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Science and Society in Historical Perspective: Implications for Social Theories of Risk

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ABSTRACT: Over the past decade risk society theory has become increasingly prominent within the field of environmental social theory. This perspective contends that conventional political divisions based on class are becoming less salient and are giving way to a politics predicated upon the distribution of risk. There is much in risk society theory, especially its central contention that public anxieties about high consequence-low probability events undermine the legitimacy of science, that has a distinctly German stamp. Through a comparative analysis of how national context has differently shaped science as a public epistemology this paper suggests we should tread carefully in moving to accept the general applicability of this theoretical approach.

KEYWORDS: Environmental sociology, public understanding of science, scientific mentality, Germany, Britain

INTRODUCTION

Due to the increasing prominence of global environmental dilemmas, as well as to specific salient events such as the Chernobyl nuclear accident, social theorists have begun to renew their interest in the disenchanting effects of an ever-widening technicised society. This new phase of attention on the dark side of social change departs from past excursions in this direction because now interleaved with the conventional array of issues is explicit consideration of public diffidence concerning the risks embedded in advanced technological systems. A handful of prominent authors has been largely responsible for framing this new theoretical agenda, one that will invariably carry us into the

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next millennium (see especially Giddens, 1990; Beck, 1992). Among a broad international cross-section of academics and media popularisers there has been an eagerness to embrace these new perspectives. For instance, some proponents of these views, drawing particularly heavily on the work of the German theorist Ulrich Beck, have come to characterise the contemporary era as a 'risk society'. Purported public preoccupation with the ill-effects of genetic engineering and toxic chemicals are signal manifestations of this new phase of societal evolution. The outbreak in Britain of bovine spongiform encephalopathy (BSE, or mad cow disease) is frequently held up as the pre-eminent illustration of the slide toward this enigmatic new status. The extent to which this largely German-inspired approach has relevance for Western societies more generally demands greater scrutiny than has heretofore been applied.

In ascertaining the rise of risk in contemporary society these prevalent treatments give pride of place to the pervasive influence of scientific expertise. These theorists are correct in their recognition that the environment, along with perhaps health and medicine, has been the leading domain in which science has established itself in the advanced nations as an indispensable form of knowledge. We have now reached a stage at which public discussion in these countries concerning the environment – whether focused on, say, ozone depletion, global warming, or declining biodiversity – is conducted largely in a rhetoric informed by science. Since the emergence of a modern environmental consciousness is typically dated to the 1960s, most social scientists have mistakenly been led to reduce the relationship between science and society to an overly short timeframe, one typically anchored at its starting point by publication of Rachel Carson's *Silent Spring*.[1] We often fail to remember that modernity has entailed a collaborative relationship with science for some four hundred years.

This paper begins from the premise that there may be some value in reaching back to the earliest manifestations of the 'new science' to gain insight into the ways in which different societies culturally interact with this knowledge system. It will be argued that some local predispositions, such as the propensity to engage effectively with science, can be remarkably resilient, even when challenged by sweeping political transformations. Proceeding in this manner may enable us to identify some foundational elements of the science-society relationship in individual countries that will shed light on the more general applicability of the recent wave of German-influenced social theory.

This approach is motivated in part by the recent contributions of a small group of scholars working in the area of political culture who have demonstrated the indomitable quality of certain societal characteristics. For instance, Robert Putnam (1993), has shown how the values underlying civil society in central Italy have endured over several centuries, persisting through periods of extraordinary turbulence. Though care obviously must be taken in embarking on such a formidable endeavour, this work suggests there are benefits to be gained from attempting to understand the contemporary capabilities of individual nations as

outcomes of long processes of cultural reproduction. This paper draws on the historical record in an effort to identify some antecedents of current societal orientations toward science.

It is important to note that by placing the cultural influences associated with the social acceptance of science at centre stage we do not mean to suggest that other factors have been unimportant in the assimilation of this knowledge. Surely, numerous economic and political factors have played critical roles in shaping public propensity for science. These influences have been extensively documented elsewhere and the guiding spirit of the sections that follow is that cultural legacies can be ineluctable and, despite developments in ancillary spheres, can be difficult to overcome.

SOCIAL SURVEYS OF NATIONAL SCIENTIFIC *MENTALITÉ*

To first root this discussion in the current era, we begin by noting that recent years have seen increased attention devoted to the public understanding of science and the emergence of several fields of expertise to investigate both theoretical and empirical questions regarding the uptake of scientific knowledge among lay members of advanced countries (see, for example, Irwin, 1995; Irwin and Wynne, 1996).[2] Numerous commentators have weighed in to explain why interest in this field of inquiry is expanding at the present time. The most general interpretations claim that public scepticism of science is on the rise and a variety of alternative epistemologies grounded in mysticism, superstition, and native and traditional religious doctrines now threaten to undermine the forward march of human progress (Holton, 1993; Gross and Levitt, 1994). Advocates of the current movement to upgrade public acceptance of science contend that to counter the effects of these inauspicious developments advanced societies must renew their commitment to the values of the Enlightenment – especially to the efficacy of social advance predicated upon the accumulation of scientific knowledge.

Michel Schwarz (1993) offers a supplementary explanation for this increasing interest in the public understanding of science that is informed by recent political events. He contends that tension between society and science took on a new dimension during the second half of the 1980s as governments and social elites attempted to recover from the damages they sustained during the heated controversies over nuclear power. Schwarz describes these initiatives as constituting a 'cultural offensive' to proclaim the promises of modern science. Though construed independently, several national programmes to enhance science in the public mind have had a similar focus. The French launched initiatives to elevate *la culture scientifique et technique* while in Britain the Royal Society called for the devotion of greater attention to the 'public understanding of science'. In the Netherlands, Schwarz observes, the response was more muted, but government

policy was articulated in terms of enhancing lay receptivity to science and technology.

In addition to new funding for science museums and other similar institutions, social surveys to measure scientific literacy have become a common feature of current efforts to promote science in the public sphere. A cross-national assessment conducted under the auspices of the European Union as part of its Eurobarometer survey series represents one such recent effort to examine public outlooks toward science.[3] The research exercise posed a variety of questions pertaining to lay knowledge, interests, and attitudes about scientific themes. For instance, respondents' knowledge of science was gauged by a battery of true-false statements such as 'The centre of the earth is very hot' and 'All radioactivity is man-made'. Scientific interest was evaluated by querying survey participants as to their television viewing habits and the extent to which they read news articles on scientific topics.

