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History of Science as Interdisciplinary Education in American Colleges: Its Origins, Advantages, and Pitfalls

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Abstract

Before 1950, history of science did not exist as an independent academic branch, but was instead pursued by practitioners across various humanities and scientific disciplines. After professionalization, traces of its prehistory as a cross-disciplinary area of interest bound to an interdisciplinary, educational philosophy have remained. This essay outlines the development of history of science as an interdisciplinary academic field, and argues that it constitutes an obvious choice for inclusion in an interdisciplinary academic program, provided faculty and administrators learn how best to manage its advantages and pitfalls.

Keywords: college education; history of medicine; history of science; interdisciplinarity; transdisciplinarity

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In the United States today, history of science is a highly specialized discipline, with well-developed subfields, and a variety of journals and conferences. However, this is a recent development. Before 1950, history of science did not exist as an independent academic branch, but was instead pursued (more as hobby than career) by practitioners across various humanities and scientific disciplines. And even after emancipation, traces of its prehistory as a cross-disciplinary area of interest, bound to an interdisciplinary educational philosophy, have remained. By virtue of its subject matter and especially its

history, the discipline of history of science should be an obvious choice for inclusion in an interdisciplinary academic program.

In this essay I outline the development of history of science as an interdisciplinary academic field and discuss the advantages and pitfalls of its incorporation in college curricula. With minor adjustments to reflect recent scholarly discussions, I employ here the nomenclature developed by participants in the First International Conference on Interdisciplinarity (Apostel, Berger, Briggs, & Michaud, 1972), and by the London Group for Research and Innovation in Higher Education (Nuffield Foundation, 1975). Accordingly, by *interdisciplinarity* I mean the integration of knowledge and methods from different disciplines, with a view to constituting a new (interdisciplinary) field of study. I use the term *multidisciplinarity* (also called *pluridisciplinarity* and *polidisciplinarity*), to signify the mere juxtaposition (without integration) of various disciplines. Multidisciplinarity may occur with or without *cross-disciplinarity*, that is, with or without communication among specialists from different areas. *Transdisciplinarity* occurs when there is merging of different disciplinary explanations and methodologies into a world-view that not only transcends any single discipline, but also relates scholarly, theoretical knowledge to nonscholarly, practical ways of life. In a scale from less to more integrative forms of teaching and research, the order goes from multidisciplinarity to cross-disciplinarity, interdisciplinarity and, finally, transdisciplinarity ("Charter of Transdisciplinarity," 1994; Klein, 2003, 2006; Petrie, 1992). In reality, any given approach lies in between these ideal categories and it is here designated by the name of its closest category in the scale.

1. Establishment of History of Science as an Interdisciplinary Discipline

The institutionalization of an area of study into an independent academic field entails the creation of a distinct academic setting (with its own department, courses, faculty, and students), a mechanism of continuance (i.e., the training of students who will become future practitioners), and the establishment of professional societies, peer-reviewed journals, and conferences (Kuhn, 1970, p. 22). Most academic disciplines in the US became fully professionalized in the early 1900s, but for history of science this happened only after the Second World War. As recollected by Thomas Kuhn (1977, p. 105; 1984), the first generation of professionals whom we can legitimately call historians of science appeared in the 1950s. To be sure, the subject had many adepts long before that; as early as 1915, *Science* reported that approximately one third of higher education institutions in the US offered at least one science course with a historical component. Most addressed the history of specific scientific disciplines (especially chemistry, physics, mathematics, and biology). Only a few of the most resourceful universities included general history of science in their curricula (Brasch, 1915).

The institutionalization of the discipline in the United States is generally attributed to the single efforts of George Sarton, who established the History of Science Society (HSS) in 1924. But in fact, its foundations were laid between the turn of the century and 1920--a period which Arnold Thackray calls the "pre-history" of the field--by a few enthusiasts from diverse (mostly scientific) fields and institutions. They included, in addition to

Sarton, the biologist William T. Sedgwick, the physicist Charles R. Cross, and the mathematician Harry W. Tyler, all at the Massachusetts Institute of Technology, the chemist Theodore W. Richards and the physiologist L. J. Henderson at Harvard University, George H. Mead, professor of philosophy at the University of Chicago, the biologist Walter Libby at the Carnegie Institute, Frederick E. Brasch, librarian at Stanford University, and the physicist Henry Crew at Northwestern University (Thackray, 1980). Greatly influenced by the French positivist philosopher Auguste Comte, they all envisioned science as a progressive field of study, inexorably leading towards truth. However, they argued, the veritable nature of science could not be grasped solely from what Comte called its "dogmatic study," that is, textbook learning of the principles of each scientific branch (cited in Kragh, 1987, p. 12). The history of science was necessary to unify all sciences into a single body of knowledge, which would impart to students the very idea of science and a common general culture, thus "bring[ing] out the solidarity of human thought" (Mead, 1906, p. 394). These high expectations intensified after the onset of the Great War, and became imbued with American values: the Comtean equation of scientific progress with progress of civilization became equivalent to the growth of American democracy (Brasch, 1915; Libby, 1914).

