhem thinks the physicist is right to endorse, goes far beyond what he is entitled to claim qua physicist.

How to proceed? Duhem's reply is to say that physicists operate (and should operate) from principles that cannot be justified in terms of their own proper method. One of these is the following postulate: "Physical theory has to try to represent the whole group of natural laws by a single system all of whose parts are logically compatible with one another" ([1905] 1914, 445). Why does physical theory *have to* do that? Duhem's answer is that otherwise the representations of theory would be *only* "convenient

summaries," *only* "artificial devices destined to facilitate the work of discovery" (p. 446). So what? If theory conveniently summarizes current knowledge (intellectual economy) and effectively facilitates the discovery of new knowledge, what more is needed?

Duhem argues that artificial classifications seldom promote (nor do we expect them to) "the work of discovery"; that the classifications actually provided by physical theories have historically promoted this work; and that theory tending to natural classification is the most plausible explanation for this. So the postulate is justified, because its end product, its limiting term, would be NC. This summary indicates two arguments, and suggests a third, for NC that Duhem offered in defense.

The first I call the "argument from the history of science," or, briefly, the "historical argument": The historical development of science testifies to its approach toward natural classification. As Duhem wrote, "Diversity fusing into a constantly more comprehensive and more perfect unity, that is the great fact summarizing the whole history of physical doctrines" (pp. 447–48). But, he added, progressive unification is only on the side of representation, not explanation; metaphysical fashions motivating such explanation come and go, like the ebb and flow of the tide. On the side of representation, he thought, "each theory passes on to the one following it a share of the natural classification that it was able to construct" ([1906] 1914, 48; also 53 and 410–11).

A second argument for NC is what may be called the "successful prediction" argument. Physical theory can predict both particular outcomes of experiment and new experimental laws. But what reason would there be for thinking that such predictions will be confirmed if physical theory is just an artificial classification, an amalgam of useful maxims, without any ontological import? Duhem's answer is: None at all (pp. 36–40, 242, 450–52). Predictive success would be an "incredible accident"—a "miracle." "But *if* . . . we recognize in the theory a *structure* tending toward a natural classification, *if* we feel that its principles express profound and real *relations* among things, *then* we will not be surprised to see its consequences successfully telling about new phenomena and stimulating the discovery of new laws" (pp. 37–38, emphasis added; also p. 451).

A third argument has its basis in the other two but is sufficiently distinct that I consider it on its own. I call this the "aspiration" or "conviction" argument. The basic idea is that the human mind naturally aspires to coherent unity. Natural scientists seek a coherent, unified understanding of the world because they think that the world *is* a coherent, unified whole—a "universe." The argument for NC is simple: If the world is a coherent, unified whole, as scientists (rightly) believe it to be, any adequate physical theory must also be coherent and unified, and so yield, in its limit, an NC.

I now cite a couple of passages that will permit our return to Rey. The first is from "Physique de croyant":

The physicist therefore finds in himself an irresistible aspiration toward a theory that would represent all experimental laws by means of a single system with perfect coherence and unity. . . .

If he wishes to be nothing but a physicist, and *if*, as an intransigent positivist, he regards everything not determinable by the method proper to the positive sciences as unknowable, then he will notice this tendency powerfully inciting his research [but will ignore it], since the only method of discovery he trusts is unable to reveal it to him.

But *if* . . . he yields to the nature of the human mind, which is repugnant to the extreme demands of positivism, *then* he will certainly want to know the reason for—the explanation of—what carries him along; he will break through the wall at which physics stops, helpless, and he will affirm something which its procedures *do not justify*. . . .

What is the nature of this affirmation? He will affirm that underneath the observable data, the only data accessible to his method of study, are hidden realities the essences of which cannot be grasped by these same methods, and that these realities are arranged in a certain order which physical science cannot directly contemplate. But he will note that physical theory, through its successive advances, tends to arrange the laws ascertained through experiment in an order more and more *analogous* to the transcendent order according to which the realities are classified; that, as a result, physical theory has advanced and will gradually advance toward its limiting form, namely *natural classification*; and that logical coherence and unity are characteristics without which physical theory cannot claim to be a natural classification. ([1905] 1914, 448–49)

A second passage is from *La theorie physique:*

Thus, physical theory never gives us the explanation of experimental laws, never reveals realities hiding behind the sensible appearances; but the more it advances and the more complete it becomes, the more we apprehend that the logical order in which theory orders experience is the reflection of an ontological order, the more we suspect that the relations it establishes among the data of observation correspond to the relations among things, and the more we *guess* that theory tends to be a natural classification.