For current purposes these assessments of the public's scientific knowledge and interests are of only passing interest. The intent for drawing attention to this particular survey is not to determine whether people in various countries have differing cognitive scientific skills or entertainment practices. Rather the point is to ascertain lay dispositions toward science in a more general sense, to gain some perspective on individual societies' scientific *mentalité*. A strong scientific *mentalité* does not necessarily entail being able to answer science-trivia questions with competence or to demonstrate diligence in watching, for example, the most recent television footage on African elephants. In essence, the notion of scientific *mentalité* is aimed at ascertaining the extent to which members of the public are prepared to endorse science as a component of popular culture. Accordingly, our focus is narrowed to a concern with those elements of the Eurobarometer questionnaire that consider public attitudes toward science. This portion of the instrument consisted of twelve statements. Respondents were asked whether they agreed or disagreed with the contents of each survey item and to report their answers using a five-point Likert scale (refer to Figure 1). There are three statements from this battery that offer especially instructive insight into differences in scientific *mentalité* across several European nations.[4]

First, respondents were queried on whether they thought 'Scientific researchers, because of their knowledge, have a power that makes them dangerous'. As reported in Figure 2A, more than 72 percent of Germans agreed (either strongly or to some extent) with this statement. In contrast, Italians were more likely to perceive science as a benevolent endeavour, though even in this case less than half of the population was unthreatened by scientific researchers.

Second, this matter of whether the public considers science to be a vehicle of human betterment or a wellspring of perniciousness was further explored by a statement that asked respondents to consider whether 'Most scientists want to work on things that make life better for the average person' (refer to Figure 2B). Britons were most inclined to associate scientific research with human and

societal improvement while Belgians, Danes, Germans, and the Dutch were less convinced that science promotes the interests of humankind.

The final question we will focus on from this section of the survey bridges from science and its practitioners to issues of technology. Respondents were presented with the statement: 'Technological progress will make possible higher levels of consumption and, at the same time, an unpolluted environment' (refer

1. Science and technology are making our lives healthier, easier, and more comfortable
2. Thanks to scientific and technological advances the Earth's natural resources will be inexhaustible
3. We depend too much on science and not enough on faith
4. Scientific and technological research cannot play an important role in protecting the environment and repairing it
5. Scientists should be allowed to do research that causes pain and injury to animals like dogs and chimpanzees if it can produce new information about serious human health problems
6. Technological progress will make possible higher levels of consumption and, at the same time, an unpolluted environment
7. Because of their knowledge, scientific researchers have a power that makes them dangerous
8. The application of science and new technology will make work more interesting
9. For me, in my daily life, it is not important to know about science
10. Most scientists want to work on things that will make life better for the average person
11. Science makes our way of life change too fast
12. Thanks to science and technology, there will be more opportunities for the future generations

FIGURE 1. Eurobarometer questions assessing public attitudes to science. Selected European nations, 1992

Source: Eurobarometer 38.1, Zentralarchiv für Empirische Sozialforschung an der Universität zu Koln, September 1995

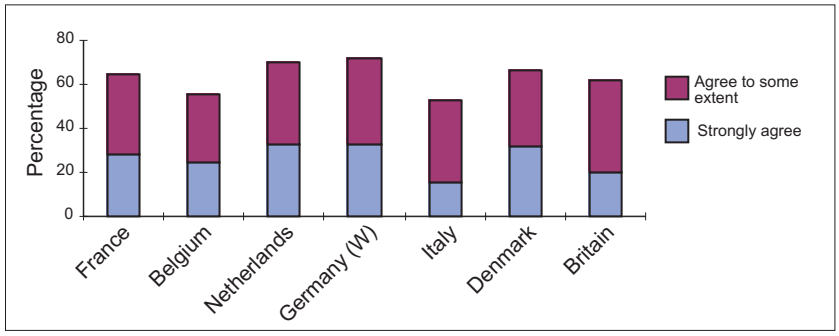

FIGURE 2A. Because of their knowledge, scientists have a power that makes them dangerous

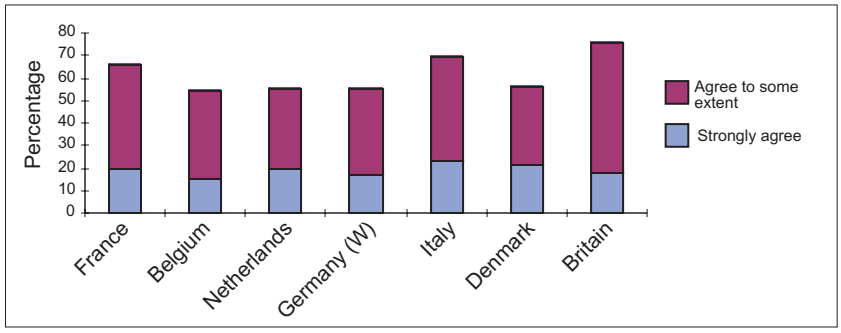

FIGURE 2B. Most scientists want to work on things that make life better for the average person

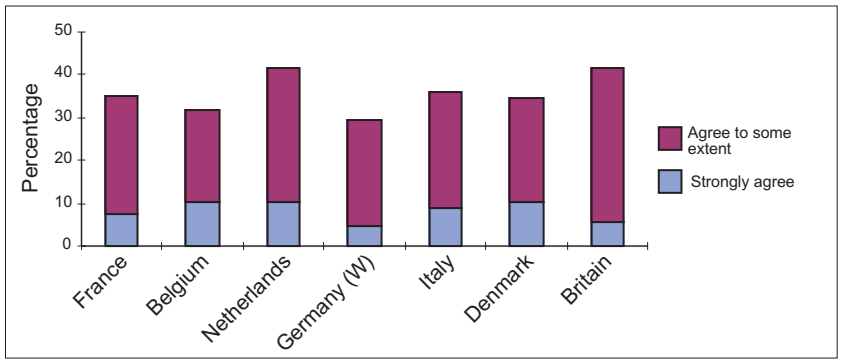

FIGURE 2C. Technological progress will make possible higher levels of consumption without damaging the environment

Source: Eurobarometer 38.1, September 1995

to Figure 2C). British and Dutch citizens appear to be the most technologically optimistic Europeans, with nearly 42 percent of the public in each country agreeing with this statement. Germans were the most pessimistic in this regard with only 29 percent of the population demonstrating similar attitudes.

A separate strand of questions from the Eurobarometer survey provides a slightly different angle from which to approach possible cross-national differences in scientific *mentalité*. This section asked respondents to select which of nine professions they respected the most and second most.[5] The results are presented in Figure 3A. Scientific researchers achieved the most favourable score in France where 68 percent of the public reported high respect (first or second position) for this profession. Science as a professional endeavour faired much more poorly in the Netherlands, Germany, and Denmark. In each of these

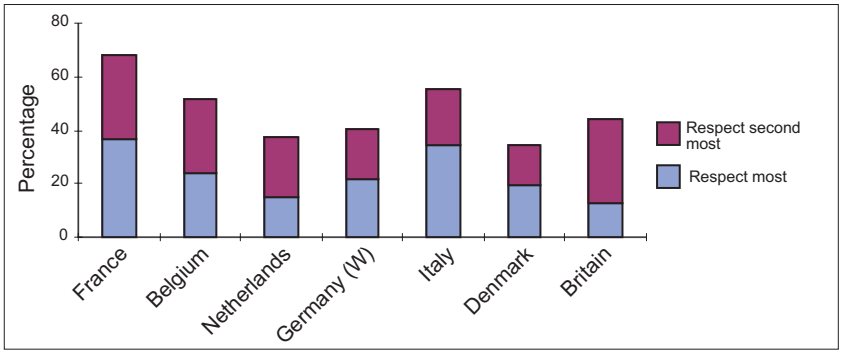

FIGURE 3A. Percent of public ranking scientific researchers as the most respected profession