When Sarton, a Belgian émigré, came to the United States during the First World War, he too hoped the history of science would be an instrument of peace, of integration, of scientific and moral progress, in sum, a means to achieve the "the unity of knowledge and the unity of mankind" (cited in Thackray & Merton, 1972, p. 481). A natural scientist by training, he had always been fascinated with history, and before coming to America, had already started a journal, *Isis*, dedicated to the history of science. Transplanted to the New World (with the necessary language conversion), *Isis* became the official organ of the HSS (Hellman, 1958; Merton, 1985; Thackray & Merton, 1972). Sarton's ideas were hardly new, but he was able to extol the virtues of history of science with unprecedented verve and propagandistic zeal. His writings articulated what would be called, several decades later, the problem of the two cultures (Merton, 1985; Snow, 1956). With characteristic optimism (lacking afterwards in C. P. Snow's exposé), Sarton remarked:

> People who have no knowledge of science, or but slight, are afraid of it . . . On the other hand, those who know science . . . are often given to viewing history with contempt . . . How will it be possible to conciliate the imperious needs of synthesis and division of labor? . . . The only possible solution is that which was recommended by Auguste Comte . . . namely, to originate a new great specialty, the study of scientific generalities. The best instrument of synthesis and the most natural hyphen between scientist and philosopher is the history of science. (Sarton, 1916, pp. 323, 330)

Following on the footsteps of Comte (who had lobbied unsuccessfully for the institution of a chair of history of science at the venerable Collège de France), Sarton spent his life trying to anchor the new field in American academia. His program was grandiose, even millenarian--the history of science was to be the cornerstone of what he called a "New Humanism," a cultural revival as momentous as the old humanism, but now centered on science. This second Renaissance would "broaden our horizon and sympathy . . . raise

our intellectual and moral standards . . . deepen our comprehension of men and nature" (Sarton, 1916, p. 357). As characterized by his most illustrious student, the sociologist Robert Merton (1985, p. 473), Sarton's was "an ecumenical vision of transcending disciplinary boundaries." It owed much to nineteenth-century developments in the philosophy of education, particularly the notion of integrated knowledge, a pedagogy that encouraged connections across disciplines, proposed in the 1830s by the German philosopher Johann Herbart and defended by Herbert Spencer, whom Sarton admired (Klein, 2006; Sarton, 1921).

During the first 30 years of his career, Sarton struggled to find a secure university position. Until 1940, when he finally received tenure at Harvard University, he held several temporary teaching and research jobs. Nevertheless, he was one of the few scholars before 1950 able to dedicate themselves exclusively to the history of science. At this time, most of those interested in the field were either natural scientists concerned with the development of their own disciplines, or philosophers working on epistemological questions. Historiographically, these two trends were often indistinguishable, because they both followed the principles of positivist philosophy and shared a similar pedagogical outlook--to educate gentlemen, to provide a broad general education to specialists (Kragh, 1987, p. 41; Thackray, 1980). Although the great majority of HSS members were scientists, it was those with a more philosophical approach that left the strongest imprint on the embryonic field. In the writings of influential historian-philosophers such as Arthur Lovejoy and Alexandre Koyré, the history of science became a subject of the history of ideas. Their main interest was to understand how scientific concepts were related to other, past or contemporaneous, concepts. Like Sarton, they paid little attention to specific social, economic, and political contexts of science (Kuhn, 1977, pp. 105-120, 135, 148-150). This situation did not change much during the interwar years. By 1940, the Vienna, Berlin and Polish schools of philosophy had reworked Comtean positivism into a new philosophy of science, logical positivism, which proposed a logical equivalence between sensory experiences (e.g., scientific experiments) and linguistic entities (e.g., scientific theories). This linguistic turn (which impacted on virtually all areas of knowledge) reinforced history of science's internalist approach and validated the view of past scientific theories as necessary precursors of more recent ones (Bynum, Browne, & Porter, 1981, p. 334; Ophir & Shapin, 1991).