The physicist cannot *prove* that his conviction is correct; the method available to him is limited to the data of observation. Hence, it cannot *prove* that the order which has been established among the experimental laws reflects an order transcending experience. . . .

But this conviction, which the physicist is powerless to justify, is nevertheless one that he is powerless to rid himself of. He cannot believe that his theories have no power to grasp reality, that they serve only to provide his experimental laws with a summary and classificatory representation. He cannot compel himself to believe that a system which is capable of ordering so simply and easily an immense number of laws . . . could be a purely artificial system. Giving way to an intuition that Pascal would recognize as one of those reasons of the heart "that reason does not know," he affirms his faith in a real order that comes to be reflected in his theories more clearly and fully as time goes on.

Thus, an analysis of the methods by which physical theories are constructed makes it completely certain to us that these theories cannot be offered as explanations of the various experimental laws; but, on the other hand, an act of faith . . . assures us that these theories are not a purely artificial system, but tend to a natural classification. ([1906] 1914, 35–36; cf. 151–53)

The Charge of Abel Rey

We return now to Rey and his charge that Duhem's scientific philosophy was the philosophy of a believer. In a brief, very polite, reply to Duhem's essay, Rey tried to clarify what he had meant in calling Duhem's "scientific philosophy" the philosophy of a believer (Rey 1906). What he had intended, Rey said, was to include Duhem in a diverse group of thinkers (such as Kant and Schopenhauer) for whom science was not explanatory (better: self-explanatory) but who thought, nevertheless, that something else—some other discipline—was. These were the *croyants* in Rey's odd use of the word. The *incroyants*, by contrast, were people, such as nineteenth-century mechanists, who thought that science was both explanatory and self-explanatory. Success by the incroyants would "replace all belief, in the usual sense of the word" (1906, 536), but Rey was agnostic and did not align himself with the incroyants. Instead, he alluded to Du Bois Reymond: "The true positivism would be neither *we will not know* (*ignorabimus*) nor *we know* (*scimus*), but [rather] *we don't know* (*ignoramus*), without judging anything further" (1906, 537).

So we ask: Was Duhem's philosophy of science the philosophy of a believer, in Rey's sense? I think it was. Duhem's postulate "Physical theory has to try to represent the whole group of natural laws by a single system all of whose parts are logically compatible with one another" ([1905] 1914, 445) goes beyond what positive method can establish, as does the belief physicists have that their efforts to coordinate and unify will lead to an NC. The latter is, Duhem confesses, a "hope," a "wish," an "act of faith." But belief in NC is not groundless; Duhem offers arguments for it—what I have called the historical argument, the predictive success argument, and the aspiration argument.

How should we view these arguments? Note that they do not, even taken together, constitute a proof, a conclusive demonstration, of Duhem's main assertions—that physical theory should try to represent all natural laws by means of a single, coherent, logical system; that such a system would be an NC; and that this ideal system would reflect the coherent, unified order of the real world. But Duhem never thought that they did; in fact, he is explicit in arguing (not just conceding) that his arguments cannot yield any proof ([1906] 1914, 156, 234). I think Duhem's arguments are best construed as what we would now call inferences to the best explanation—the most plausible, reasonable explanations, given the circumstances. He argued, as we have seen, that such an inference best explains the progressive unification of the natural sciences, the predictive success of physical theories (as well as the failures that motivate improvement), and also the aspiration that theorists have (and have always had) toward coherence and unity. Duhem was fully aware that such things cannot be proved, but he nevertheless thought they were defensible. He rejected the *ignorabi-*

mus and sought, with his idea of NC, a way between the *scimus* and the *ignoramus.* He was, therefore, a *croyant* in Rey's sense.

Still, Duhem evidently was not satisfied with his naturalistic arguments for NC and so often backs them up with an appeal to a quasi-Hegelian "directing idea" ([1903] 1905, 345) or—sometimes quite explicitly—to Providential direction. And then he shows himself, even in his work, to be a *croyant* in a much deeper, clearly religious, sense. Here is a passage that forms the last paragraph of *Les origines de la statique*, first published, coincidentally, in October 1905, the same month as the first part of "Physique de croyant." In it Duhem brings together, triumphantly, fifteen centuries of work in statics.