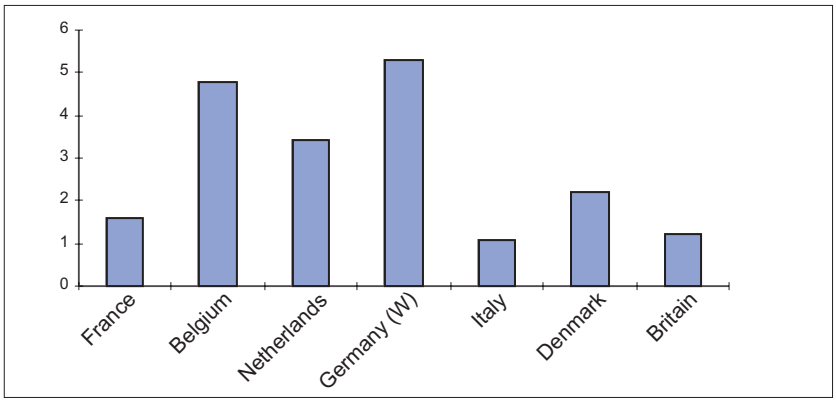

FIGURE 3B. Percent of public ranking scientific researchers as the least respected profession

Source: Eurobarometer 38.1, September 1995

countries scientific researchers were well respected by less than forty percent of the public. Figure 3B displays the results derived when the question was reversed and respondents were asked which profession they respected least.[6] Although the absolute values are small, these data reinforce an emerging pattern suggesting that in comparative terms less respect is afforded scientific researchers in Germany (and Belgium) than in the other European countries included in the survey.

These general trends regarding national scientific *mentalité* are confirmed by a recent report prepared for the Organisation for Economic Cooperation and Development (OECD) (Miller, 1996; see also Normile, 1996). Of a sample of fourteen OECD countries, public interest in science was highest in Britain, Canada, France, Greece, Italy, the Netherlands, and the United States. Researchers classified, on the basis of survey responses, more than 50 percent of the public in these countries as either very attentive or interested in science. Germany, Japan, and Portugal evidenced the lowest interest in science within the OECD sample.

We can use the responses to these questions on public attitudes about science and scientific researchers to develop a provisional ranking of select European countries in terms of their scientific *mentalité*. These data suggest that among our sample of surveyed nations Germans are most circumspect about science and technology. In contrast, for most of the British public there are few indications that science, both in its pure and applied forms, is viewed in a disagreeable light. The Dutch present a seemingly paradoxical case that requires a more subtle interpretation. On one hand, we find the public in the Netherlands expressing doubt about science, yet, on the other hand, evidencing strong technological optimism. This apparent inconsistency seems to suggest that the Dutch make careful distinctions between theory and practice. While there is some unease about science and the goals and aspirations of scientific researchers in the Netherlands, the lay public remains largely supportive of the outcomes that flow from technological innovation.

EXPLORING NATIONAL SCIENTIFIC *MENTALITÉ* IN HISTORICAL CONTEXT

A healthy understanding of science or, at the very least, a willingness to defer to scientific authority in matters of consequence is typically taken to be a prerequisite of civic responsibility. Despite calls over the past century of their pending demise, numerous alternative knowledge systems continue to persist among members of the lay public. Some of these competing epistemologies are associated with earlier, less sophisticated epochs and others are more future-oriented, comprising a heady mix of quantum physics and new-age spiritualism. While perhaps suitable for amusement, such non-scientific forms of expertise

are conventionally regarded, at least by societal elites, as poorly suited for the exacting, high-stakes demands of the public-policy arena. Individuals who fail in serious discourse to acknowledge the hegemony of science risk subjecting themselves to stern censure. Certain environmental activists have been especially prone to violations of this norm and they regularly expose themselves to criticism alleging that their reactions are hysterical and fallacious. The custom of branding as heretics individuals who threatened the social order was common in the pre-scientific era. This practice has become anachronistic and contemporary scientific societies instead use the charge of 'irrationality' as the preferred mechanism for ostracism.

One reason for these charges is that science exists in two separate realms. On one hand, science is a rigorous methodology for interrogating nature that takes the control and predication of environmental uncertainty as its point of departure. On the other hand, scientific knowledge fulfils a role in advanced societies as a civic epistemology. In this second context, science is not about objectivity and truth finding in the narrowly instrumental sense, but is rather an intellectual device people use for securing social identity and for defining the self. Individuals who are disposed to a rational worldview and to a perpetuation of existing social hierarchies intuitively find science to be a useful knowledge system for underpinning their political commitments. In contrast, people with more humanistic leanings and stronger egalitarian inclinations will demur from science as a civic epistemology because of the conflicts it creates for their worldview. Instead, such individuals will gravitate toward knowledge systems with organising principles more consistent with their particular proclivities.

To appreciate the socially-embedded role of science, it is useful to consider the historical factors that have conditioned the use of this knowledge system in the public sphere. Some societies have proven themselves to be well equipped to accomplish the arduous task of assimilating science into popular culture. In other countries, religious doctrine, moral prescripts, historical precedent, or simple inertia have buffered science's penetration into the public realm. These antecedents, in some cases dating back to the early days of the Scientific Revolution, are discernible and can be used to help explain the national differences in scientific *mentalité* that we observe today.

To accomplish this task, the following sections draw heavily on certain strands within the history of science. A new generation of scholars has over the last couple of decades transcended the discipline's conventional preoccupation with scientific heroism and begun to devote timely attention to how social and political context has influenced the intellectual development of science (for example, Jacob, 1988; Toulmin, 1990; Shapin, 1994). By combining this sociologically-informed perspective with evidence from the history of education, social history, and the history of ideas we can begin to explore the predisposing factors that have shaped the public face of science in different nations. In particular, we will be interested in determining the country-specific

processes by which science, to paraphrase Robert Merton, established its authority as a social institution in the public mind.

The pervasive linkages between science and industrial enterprise might suggest that examination of the cultural absorption of science in different societies is no more than an exercise in economic history. Adherents of this approach contend that the Industrial Revolution first took hold in Lancashire and Derbyshire because of an elevated English commitment to mechanism. Inevitably, history is more complex and it would be imprudent to claim that industrial prosperity can serve as a simple proxy for scientific *mentalité*. An ultimately more satisfactory discussion of how science established its legitimacy in various countries must go beyond the narrow economic realm.