Thus, the history of science achieved only "an imperfect kind of institutionalization" between the two wars (Thackray, 1980, p. 461). None of the historiographical currents mentioned above led to the creation of an independent discipline. History of science continued to be regarded as something scholars could do on the side, without abandoning their departments or disciplinary approaches, and as such not justifying the human resources or financial investment necessary to the creation of new academic departments. In 1950, there were less than 10 historians of science with tenured posts. Despite Sarton's tireless propaganda, by the time he died in 1956, history of science had barely entered the American university system and it was very unclear whether it would survive as an independent discipline. We owe it to Thomas Kuhn that it did (Kuhn, 1977, p. 111; Thackray, 1980).

True to the norm at the time, Kuhn's interest in the history of science evolved from his training in the natural sciences. In 1947, when Kuhn was writing his doctoral dissertation in theoretical physics, the president of Harvard University, James Bryant Conant, asked him to teach a set of classes on seventeenth-century mechanics, as part of the General Education and the History of Science Program. This was a pioneer course very much along Sartonian lines, aimed at enlightening nonscientists about basic science through historical case studies. After obtaining his PhD in physics in 1949, Kuhn decided to dedicate himself entirely to the history of science. In 1951 he became instructor (and soon afterwards assistant professor) in Conant's program (Kuhn, 1984). *The Copernican Revolution*, Kuhn's first book (1957), grew out of his lectures, and provided a historical case study to test the philosophical ideas that he would advance shortly afterwards in *The Structure of Scientific Revolutions* (1962). The model of scientific development proposed there is a milestone in the historiography of science and, to use the book's own concepts, provided the paradigm necessary to complete the process of the discipline's professionalization.

According to Kuhn (1984), that process received an impetus in the aftermath of the Second World War, with the realization of the (double-edged) power of recent scientific developments and the acknowledgement that this information ought to be provided to voters. Similarly to what had happened after the First World War, there was a renewed awareness of the disjunction between humanistic and scientific cultures and, once again, the history of science was seen by educators and, more decisively, by college administrators like Conant, as a solution to bridge the gap. But contrary to what happened in Sarton's time, now the university system was expanding and the general availability of funds enabled the creation of departments to train and nurture those who would teach the new courses. Thus Kuhn was able to complete the professionalization of history of science started by Sarton, even if in the process he repudiated Sarton's most cherished ideas--the positivist notion of science and the concept of history of science as an interdisciplinary field.

Kuhn's model of scientific development challenged both the positivist view of a linear process of increasing knowledge and the logical positivist notion whereby a given scientific theory logically includes preceding ones. For him, a scientific paradigm (that is, a discipline's theories, rules, practices, and instrumentation) replaced another through what he called a "scientific revolution," rather than through continuous accumulation of knowledge. His idea of scientific development was a process akin to biological evolution, whereby successive paradigms were neither truer nor better in any absolute sense, but merely better adapted to the collective needs of a given scientific community. Science textbooks and popularizers, Kuhn noted, were responsible for the widespread idea of science as a cumulative enterprise, because they were written by the holders of the most recently accepted paradigm, who rarely described preceding paradigms or the revolution that produced new ones (Kuhn, 1970, pp. viii, 5, 10, 98, 103, 109, 136-137, 172-173). Kuhn also shook the then prevalent idea that science was solely driven by epistemological factors, such as the phenomena under study and the utterances used to describe them. He argued that, besides these internal features, idiosyncrasies of individual scientists and their group interactions were responsible for paradigm shifts. Nevertheless,

The Structure did not make much space for external, social factors. Kuhn's view was still much closer to Sarton's internalist history of science than to the social interpretations of the 1970s and a long way from the social constructivist trends of the 1980s and 1990s (Kuhn, 1970, pp. 153-155).

Kuhn opened the doors for the social turn that would become predominant in history of science. His compelling criticism of the positivist approach was crucial to finalize the professionalization of the discipline. His interpretation of scientific development as evolutionary and discrete, at odds with the view shared until then by most scientists and humanists, provided a justification for the creation of new academic departments where the teaching of the new-fangled history of science would take place. During the decade following the publication of *The Structure*, Kuhn (1977) refined the philosophical underpinnings of the field, and wrote a series of essays carefully differentiating it from two other closely related disciplines, history and philosophy of science. Moreover, his insistence on studying the histories of different sciences (instead of Sarton's science as a whole) fostered specialization, a sign of disciplinary maturity.