> How could all these efforts combine with such precision and bring to completion a plan which was not known to the individual laborer, unless this plan existed previously in the mind of an architect, and if this architect did not have the power to direct and co-ordinate the labor of the masons? Even more than the growth of a living being, the evolution of statics is the manifestation of the influence of a guiding idea. Within the complex data of this evolution, we can see the continuous action of a divine wisdom which foresees the ideal form towards which science must tend and we can sense the presence of a Power which causes the efforts to converge towards this goal. In a word, we recognize here the work of Providence. (Duhem 1905–1906, Vol. 2:447–48; see also Duhem 1896, 449)

How should one view this passage—as also an inference to the best explanation? or as the imposition of a religious reading on the historical development? I am inclined to think that it is the latter, so that if Rey did not actually accuse Duhem of importing religious beliefs into the development of physical theory, he rightly could have, because Duhem's view of that development is that of a religious believer.[10]

Conclusion

I have argued that Duhem sought to carve out an intellectual position between two opposing camps, both of which sought his allegiance. He sought to distance himself from positivist Republicans, even while accepting (and promoting) many of the basic tenets of positive science; and he sought to distance himself from Catholic intellectuals who wanted to deploy natural science in the cause of Christian apologetics. Against the former, he insisted on the value and legitimate rights of physical theory by arguing that its classification schemes were tending more and more toward an NC as their goal, a terminus that would reflect the underlying natural order. Against the latter, he argued that his physics was autonomous, that it did not depend on metaphysics—religious-oriented or otherwise. Central to both responses, I have argued, was Duhem's sharp distinction between physics and cosmology—the metaphysics of inanimate nature. This allowed Duhem to protect metaphysics and religion from the positivist scalpel and, at the same time, protect physics from misuse by fellow Catholics.

Duhem sought to separate physics from metaphysics, but, I have argued, he also tried to bring them into contact. The key to this rapprochement was the concept of NC, the idea that physical theory tends to a classification of physical and chemical phenomena that mirrors the ontological order of nature. This is one of a pair of tensions in Duhem's work. The other is that while his "scientific philosophy" offered arguments for natural classification that did not depend on religion, Duhem could not resist bringing Providence back in as the ultimate explanation for the approach of physical theory to NC.

Notes

A version of this essay was presented at the fourth biennial meeting of the History of Philosophy of Science Society (HOPOS), University of San Francisco, 25 June 2004.

1. The translation is mine, as are all the translated passages from Duhem and Rey in this essay.
2. Rey had called Duhem's "scientific philosophy (by which he presumably meant his philosophy of science) the philosophy of a believer and did not evaluate his scientific work. Duhem, however, seems to have thought that Rey was also challenging his physics..
3. "Spiritualistic philosophy": See Gutting 2001, chap. 1, for brief discussions of Félix Ravaisson, Charles Renouvier, Jules Lachelier, and Émile Boutroux. Gutting writes that "Spiritualism has a good claim to be the national philosophy of France" (p. 9).
4. Duhem was born in 1861 and died in 1916. He wrote some twenty-two books and nearly four hundred articles in a career spanning thirty years.
5. The different career trajectories of Duhem and Rey are revealing. After graduation from the École Normale, Duhem went first to Lille (1887–1893) and then briefly to Rennes (1893–1894) before settling in Bordeaux (1894–1916). He was never called to Paris. Rey completed his dissertation in 1907, was appointed professor of philosophy in Dijon in 1911 (Paul 1979, 137 n1), and succeeded Gaston Milhaud in the chair of the history of philosophy and its relation to the sciences at the Sorbonne in 1919. The chair had been created for Milhaud in 1909 (Brenner 2003, 101).
6. The timing may have been important. Rey's essay was published in November 1904. Duhem had already been at work for more than half a year in putting together *La théorie*. It appeared in the *Revue de Philosophie*, starting in April 1904 and continuing thereafter in approximately monthly installments (thirteen in all) until it was completed in June 1905. I conjecture that Duhem was too occupied with writing *La théorie* to reply to Rey immediately, as I think he would have liked to. Instead, he waited. "Physique de croyant" was published in two installments in October and November 1905.
7. Duhem 1892; 1896; Brenner 1990; Ariew and Barker 1996. The best source to consult for an understanding of the time in which Duhem worked is Martin 1991, on which I rely and to which I am much indebted.
8. The standard English translation misrepresents Duhem in rendering the French "positif" as "positivist" or "positivistic." Compare Duhem [1905] 1914, 416, 422, 423, and 428—all from "Physique de croyant"—with the English (1954, 275, 279, and 282).
9. We need to ask, of course, what *analogy* amounts to here. My suggestion is that, in the limit, it is some kind of formal or structural isomorphism. With NC there will be an isomorphism between the representation provided by physical theory and the representation provided by (the relevant part of) metaphysical theory, such that while the representations "correspond" in this (strong) formal or structural sense, there are no reality entailments either way and, in consequence, no bases for correspondence claims to truth. More precisely: A complete physical theory (an NC) would not entail the truth of the ontology to which it is correlated, and a perfected ontology would not guarantee the truth of the NC to which it corresponds. All that may be said is that both have succeeded in arranging the elements of their respective domains in the same order. For a more detailed discussion, see Deltete 2004.