Because each nation has had a distinct historical experience with science, it is unrealistic to examine here more than a couple of specific cases. Accordingly, the following sections are devoted to comparisons of the ways Britain and Germany have managed to culturally assimilate science. Furthermore, space constraints make it necessary to confine the timeframe covered by this review to the period prior to 1900. With the dawn of the twentieth century, and particularly due to the impetus provided by World War I, science gained considerable momentum. Though societal manifestations of this knowledge system have become infused into the structure of advanced societies over the course of the past one hundred years, this essay contends that pre-existing public dispositions have not been entirely subverted.

Science in Britain

Though a coterie of seminal figures such as Francis Bacon, Robert Boyle, and Samuel Hartlib played key roles nurturing early scientific enterprise in England, the emergence of the 'new science' in the country during the sixteenth and seventeenth centuries was more generally an outcome of the religious ferment of the Civil War years. Beginning with Robert Merton's Puritanism thesis dating from the 1930s, scholars have carefully explored the connections between the various sects active during the Interregnum period – ranging from Millennialism to revival Hermeticism – in an effort to identify the precise way in which religion gave rise to science (Merton, 1970 [1938]; Webster, 1974; Cohen, 1990). Though emphasis varies, historians are quite consistent in their view that these Protestant sects imparted new values on large segments of society and encouraged people to cast aside a scholastic worldview in favour of the *vita activa*.

During this period of profound intellectual turmoil, Latitudinarian Anglicans acquired central authority, eventually managing to quell the theological passions that divided Anglo-Catholics, Calvinists, and numerous radical sectarians (Henry, 1992). The Latitudinarians' strategy for reconciliation was based on an eschatology that promoted doctrinal minimalism as a means of easing conflict and discouraging speculative theorising. The emphasis this influential group of theologians placed on scepticism and empiricism reinforced developments

taking place among natural philosophers who found this methodology amenable to their purposes of trying to free inquiry from ideological commitments. These developments ultimately led to the founding of the Royal Society of London in 1660 and defined English science as a decidedly pragmatic pursuit.

Despite these extraordinary accomplishments, science in England throughout the seventeenth century remained confined to an extremely narrow segment of elite society. With reference to this period, one historian has remarked, 'The impact of any question of abstract science upon a human brain was exceptionally infrequent – it could only happen to say, one individual in a hundred thousand' (A. R. Hall as quoted in Mathias, 1972: 77). While this era was of tremendous importance in establishing the intellectual foundations of science, the knowledge emanating from such circles remained remote from everyday life. Moreover, science in the seventeenth century had not yet developed a popular means of expression and we need not devote much attention to this period here.

Wider public diffusion of scientific knowledge in England did not begin to take place until the first half of the eighteenth century, a process facilitated in large part by a corps of itinerant lecturers. These men of early modern science travelled the country making presentations to fraternal organisations, business societies, and a growing number of amateur science associations.[7] Also influential in promoting scientific learning were the so-called Boyle and Newton lectures that gave theologians opportunities to deliver sermons informed by the emerging body of natural philosophy. Though members of the nascent middle class and some upper-class dilettantes evidenced interest in these lectures, the new knowledge still failed to touch society more generally. Both the 'lower orders' and the upper reaches of the country's aristocracy continued to remain beyond the range of the radiating eddies of scientific thinking. Additionally, the ancient universities of Oxford and Cambridge during this period maintained a fierce intellectual hostility to science and the entrenched conservatism of these institutions easily frustrated the attempts of the odd maverick to modernise the curriculum. Due to the close affinities between the ancient universities and the nation's patrician public schools, steadfast resistance to science was also common among the headmasters responsible for training the children of the country's elite.

The integration of science into wider English society did not begin until about 1750 when the first definable accomplishments of applied science were introduced into manufacturing and agriculture. The absence of public funding for research (as existed, for example, in France), perpetuated a pragmatic bent in science as purveyors of this knowledge were, by necessity, forced to adopt an applied, entrepreneurial posture. Developments along these lines were quite pronounced in Lancashire, Derbyshire, and Yorkshire, areas that would play decisive roles in the impending Industrial Revolution. The country's rapidly expanding middle class demonstrated an especially keen regard for science, apparently because of the opportunities it created for social and economic advancement. According to one historian, '[I]nterest in the [scientific] subjects

themselves was secondary to interest in the social mobility they could afford. Whatever their intellectual value, their social function probably lay in providing easier access to ruling class circles' (Morris Berman as cited in Inkster and Morrell, 1983).

Though scientific thinking proved attractive to certain elements of English society, the stultifying effects of rationalisation and industrialisation inspired by this knowledge system encouraged a strong backlash at the turn of the century. English Romantic writers, most notably William Wordsworth, Samuel Coleridge, and Thomas Carlyle, railed against the inhumanity of the entire endeavour and a new understanding of 'culture' was born as a means of defending society against these allegedly corrupting forces (Williams, 1958; see also Bate, 1991). These were not the musings of a few irritable grousers caught under the wheels of progress. Several developments – the most prominent of which were the increase in literacy rates, the launch of popular newspapers and magazines, and the establishment of public libraries – were instrumental in generating an avid audience for these authors' work. Also important in popularising these circumspect sentiments was the emergence of the novel as a new literary genre and this gave rise to a wave of books subjecting the dark side of technological and scientific advance to careful scrutiny (e.g., *Mary Barton*, *Hard Times*). Though other romantic reformers such as John Ruskin, Matthew Arnold, and William Morris would later turn their attention to similar concerns, it was largely the earlier generation of scholars that established the tradition of subjecting science and industrial activity to incisive social critique.

By the middle of the nineteenth century, the so-called Golden Age of British Capitalism, the country's period of unchallenged economic dominion was already in eclipse as new international competitors came into view. This period was characterised by a slowing of economic growth and a hardening of class boundaries. With fewer opportunities for upward advance, science began to lose its instrumental function as a means of social mobility. Further, this knowledge system never managed to resolve its problems of incompatibility with English aristocratic values. As the middle-class sons and grandsons of the early industrialists grew increasingly comfortable with their gentry lifestyles, science came to be dismissed among the members of this influential social strata as nothing more than a hobby (see, in particular, Weiner, 1981: 16-24). Science could have been employed at this time, as Inkster and Morrell (1983: 43) argues, as a mechanism to uphold the prerogatives of industrial elites, but other cultural, educational, and political institutions proved to be more readily suited for this purpose. He explains, 'Perhaps it was because of such reasons that between the 1840s and 1870s British science appears not to have produced a popular movement or image or to have been purposely cultivated by any characteristic social grouping to a degree even comparable with that of the earlier period'.

This disregard of science was particularly pronounced within British education during the nineteenth century. Even at Rugby, which by many accounts was the public school most receptive to science, conditions were austere and

pedagogy was limited to the classics and mathematics. Martin Weiner (1981: 17-18) relates the experience of J. M. Wilson, an astronomer teaching at the school who was permitted to offer four hours of natural philosophy instruction per week 'as long as it did not interfere with the fourteen hours he put in on algebra, geometry, and trigonometry'. Even under such circumstances 'no room could be found on the premises at Rugby, and the experiments were performed out of sight, in the cloakroom of the Town Hall a hundred yards down the road from the school, with the apparatus locked up in two cases so that the townspeople could use the space for other purposes at night'. As grim a situation as this description suggests, the circumstances at other reputable public schools, as well as at the disordered assortment of endowed and proprietary schools that existed at the time, were even less supportive of science.