Since Kuhn, the proliferation of history of science specialties and subspecialties has been evidenced in scholarly conferences, publications, and to a lesser extent in teaching programs. Specialization might well have led to a loss of the field's interdisciplinary character, if not for two significant events: history of science's defining and not too distant beginnings as an interdisciplinary area of interest, and Kuhn's (cautious) pointing to an external history of science, which opened the dialogue with other fields, particularly philosophy, sociology, and anthropology. The latter development led to the formation of truly interdisciplinary "super fields," most prominently Science and Technology Studies (STS), which in the last 25 years have infused the history of science with methodologies from other disciplines and have integrated the histories of technology, medicine, and the environment in their scope. Whereas the development of research specialties has never been fully mirrored in academic curricula, STS's growth as a field of research assured the ongoing (albeit limited) teaching of general history of science.

There are currently some 60 history of science graduate programs in the US, with more or less comprehensive titles, from "Science, Technology, Medicine, Business, and the Environment" (e.g., at Carnegie Mellon University), to "STS" (e.g., at Cornell University), "History and Philosophy of Science" (e.g., at the University of Montana, Indiana University, and Notre Dame University), "History and Sociology of Science' (e.g., at the University of Pennsylvania), and even the Sartonian-sounding "Science in Human Culture" (e.g., at Northwestern University), in addition to those simply named "History of Science" (e.g., at the City University of New York, Harvard University, Kansas State University, University of Florida, and University of Maryland). However, less than a third of all institutions awarding humanities and social sciences doctoral degrees house history of science graduate programs. It is not surprising therefore, that most college undergraduate programs do not offer history of science courses on a regular basis. In some instances such classes are taught as options, either in science and humanities departments, or as part of general education programs (Carnegie Foundation, 2007; History of Science Society, 2007). The didactic richness of history of science

remains underexplored. And yet, its ability to connect themes, research methods, and writing styles of the two cultures, as well as its power to relate to social experience should make it an integral part of higher education. The old Sartonian pedagogical vision remains relevant today, even if it needs to be toned down. Post-Kuhnian historians of science ought not to throw out the humanistic, interdisciplinary baby with the positivist bath water.

2. Contributions of History of Science to the College Curriculum

The history of science remains, *pace* the oxymoron, an interdisciplinary discipline. What makes it interdisciplinary is its ability to address problems that pertain to different fields of study and to integrate "knowledge and modes of thinking [of] two or more disciplines to produce a cognitive advance . . . in ways that would have been unlikely through single disciplinary means" (Klein, 2006, pp. 14-15). What, nevertheless, keeps it a coherent discipline is its characteristic, post-Kuhnian, contextualist outlook, adumbrated above.

Most courses on the subject require a basic acquaintance with the scientific events being studied, the analysis of their historical contexts, the understanding of scientific and historical methods of research and writing, and often the cross-fertilization with perspectives from other humanities and social sciences. These are undoubtedly valuable skills, necessary to all college students, regardless of their majors. For example, a history of science survey which I taught from 2003 to 2005 included a group of classes on Galileo that utilized insights from physics, history, and philosophy so as to introduce students to: Galileo's experiments on motion and astronomical observations, the way he performed them, and the instruments he used; the appreciation of his political and social milieu; the examination of selected pages of his treatises, in the light of their targeted audiences; the contextualization of his work in the natural philosophy of the time, its scientific implications, and its reception; the discussion of his falling-out with the church in the light of the relationship between science and religion, and the political circumstances surrounding the case; and finally, Galileo's contributions to the methods and public authority of natural philosophy.

To use another example, in my history of medicine undergraduate courses, the section on the germ theory of disease usually combines themes and approaches from medicine, history, sociology, and anthropology in order to achieve an overview of: nineteenth-century competing theories of disease, various notions of infection and contagion, and related terminology; the proponents of these theories and the institutions where they worked; the social applications of the new ideas, such as the institution of new surgical and therapeutic approaches, and public health campaigns of sanitation and vaccination; the cultural impact of the germ theory on habits of house cleaning, ventilation, and personal hygiene; and its possible implications for today's public responses to infectious diseases, such as AIDS.