10. In his reply, Rey says only that Duhem is "somewhat unfair" in attributing to him (Rey) the idea that "[Duhem's] metaphysics was absolutely necessary for accepting his doctrine of physical theory" (1906, 535). That is, he refers to Duhem's quasi-Aristotelian natural philosophy, not to his religious beliefs. In any case, Rey did not use the "croyant" label in his dissertation (Rey 1907) to describe Duhem's position, a work that otherwise included—often verbatim—the account of the earlier essay.

References

Ariew, Roger, and Peter Barker, eds. 1996. *Pierre Duhem: Essays in the History and Philosophy of Science*. Indianapolis: Hackett.

Brenner, Anastasios. 1990. *Duhem: science, realité et apparence*. Paris: Vrin.

———. 2003. *Les origines françaises de la philosophie des sciences*. Paris: Presses Universitaires de France.

Deltete, Robert. 2004. "Duhem and Natural Classification: A Critical Appreciation." *Studies in the History and Philosophy of Science* 44:32–78.

Deltete, Robert, and Anastasios Brenner. 2004. Essay Review of Pierre Duhem, *Le mixte et la combinasion chimique*, ed. and trans. with an Intro. by Paul Needham. Dordrecht: Kluwer, 2003. In *Foundations of Chemistry* 6:203–32.

Duhem, Pierre. 1892. "Commentaire aux principes de la thermodynamique." *Journal de mathématiques pures et appliquées* I:8:269–330.

———. 1893a. "Une nouvelle théorie du monde inorganique." *Revue des questions scientifiques* 33:90–133.

———. 1893b. "Physique et métaphysique." *Revue des questions scientifiques* 34:55–83.

———. 1893c. "L'ecole anglaise et les theories physiques, à propos d'un livre récent de W. Thomson." *Revue de questions scientifiques* 34:345–78.

———. 1896. "L'évolution des théories physiques du 17me siécle jusqu'a nos jours." *Revue des questions scientifiques* 11:463–99.

———. [1903] 1905. *L'évolution de la méchanique*. Paris: Herman.

———. 1905–1906. *Les origines de la statique: Les sources de théories physiques*. 2 vols. Paris: A. Herman.

———. [1905] 1914. "Physique de croyant." In *La theorie physique, son objet—sa structure*, 2d ed., 413–72. Paris: Chevalier et Revière.

———. [1906] 1914. *La theorie physique, son objet—sa structure*. 2d ed. Paris: Chevalier et Revière.

Duhem, Pierre. 1954. *The Aim and Structure of Physical Theory*. English trans. of Duhem 1914 by P. P. Weiner. Princeton, N.J.: Princeton Univ. Press.

Gutting, Gary. 2001. *French Philosophy in the Twentieth Century.* Cambridge: Cambridge Univ. Press.

Martin, R. N. D. 1991. *Pierre Duhem: Philosophy and History in the Work of a Believing Physicist.* La Salle, Ill..: Open Court.

Paul, Harry. 1979. *The Edge of Contingency: French Catholic Reaction to Scientific Change from Darwin to Duhem.* Gainesville: Univ. of Florida Press.

Rey, Abel. 1904. "La philosophie scientifique de M. Duhem." *Revue de Métaphysique et de Morale* xii (November): 699–744.

———. 1906. "La physique de M. Duhem." *Annales de Philosophie Chrétienne* cli: 535–37.

———. 1907. *La théorie de la physique chez les physiciens contemporains*. Paris: Alcan.