Though some prescient observers such as Charles Babbage had begun to warn as early as the 1830s that this neglect held the seeds of decline, official recognition of the problem remained muted until the middle of the century. Galvanised into action by the Great Exposition of 1851, the government launched a series of inquiries, most of which advised on the need to overhaul the country's antediluvian educational system and to upgrade the effort devoted to science and technology. Despite this attention, the establishment of an integrated and comprehensive secondary school system would have to wait until the Education Act of 1902. In the mean time, the Clarendon Commission formed in 1864 found that even within the most selective public schools 'classical teaching was frequently unsatisfactory and that modern subjects were considered inferior and not worthy of attention' (quoted in Roderick and Stephens, 1972: 31). The authors of the Commission's final report recommended that the curriculum be remodelled along the lines of the German gymnasia, a reorganisation that would require the full acceptance of mathematics, modern languages, and science.

Initiatives to improve science instruction in the public schools met stiff resistance. According to one historical account, 'Opinion among the [public school] headmasters was that classics was the best training for first-class minds. Modern studies was for 'boobies' and did not have high educational value'. However, another headmaster was not entirely dismissive of an updated curriculum, indicating that science offered an area in which 'the most backward in classical knowledge can take refuge. There they can find something to interest them' (Roderick and Stephens, 1972). It is from such attitudes that science became stigmatised among educators and the public at large as a wholly vocational pursuit, suitable only for students with inferior abilities.

On the basis of such assessments, there is a tendency to attribute the slow pace of English educational reform to strident and uncompromising resistance to innovation. However, this interpretation misses the mark because in some public schools there was an openness to new ideas. A comment made by the Rugby headmaster in testimony before the Clarendon Commission provides instructive insight into why science studies faced such stiff resistance. 'The real defect of mathematics and physical science is that they do not have any tendency to

humanise. Such studies do not make a man more human but simply more intelligent' (Roderick and Stephens, 1972).

The situation for science in other parts of the educational landscape was not quite as dire. Several new institutions of higher education were created during the first half of the nineteenth century – University College London in 1826, King's College (London) in 1828, and Owen's College (Manchester) in 1851 – as alternatives to the ancient universities. Then, in the 1850s, the government took its first tentative steps to upgrade vocational and technical education. However, fears that public intervention would lead to state control created circumstances in which the implementation of these programmes remained a largely local responsibility. The government noted in 1859, 'It is hoped that a system of science instruction will grow up among the industrial classes which will entail the least possible cost and interference on the part of the state' (Roderick and Stephens, 1972: 13).

To address the chronic need for technical education, wealthy residents in most of the industrial cities banded together to endow a vast array of new institutions to teach science. The largesse of these benefactors in cities such as Leeds, Liverpool, and Bristol was responsible for the creation of a crazy-quilt of civic universities, polytechnics, Mechanics' Institutes, technical high schools, evening education programmes, and technical centres. Public support for these schools first became available after 1853 when the government established the Department of Science and Art, but funds were meagre and did little to curtail the chronic shortage of supplies and experimental apparatus. As schools grew from pressing demand, administrators were forced to provide new laboratories in scattered locations around the rapidly expanding cities. More detrimental than the dearth of centralised facilities, however, was the lack of any coordination among the various educational offerings and the struggle students faced trying to attend evening classes after working a twelve or fourteen hour day. Invariably, attendance was irregular and the rate of attrition was high. Most serious students who had the financial means to do so travelled to Germany for training. For anyone desiring advanced study, especially in chemistry, a German institution was the only viable option.

In select areas of public life, principally within the ranks of the British military, the potential for modern science to confer certain benefits, particularly in the areas of ballistics and navigation, was quickly recognised and developments in these specialised spheres departed from the prevailing trends. Within government ministries more generally during the nineteenth century, attention turned to science and the first steps were taken to introduce scientific knowledge, albeit very tentatively, into the Civil Service. This commitment took the form of the establishment of several government laboratories and astronomical observatories, along with the appointment of a handful of personnel to staff these facilities. Despite progress in these areas of seemingly high influence, science continued to carry a heavy stigma. Employment prospects remained poor and capable students were regularly advised to pursue more conventional and

remunerative lines of work. This view was confirmed by the Royal Commission on Scientific Instruction in the 1870s: 'It is acknowledged that Science is neither recognised, nor paid nor rewarded, by the State as it ought to be, that mainly owing to this, there is no career for Science and that parents and masters are justified in avoiding it' (Roderick and Stephens, 1972: 40).

The official recognition that science managed to achieve in England during these years was the result largely of a small cadre of reformers – many either German-educated or self-trained and thus outside the ranks of the Oxford and Cambridge educational elite – who set themselves the arduous task of institutionalising British science. Motivated to a large extent by a drive to preserve the country's economic competitiveness, this activist group approached this challenge from several different angles: the reorganisation of the Royal Society as an association of professional scientists, the enhancement of scientific recruitment through the establishment of formal education programmes, and the encouragement of coordinated government sponsorship of research. These Victorian-era reformers embarked on their task with characteristic aplomb, but still found it difficult to stimulate pervasive and self-sustaining public interest in science. The dearth of educational and employment opportunities at home encouraged many budding young British scientists to strike out for more promising locales, principally Germany and the United States (McLeod, 1972).

By the middle third of the nineteenth century, the neglect of science began to have unavoidable impacts on British industrial competitiveness. This was especially the case as economic advance became more dependent on scientific input in growing fields such as chemistry, metallurgy, and steel. David Landes (1969), the dean of economic historians, observes in his magisterial account of European industrialisation that '[t]he really important research in theoretical and applied chemistry was being done abroad where the education of chemists was already more systematic and thorough than in Britain'. The country's advantages in scale and resource availability provided some cushion from the crushing blows of increasing international competition, but the waning influence of these assets would eventually have serious ramifications. The unavoidable symptoms of decline prompted the government to convene another round of commissions to investigate and this attention encouraged the ancient universities to take their first halting strides toward modernisation.[8] These gains were largely limited, however, to the establishment of a few supplementary university fellowships, the creation of a handful of teaching posts, and the provision of a small pool of funds to support scientific research. Not without irony, these minor improvements were ambivalently endorsed by the small, struggling community of British researchers, a reaction that reflected a larger debate concerning the appropriate role of the state in scientific affairs and the extent to which public participation would compromise professional autonomy (Alter, 1987).

Even if the government and major educational institutions had been inclined to take more aggressive action to promote science during the nineteenth century, public attitudes toward the purveyors of this form of knowledge were not

especially conducive. Throughout the 1880s the country experienced forceful resistance to science amid accusations of 'arrogance' by its proponents and concerns about the emergence of a 'priesthood of science'. A fresh wave of romanticism swept the country and some of the social critics associated with this movement gave new life to the contention that science promoted atheism and materialism.