These and other case studies portray science as process, instead of product, pointing to the contingent aspects of knowledge in the making, shaped by and shaping its social context. They describe science as a human and social activity and demystify the image of

scientists as geniuses or Frankensteins. The study of past scientific theories and practices in their own contexts leads students to discover that these theories are not simply wrong but are instead well adapted to the social (intellectual, technological, political, economic) needs of their times. The attention to the historical details of scientific development also prevents so-called Whiggish interpretations of science (whereby old concepts and events are seen as necessary precursors to the current scientific status), by revealing a crisscross of pathways (many of them dead ends), instead of a straight road between past and present. Historical interpretation dispels the idea of science as certain and privileged knowledge, two popular notions transmitted to students by most grade-school teachers and textbooks and still defended by some practicing scientists. The study of history of science contributes to a much more sophisticated and critical understanding of science as a complex, crucial feature of our society.

Thanks to their content and methodological eclecticism, history-of-science courses draw the two cultures together and contribute to a well-rounded college education. They help students understand the similarities and differences between humanistic and scientific approaches, and provide them with different perspectives to, and relationships among, the different disciplines in their curricula. Moreover, history-of-science classes invite collaboration of students with different interests and strengths. The same question, when analyzed by students from different areas, generates variant interpretations of the past and leads to different prescriptions to remedy present problems and prevent their future escalation. Furthermore, as pointed out by Jasmin Godemann (Godemann, 2006, pp. 51, 54), the cooperation among students with different strengths is not much different from the transdisciplinary communication between experts and laypersons.

In an undergraduate, upper-level seminar on the history of medicine, which I taught in 2004-2005 in a small liberal arts college, students with backgrounds in history, sociology, and anthropology compared their diverse approaches to the recent problem of drug-resistant tuberculosis (TB), and discussed their applicability. Not surprisingly, history majors suggested that we trace the scientific and social history of TB through primary sources, which would inform us about the different medical theories, therapies, and their social impact at different times. According to these historians-in-the-making, the goal was to construct a grounded narrative that would help us explain current understandings and treatments of drug-resistant TB. Sociology majors thought much more in terms of the actors and institutions involved in the construction and application of knowledge about TB and their relative power. They sought a quantitative, graphic description of the impact of the disease and therapeutic interventions on various groups (such as people of different gender, socio-economic class, or ethnicity), and believed that a solution to the problem entailed a better appreciation of any social discrepancies found. Finally, anthropology majors were particularly interested in constructing a narrative in terms of the actors' own voices and behaviors. The decoding of this semiotics would reveal people's reactions to the disease and its treatment, and would lead to interventions co-designed and co-run by the community. After discussing their different approaches to the problem at hand, students distilled some methodological conclusions in a summary table, which provided the grounds for further discussion.

Exercises like this introduce students to the relationship between scientific theory and practice. Humanistic imagination cultivates good science, by providing its future practitioners with the ability to understand and account for the social impact of their work and to participate more efficiently in the negotiations leading to the establishment of scientific explanations among the scientific community and the public (Allchin, 2002). Moreover, history of science classes engage students in citizenship, something the pioneer historian of medicine Henry Sigerist (1944) noticed long ago. For education scholars like Hugh Petrie (1992), this ability to show how to use theoretical knowledge in practical, real life situations is the most important contribution of interdisciplinary education.

3. Solving Interdisciplinary Problems in the Classroom: Epistemological and Procedural Problems in History of Science Courses

The successful integration of history of science in college curricula depends, not only on the exploitation of the above-sung virtues, but also on the awareness and management of a range of epistemological and procedural problems, which derive primarily from the field's interdisciplinary character. Below I discuss some of these problems, based on my experience teaching history of science and medicine in two different settings (a large medical school and a small liberal arts college, both in the US).

My training in interdisciplinary modes of teaching occurred between 1995 and 2000, when I became a key player in the curricular development of the medical humanities program at a large medical school. This was a 4-year, interdisciplinary program, which combined approaches from ethics, law, history, literature, sociology, and anthropology, to offer students a comprehensive, humanistic view of the medical profession (Coulehan, Belling, Williams, Van McCrary, & Vetrano, 2003). From 1998 to 2000, I co-directed the 2nd-year segment of the program, which involved collaborative teaching by more than 20 voluntary faculty members from humanities and medical departments. The program design was innovative, consisting of several mandatory components: lectures, small discussion seminars, on-line discussions, and selective mini-courses. Each 3-hour class started with a 1-hour lecture, after which students split into discussion groups of 9 to 15 participants, to focus on a concrete problem.