As the nineteenth century came to a close, many scientists in Britain felt the darkest days were in the past. The government took several steps to institutionalise science and place research on a more dependable financial footing. These years witnessed establishment of the London School of Tropical Medicine, the Imperial Cancer Research Fund, and a host of private endowments for scientific work. The number of university posts in science and technology increased from sixty in 1850 to 400 in 1900 (Mcleod, 1972). Though far short of the German government's appropriations for science, the first decade of the twentieth century in Britain brought increased public support to research and education. The country passed an important milestone in 1905 when financial assistance from the public sector for the first time exceeded endowments and donations. Nonetheless, the number of scientists and technologists produced by German universities and technical schools remained during this period five times as great as the number produced by British institutions of higher education (Roderick and Stephens, 1972).

Science in Germany

Historians have typically attributed the initial growth and expansion of science in the German states to eighteenth-century Pietism, an ascetic religious movement dating back to the 1650s that attempted to reform the Lutheran Church (Weber, 1958; Merton, 1968). Pietism emphasised the importance of education on human development and several Pietists such as Johann Julius Hecker and August Hermann Francke played important roles in German educational reform during the eighteenth century. More recent scholarship, however, has drawn attention to the incompatibility of several Pietist religious strictures with the new science and this reinterpretation has cast doubt on the actual influence of this sectarian group in promoting the emergence and diffusion of this mode of thought in Germany (Becker, 1984, 1986, 1991, 1992; cf Merton, 1984).

While certain Pietist beliefs such as the systematic reordering of life in terms of empiricism and utilitarianism were supportive of science, other elements of their religious thought forced inquiry to proceed within a doctrinaire Christian frame. Particularly antagonistic to the rationality and objectivity required for science was the Pietist concept of *Herzensreligion* (heartfelt religiosity) and a series of practices based on spiritual enthusiasm. Under these constraints, natural philosophy was not discouraged outright. Instead, German Pietists subordinated scientific findings to theological knowledge and favoured a form of inquiry

based on phenomenology that ran counter to the sceptical methodologies undergirding the new science elsewhere. These particularistic qualities of Pietist science would eventually require members of this religious cluster to confront the epistemological contradictions inherent in their belief system, though this challenge would not occur until the more conventional natural philosophy practised in Western Europe had gathered sufficient momentum.[9]

Unlike in Britain, the formal educational system played a key role in the early dissemination of scientific knowledge in the German states. Several scholars, including Merton, have pointed to Pietist educational reforms, namely Franke's *Pädagogium* and the creation of the *Realschulen*, both alternatives to the classical *Gymnasium*, as progressive forces for science.[10] However, non-Pietist educators such as Johann Julius Hecter and Johann Joachim Becher also seem to have played important roles in promoting the benefits of incorporating science into school pedagogy. Taking issue with the conventional Mertonian interpretation, Becker (1984) extends this view concerning the role of non-Pietists in the promotion of science, contending that '[O]ther elements of German society, particularly the nobility and those associated with eighteenth-century rationalism and Enlightenment thinking fostered scientific education activity and more enthusiastically [than the Pietists]'. The emphasis on science among this elite group appears to have been due to the benefits imparted by this knowledge in pursuing the techniques of war and fortification. Under these circumstances, the incorporation of some scientific content into the curricula of the reformist Pietist schools, Becker argues, was motivated more by the need to compete with the pragmatic *Ritterakademien* to which the nobility typically assigned their sons than by any deeper-seated pedagogical commitment. Despite these demands, scientific inquiry in Pietist secondary schools during much of the eighteenth century was subordinated to theological considerations.

At the university level, the institutions at Halle and Königsberg offered students during the first half of the eighteenth century early exposure to the emerging natural sciences.[11] The dominance of Pietist influences at these universities has been used to support allegations of a link between Pietism and German science. Though Pietist influences were widespread at both of these institutions, Becker argues that it was rather the forcefulness of the non-Pietist rational philosopher Christian Wolff at the University of Halle that was responsible for encouraging an emphasis on science. Wolff, however, pressed his case too strongly and the Halle Pietists were able to engineer his expulsion from Prussia in 1723. During his eighteen-year exile, Wolff was appointed to the Paris Academy of Science and was embraced throughout the non-Prussian academic world for his scientific and mathematical accomplishments. Catherine the Great even bestowed upon Wolff the distinction of Honorary Professor and granted him an annual honorarium (Becker, 1991: 149-150). Many scholars point to this episode as the turning point in the advance of rationalism and reason in the German states. By the time Wolff returned to Halle in 1740, the Pietists were in

retreat and most institutions of higher education, in keeping with the spirit of the Enlightenment, began to implement broad scientific instruction as had already been achieved at the Universities of Göttingen and Altdorf.

During the second half of the eighteenth century most currents of Pietism, with the exception of the *Herrnhut* faction associated with Nicolaus Ludwig Zinzendorf, were absorbed by mainstream Lutheranism. This development enabled science to advance in the German states without serious challenges to its intellectual content and paved the way for initial advances in industrial development. However, by the later portion of the century, Pietism began to experience a 'reawakening', a response that was partly a reaction to the expanding cultural authority of science and mechanism more generally. Fomented by the *Herrnhuts*, this new Pietistic variant represented a reactionary movement against secular Enlightenment influences and contained a distinct anti-rationalism (Becker, 1984: 1083). Shorn of its progressive tendencies, nineteenth-century Pietism entailed enhanced emotionalism and a greater emphasis on spiritualism. Foremost perhaps was the privileged position given over to intuition at the expense of experimentation.

Though the direct impact of this re-emergent Pietism on the larger society was quite modest, it inspired a romantic backlash that criticised science for its latent irrationality. The principal proponents of this view were Hamann, Goethe, Schelling, and the larger group of radical intellectuals associated with *Naturphilosophie* (Becker, 1984: 1084; see also Pinson, 1934). This countermovement had a powerful impact, transforming broad sections of the German cultural map, though its effects were most profound in the areas of music, art, and literature. The sentiments of the German romantics would remain volatile, gaining particular resonance during periods of economic and political distress.

Supported by favourable developments in the universities, the German states embarked upon aggressive modernisation programmes during the 1830s. At least until the middle of the nineteenth century, the bureaucrats of each political jurisdiction retained authority to appoint senior university personnel and this enabled the government to craft an educational system specifically suited to its utilitarian interests. In particular, this administrative procedure facilitated the creation of a system of higher education oriented toward professional education (McClelland, 1989). A complimentary network of institutes was created for purposes of research. It was through these institutional mechanisms that German universities were able to channel during the mid-nineteenth century large numbers of scientists to the country's growing chemical industries. The availability of an ample supply of expertly trained scientific personnel at this auspicious period in the evolution of industrialisation created beneficial feedbacks. As McClelland (1989: 294) explains,

> From the late 1860s onward, the entire university system experienced unprecedented growth in enrolment, and even when these slowed down, growth in the expanding technical colleges often accelerated. Mounting prosperity and industrialisation

provided unprecedented funds for governments to invest in the higher educational system, not only to accommodate the swelling student population but also to encourage the scientific and scholarly results that had already begun to enhance the prestige of the German states.

Though concerns emanating from some sectors of society about the irreligious tendencies of science, especially during the revolutionary years of the late 1840s, forced educators to increase temporarily the attention devoted to classical subjects, the overarching trend was for science to gain in influence. The penetration of this knowledge system into society ever more deeply contributed to a number of developments. First, institutional expansion triggered a process of reductionism and German science would be the first to experience the effects of increasing specialisation. Second, the narrowing of scientific disciplines brought increasing professionalisation. Third, the inchoate German nation recognised before its neighbours the economic and political benefits that could flow from harnessing science to both higher education and the objectives of the state. Finally, the spread of technical knowledge enhanced public respect for science in the German states. These factors in combination gave rise by mid-century to a 'a national myth of *Wissenschaft*' (Turner, 1989).

With unification in 1871, the speed of German industrialisation was further intensified and the vestiges of feudal society began to recede before a rapidly advancing modernity. Urbanisation accelerated, transforming the newly-consolidated country and further infusing science into the core of German culture. So wide-ranging were these transformations that Germany began to threaten British economic pre-eminence on both the European and international stages, especially in chemicals and other science-intensive manufacturing processes.

This extraordinary phase of modernisation provoked another sharp backlash against technological and scientific progress, drawing its inspiration from the romantic influences that had coalesced more than fifty years earlier. Though the sentiments would not come into full flower until the Weimer period following World War I, a brooding sense began to build across the country that scientific rationality was sapping the nation's cultural spirit and sense of purpose, motivating an existential crisis that was felt most profoundly among German youth. In some intellectual circles these concerns were expressed as a refutation of reductionist science in favour of approaches such as Gestalt psychology and vitalist biology that promised to reinfuse holism and enchantment back into nature. Mechanism came to be viewed in many circles as a peculiar form of 'English sickness', an attitude that would later crystallise in historian Oswald Spengler's mind as the 'dead Nature of Newton' (Harrington, 1996; see also Ash, 1995). Scholars have advanced several explanations to account for this phenomenon, the most prominent of which pay attribution either to the speed and arduousness of Germany's modernisation during the second half of the nineteenth century (e.g., the so-called *Sonderweg* thesis) or cultural despair and devastation after World War I. These various holistic movements to overcome

scientific fragmentation would eventually be put to nefarious purposes by the promoters of the racial hygiene policies of the Nazi era (Bramwell, 1989; Harrington, 1996).

CONCLUSION

The preceding discussion highlights in broad form some of the influences that have conditioned the cultural absorption of science in Britain and Germany. Though this account has obviously simplified a great deal of complicated history and side-stepped any number of scholarly controversies, it suggests that the public face of science found today in each country has been uniquely shaped over a long period of time. As systemic, rational knowledge has come to occupy an increasingly important role as a civic epistemology in advanced nations over the course of the preceding century, these differences have invariably narrowed. Nonetheless, even casual familiarity with the two countries scrutinised here confirms that these legacies have not been entirely overwhelmed by more recent events and that certain enduring qualities pertaining to each nation's disposition toward science remain relevant for the present era. To appreciate properly each country's national scientific *mentalité* it is useful to interpret this capability within an historically-informed context.

In particular, there are three elements that give distinctiveness to the profile of science as a civic epistemology in Britain and Germany. First, the historical record prior to 1900 attests to striking differences in the relationship between science and the lay public. In Britain, convergence between science and the state did not begin to take place until the twentieth century and many of the suspicions inculcated during the era of scientific *laissez faire* continue to linger today in mutated form. Importantly, most British government officials have had less exposure to science than their peers in other advanced countries, a factor that contributes to indifference when competing issues vie for attention at the highest levels of public administration. In contrast, Germany has demonstrated a far greater willingness to use public resources to assist science, in terms of research and education. This affinity conferred upon scientific knowledge a degree of legitimacy that it did not enjoy in Britain and promoted a consistency between national and scientific aims.

Second, British educators, both at the secondary and university levels, have displayed an obdurate reticence over the years to embrace science. The country's class-bound public schools and ancient universities have erected high barriers to curricular reforms that have attempted to elevate the status of science. Furthermore, by labelling scientific learning as an inferior form of education, one incapable of challenging students in the same way as the classics and other components of a 'liberal education', these prestigious institutions have stigmatised science. In other educational spheres, this form of knowledge has been embraced episodically as a vehicle for social mobility, but interest in science has

typically waned once its instrumental utility was exhausted. This situation stands in stark contrast to the German system for science education that was put into place early in the nineteenth century. Alternatives to traditional education were widely available and protected from becoming discredited as vocational and only appropriate for students of lesser ability.

Finally, Britons and Germans have developed separate means for giving voice to their misgivings about science's tendency to rationalise and disenchant the world. In Britain, this antipathy has been expressed primarily by social reformers, literati, and humanists. Foremost contributors to this cultural repository have been the likes of Wordsworth, Carlyle, Ruskin, and Morris. While the German resistance to science has comprised similar romantic figures, as we have seen, it has also contained a unique auxiliary feature. Goethe's scientific ambivalence has inspired a diverse range of scientists – psychologists, neurologists, and biologists – who have channelled their dissatisfaction with reductionism toward efforts to formulate more humanising and holistic epistemologies. In some cases, these dissenting approaches have been buttressed by an explicit ideological agenda as in, for instance, the 'research' of Joachim Mrugowsky and Viktor von Weizsäcker (see Harrington, 1996). As a result, the German critique of rational knowledge, because it has been generated from within the body of science itself, has been more dynamic and confrontational. The closest British approximation to this sort of criticism of science has come from lone iconoclasts such as J. D. Bernal and has been projected in the form of polemical pronouncements rather than organised programmes seeking alternative knowledge predicated on experimental insights.

Taken in total, these points of contrast speak to the continued existence of important distinctions in the public face of science in Britain and Germany. One does not have to adopt a stridently externalist posture to infer that German social theorists have been influenced by the country's particular formulation of science as a civic epistemology. It is therefore advisable to tread carefully when trying to generalise about the relationship between science and society from what are largely German-inspired theoretical insights. Perhaps most pointedly, we have seen that the process by which science has been culturally assimilated in Britain stands in sharp contrast to the German archetype and presumably this diversity would expand if we were to subject other countries to similar scrutiny.