Facilitated by two faculty members with different academic backgrounds, these small groups followed a methodology based on Problem-Based Learning (PBL), an integrative instructional procedure developed in the 1970s and 1980s, mainly applied to medical education (Neame, 1981; Neufeld & Barrows, 1974; Schmidt, 1993). Students were given a realistic, medical case requiring resolution (for example, deciding whether to withdraw treatment of a comatose patient), which necessitated knowledge from several, scientific and humanistic fields. Students' first task was to analyze the case and identify what information they needed in order to reach a conclusion. This could include, for example, knowledge about the medical condition in question (its etiology, pathology, physiology, natural history, and therapeutics), its scientific and social history, the patient's social and cultural background, and the ethical and legal matters involved. Each of these research topics was then assigned to groups of two to four students, and one week later they

reported to the entire class what they had learned. Finally, upon discussion and synthesis of all the information, students were expected to reach a consensus on how to resolve the case. In some instances, they were asked to stage their deliberations as if in a hospital ethics committee, each student role-playing a different element of the committee (e.g., a family physician, a specialist, a nurse, a minister, a member of the community). Discussion was often continued in structured groups on the Web, moderated by faculty.

Besides multi- and interdisciplinary components, this program also exhibited transdisciplinary characteristics, such as conversations with community health-care practitioners, patients and their families. Moreover, the academic program was complemented by a variety of outreach activities--public conferences, concerts, and a newsletter--organized by an institute. As associate director of this institute and co-editor of its newsletter, I participated fully in these transdisciplinary initiatives. Most memorable among them was a project on multiculturalism, which debated the necessity of cultural interpreters in the hospital and helped jump-start an elective course on medical Spanish (which has become mandatory since then) (Viterbo, 1999).

Several years later, I adapted my experience in the medical school to the teaching of history of science and medicine in a small liberal arts college. Classes remained strongly interdisciplinary, geared towards the development of a shared knowledge-base and its application to given case studies (as mentioned in the first part of this essay). This was not an easy task, however; case-based classes proved less adequate to liberal arts education than to the more applied medical training, and unlike the medical humanities program, these college courses lacked adequate institutional integration and support. The problems discussed below, although present in the medical program, were particularly challenging in the college setting.

3.1. Communication Problems

Critics of interdisciplinarity (e.g., Godemann, 2006) have pointed out that the cross-fertilization among different humanities and science disciplines raises communication obstacles in the classroom. My college courses were no exception: the study of history of science topics using terminology, concepts, approaches, and values characteristic of different fields led to frequent misunderstandings. It demanded that students discuss key texts in the discipline of history of science with a critical and methodological awareness most of them did not possess yet. Minimizing this problem required me to pay close attention to course preparation (especially the choice of adequate readings) and to classroom techniques to encourage communication, moderate discussions, and synthesize materials. Assigned readings must introduce students, not only to the topics under discussion, but also to several disciplinary approaches to them. Time and again, I had to adapt the reading list, to account for students' level of acquaintance with the topics and disciplinary methodologies in the syllabus. A Web-based software application, available to all course participants, enabled frequent course updates, weekly evaluation of students, as well as communication among students and between students and me.

3.2. Too Complex or Too Simple?

Given the content and methodological variety of these courses, there was always the danger that they might become overly complex or, in my effort to attain synthetic explanations, too simplistic. At times, my students criticized the superficial, incomplete treatment of some of the subjects in the syllabus. Science majors occasionally resented the lack of detail and rigor of the assigned readings, which, they believed, lead to a "dumbed-down" misrepresentation of the scientific problems under study. Likewise, humanities students regretted the absence of real-life complexity in some of the texts provided and in class discussions. Time constraints, the difficulty of the project, and the attempt to maintain the interdisciplinary character of classes often resulted in explanations that were so general as to be applicable to everything, and thus with little explanatory power--a common pitfall of interdisciplinary projects.

3.3. Problem of Methodological Relativism

Surprisingly, most students in my history of science and medicine courses fell into one of two stereotypical categories: those (mostly science majors) for whom (good) scientific explanations were, throughout history, progressively more objective and more complete depictions of reality, and those (mostly humanities majors) who regarded science with suspicion, as a product of individual or corporate interests progressively leading towards dehumanization. The use of historical case studies and interdisciplinary methodology in class enabled me to efficiently counter the view, held by the students in the first category, of science as a truth-generating, ivory-tower activity, isolated from social factors. The prejudices held by the second group of students were more difficult to dislodge. Contrary to what I expected, humanities majors were the ones whose starting viewpoints, if not criticized, tended to become even more biased, as a result of the multiplicity of approaches to science introduced in the course. At the onset of the course, these students needed to be shown that humanistic and social-science interpretations were not necessarily less tentative, theory-laden, or biased than scientific methods. Unfortunately, once students came to this realization, they sometimes fell into another pitfall, perhaps the most serious in interdisciplinary classes: the conclusion that all explanations, all approaches to a problem are equally valid. This dangerous relativism is often aggravated by the common practice of team-teaching without any attempts at integration or synthesis.

3.4. Problems of Shared Knowledge and Language

My courses shared with other interdisciplinary ventures the lofty goal to develop a shared understanding (and, if possible, a common language) that transcended the mere superimposition of various disciplinary insights. Together with many science historians, philosophers, and educators, I still hold Sarton's belief that such a synthesis would help students shed misconceptions created by disciplinary excesses and thus contribute to a better understanding of the scientific enterprise (Crowe, 1991; Hagen, 2000; Matthews, 1992). Unfortunately, as pointed out by several critics, there is not enough evidence that permit us to reach that conclusion (Abd-El-Khalick, 2001; Aikenhead, 1994).

Nevertheless, until new evidence makes me change my mind, I continue to draw reassurance from classroom experiences and remain faithful to the interdisciplinary ideal.

Pessimists have also argued that a shared language may be just too difficult to attain. As pointed out by Richard Rorty (1982, pp. 197-208), we may be left with the old multidisciplinary predicament, whereby scientific languages and notions are used to describe so-called natural events, while all other social events (including policy and moral decision-making) continue to be dealt with the traditional humanistic tools. Such a solution harks back to Karl Manheim's (1936, pp. 50, 253) epistemological and methodological distinction between the "cultural sciences" and the "exact sciences," as well as Robert Merton's (1973, p. 9) separation between science as cognitive system and science as social system. Both approaches seem to undermine the very nature of interdisciplinarity as understood here.

Grand interdisciplinary explanations akin to Bruno Latour's (1991) proposed syntheses, situated perpendicularly to a line linking the two explanatory poles of nature and society, are indeed utopian, at least in the classroom. Instead, in my history of science and medicine courses, students treated different methodologies as different languages to explain different aspects of the same problem. Through case studies, they came to understand that to tackle most scientific and medical problems we cannot ignore their intrinsic social dimensions and must resort, in addition to scientific methods, to approaches provided by humanities and social studies disciplines.

Returning to the case of drug-resistant TB, mentioned in section 2 above, students discussed how they would approach the goal of developing a new vaccine. Such a project, they concluded, would require a multidisciplinary effort, comprising, at least, the following: various, specialized *scientific methods* to study the physiology of the pathogens involved, their interaction with humans and with various vaccine candidates; *sociological research* to explain the social distribution of the disease; *anthropological studies* to learn about communities' attitudes and behaviors towards drug-resistant TB and vaccination; study of the *economical issues* involved; analysis of the *ethical aspects* of the project; and *historical research* to learn about past events that might shed light on the present problem. More important, students realized that projects like this were not merely multidisciplinary, but also required the coordination of methods and results from several disciplines in order to achieve the final goal. A given disciplinary approach, with its well-developed language and methodology, was not considered superior or inferior to any other used in the project, but simply more adept at certain tasks. According to this view, interdisciplinarity no longer demanded the development of a unified *language* in the classroom, but rather the sharing of a minimal, polyglot *knowledge-base* and the realization that distinct disciplinary approaches can be brought to collaborate in a multifaceted, complex synthesis.

3.5. Problem of Transdisciplinarity

The transition of history of science from an interdisciplinary to a transdisciplinary status, that is, its power to bridge not only academic disciplines, but also to link academic to

mundane problem-solving (the ultimate goal of any interdisciplinary project), has been rarely effected. Part of the problem, I suggest, may result from historians' fear of Whiggishness and presentism. An incorrect interpretation of this fundamental tenet of historiography may lead scholars to adopt a strict contextualist stance that avoids any transposition of knowledge from one context to another (including from past to present situations or across contemporaneous cultures). Of course, Whiggish and presentist interpretations only proscribe the imposition of the present into the past, not the use of historical knowledge as a resource to understand the present. Failure to realize this robs history of science from one of its most relevant applications, the use of historical interpretation as a resource in current scientific debates. In my history of science and, especially history of medicine, courses students were alerted to Whiggish and presentist fallacies, but they also learned, through case studies, how historical interpretation could contribute to the understanding and amelioration of present situations. Despite Reinhold Hedtke's (2006) well-taken point that academic knowledge was not developed for people's use in their day-to-day lives, those of us who are involved in inter- and transdisciplinary projects believe that interdisciplinary knowledge learners are more competent to understand and act in the world. Only the results of multiple longitudinal studies, yet to be conducted, will tell whether this belief ought to be abandoned.

3.6. Institutional Problems

The problems discussed so far compound on the practical difficulties of fitting an interdisciplinary discipline in a given institutional structure. In the absence of a history of science department (as is the case in most liberal arts colleges), where should history of science courses be housed? In a humanities department or in a science department? Which particular department? Or should they be placed in an interdepartmental, general studies program, or perhaps a research center? This is an important decision, since the particular institutional setting will influence course content and approach. My experience teaching history of science and medicine in a small liberal arts college was revealing. Although officially offered by the history department (and cross-listed with other programs), my courses had a much more varied group of students, majoring in different humanities and science fields, when classes took place in the humanities side of the campus. When both my office and classes moved to the sciences building, the proportion of humanities majors dropped considerably, which required me to adapt the syllabus accordingly. And, surprisingly, when one of my courses became part of the General Education Program, students' expectations changed--now they found the course's interdisciplinary approach too complex and too demanding, not simplistic.

We must also consider the question of when, in the college curriculum, interdisciplinary science studies should be taught. On the one hand, it makes sense to teach it in upper-level courses, since students would profit from a certain familiarity with the content of several disciplines. Moreover, small, discussion-oriented classes (a characteristic of most upper-level seminars) are especially appropriate to interdisciplinary courses. On the other hand, as already pointed out, these seminars are difficult to implement and incur the risk of becoming too general, simplistic, or merely a juxtaposition of disciplinary insights. To teach history of science at the entry level is not ideal either, because many students at this

stage lack the necessary disciplinary background that enables them to make useful interdisciplinary connections.

Where and when to teach these courses cannot be separated from methodological considerations. In institutions without history of science departments, faculty in the field (ideally in collaboration with colleagues and administrators) must adapt classes to their setting, be it a history department, a science department, or an inter-departmental program. Similarly, courses must be designed according to their place in the curriculum. Offered in the 1st or 2nd year, history of science is an excellent venue for students to learn about the college program, different disciplinary approaches, as well as research and writing methods. When taken in the last years of college, it capitalizes on students' different academic backgrounds, fosters their synthetic abilities, and encourages their exploration of relationships between academic and nonacademic worlds.

Writing about the teaching of history of science during the inter-war years, Thackray (1980, p. 472) remarked that the subject received "much rhetorical but little financial or institutional support," and that "it was taught as an adjunct subject in existing departments which were not very friendly to it." Sadly, this seems to remain the case in many liberal arts colleges today. As Steve Fuller (2003) has commented, interdisciplinary ventures continue to be perceived by many academics as a threat to their disciplinary feuds, a climate that makes interdisciplinarity unattractive to untenured faculty. The inclusion of history of science in the college curriculum can be implemented only if faculty and administration recognize and are willing to exploit the many advantages of such an enterprise, all the while attending to its challenges. Without strong political will, the difficulties may seem daunting, and the necessary financial and human resources will never be recruited.

4. Conclusion

Like all academic fields, history of science is a social construct, product of the historical context in which it arose and the interactions among several actors who have contributed to its growth. However, contrary to most disciplinary fields, whose development qua college disciplines has rarely accompanied their development qua research fields (Audigier, 2006), the discipline of history of science originated with, and still maintains a strong pedagogical agenda as one of its main goals. Moreover, it has kept a characteristic interdisciplinary identity in the academic and classroom settings.

The problems we encounter in the real world are complex, multifaceted issues, more likely to be understood if we resort to various disciplines, rather than viewing them through a single disciplinary lens. The topics studied in history of science classes are good examples of this complexity and constitute excellent didactic materials to show how interdisciplinary methods work. In American college education, constructed from a series of disciplinary courses, organized in time-limited classes, history of science has a fundamental role to play. Interdisciplinarity does not in any way eliminate the necessity of disciplinary training; what history of science and other interdisciplinary courses may realistically aim at is the building of a shared knowledge-base, instead of a utopian, new

mega(inter)discipline. As proposed by Steve Fuller (2003), let college itself be the interdisciplinary arena, by offering the usual disciplinary courses alongside those that promote their interaction, impart cohesion to the curriculum, and help students connect their education to the world outside college.

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