While this evidence favours circumspection in the realm of social theory, the striking difference in the public profiles of science in Britain and Germany still begs consideration. In particular, the concept of an historically decontextualised public understanding of science emerges as a dangerous fallacy. It appears that German culture is characterised by a certain Janus temperament with respect to science. Whether the repudiation of rationalisation by sizeable segments of a society profoundly dependent on scientific knowledge is a transient expression of *fin de siècle* angst or a more profound upwelling of deeply-rooted anxiety remains a provocative and puzzling question. In any event, no other country in Europe seems to evidence a similar degree of discomfort with the social upheaval

being caused by the current wave of modernisation and globalisation. Though some observers have treated German trepidation about science as a bellwether of more general human resistance to the advanced stages of modernity, there is little reason to believe *prima facie* that these sentiments have the same resonance in other national contexts.

NOTES

[1] This statement is obviously less true for historians of science and many sociologists of science. This characterisation does, however, capture the prevailing thinking of most social scientists with an interest in the environment.

[2] See, in particular, the journal *Public Understanding of Science*, though the origins of this research can actually be traced to the 1930s.

[3] This exercise consisted of face-to-face interviews with approximately 13,000 people over the age of eighteen in twelve European Union-member countries during November 1992.

[4] The results for Luxembourg, Ireland, Northern Ireland, Greece, Spain, and Portugal are not reported here. Data for Germany refer only to the pre-1989 Federal German Republic.

[5] The list of professions comprised the following: judges, medical doctors, lawyers, scientific researchers, businessmen, journalists, bankers, engineers, and architects.

[6] In broad terms, businessmen, bankers, and journalists ranked as the least respected professions in most of the sampled countries.

[7] The most prominent of these groups was the Lunar Society of Birmingham which historians claim played an especially important role in disseminating and popularising scientific knowledge during this early phase. Accounts of the Lunar Society are widespread in the literature pertaining to English science during the late seventeenth century. Refer, in particular, to Schofield (1963).

[8] Though creeping awareness of various institutional difficulties concerning science in Britain had already begun building during the 1830s, this consciousness did not become widespread until the second half of the nineteenth century. This period is given extensive treatment in Roderick and Stephens (1972) and Mcleod (1972).

[9] This is not the place to enter into a discussion concerning the claims and counterclaims regarding the role of Pietism in the emergence of German science during the eighteenth century. This dispute ultimately centres on matters of interpretation regarding certain historical figures such as Franke, as well as the imprint they imposed on the institutions with which they were affiliated. Amid the flying feathers of the various controversies regarding the relationship between Pietism and science in Germany there appears to be a glimmer of light. Both Merton and Becker concede that Pietism may have led to a preference for practical expertise rather than an orientation focused more specifically on scientific theory. For further details refer to Pinson (1934), Merton (1984), and Becker (1984).

[10] It is necessary to note that the content of instruction offered by the early *Realschulen*, particularly in terms of the attention devoted to the natural sciences, is not without controversy. Becker observes that the largely pre-industrial structure of the eighteenth century German economy 'limited the demand for individuals with scientific and technological skills…[These schools] provided instruction in religion, German, French, Latin, writing, as well as an unspecified content area aimed at specific practical applications' (Becker, 1986).

[11] The universities at Göttingen and Altdorf have also been regularly identified as playing important roles encouraging the advance of science. Though Merton asserts that these institutions were subject to heavy Pietist influence, Becker (1984: 1077-1078) provides plausible evidence to refute this claim.

REFERENCES

Alter, Peter 1987. *The Reluctant Patron: Science and the State in Britain, 1850-1920*, Angela Davies, trans. Oxford: Berg.

Ash, Mitchell 1995. *Gestalt Psychology in German Culture, 1890-1967*. Cambridge: Cambridge University Press.

Bate, Jonathan 1991. *Romantic Ecology: Wordsworth and the Environmental Tradition*. London: Routledge.

Beck, Ulrich 1992. *Risk Society: Towards a New Modernity*. London: Sage.

Becker, George 1984. 'Pietism and Science: A Critique of Robert K. Merton's Hypothesis', *American Journal of Sociology* **89**(5): 1065-1090.

Becker, George 1986. 'The Fallacy of the Received Word: A Re-examination of Merton's Pietism-Science Thesis', *American Journal of Sociology* **91**(5): 1203-1218.

Becker, George 1991. 'Pietism's Confrontation with Enlightenment Rationalism: An Examination of the Relation between Ascetic Protestantism and Science', *Journal for the Scientific Study of Religion* **30**(2): 139-158.

Becker, George 1992. 'The Merton Thesis: Oetinger and German Pietism, A Significant Negative Case', *Sociological Forum* **7**(4): 641-660.

Bramwell, Anna 1989. *Ecology in the Twentieth Century: A History*. New Haven: Yale University Press.

Cohen, I. Bernard (ed.) 1990. *Puritanism and the Rise of Modern Science: The Merton Thesis*. New Brunswick, NJ: Rutgers University Press.

Giddens, Anthony 1990. *The Consequences of Modernity*. Cambridge: Polity Press.

Gross, Paul R. and Norman Levitt 1994. *Higher Superstition: The Academic Left and its Quarrels with Science*. Baltimore: Johns Hopkins University Press.

Harrington, Anne 1996. *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler*. Princeton: Princeton University Press.

Henry, John 1992. 'The Scientific Revolution in England', in Roy Porter and Mikulas Teich (eds), *The Scientific Revolution in National Context*, pp. 178-209. Cambridge: Cambridge University Press.

Holton, Gerald 1993. *Science and Anti-Science*. Cambridge: Harvard University Press.

Inkster, Ian and Jack Morrell 1983. *Metropolis and Province: Science in British Culture, 1780–1850*. London: Hutchinson.

Irwin, Alan 1995. *Citizen Science: A Study of People, Expertise, and Sustainable Development*. London: Routledge.

Irwin, Alan and Brian Wynne (eds) 1996. *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.

Jacob, Margaret C. 1988. *Cultural Meaning of the Scientific Revolution*. Philadelphia: Temple University Press, 1988 (revised and retitled as *Scientific Culture and the Making of the Industrial West*. Oxford: Oxford University Press, 1997).

Landes, David 1969. *Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*. Cambridge: Cambridge University Press.

Mathias, Peter 1972. 'Introduction', in Peter Mathias (ed.) *Science and Society, 1600-1900*. Cambridge: Cambridge University Press.

McClelland, Charles E. 1989. 'Commentary', in Kathryn M. Olesko (ed.), *Science in Germany: The Intersection of Institutional and Intellectual Issues. Osiris* (Second Series), 5, pp. 291-296.

McLeod, Roy M. 1972. 'Resources of Science in Victorian England: The Endowment of Science Movement, 1868-1900', in Peter Mathias (ed.), *Science and Society, 1600-1900*, pp. 111-166. Cambridge: Cambridge University Press.

Merton, Robert K. 1968. 'Puritanism, Pietism, and Science', in *Social Theory and Social Structure*, pp. 628-660. New York: Free Press.

Merton, Robert K. 1970 [1938]. *Science, Technology, and Society in Seventeenth Century England*. New York: Fertig.

Merton, Robert K. 1984. 'The Fallacy of the Latest Word: The Case of Pietism and Science', *American Journal of Sociology* **89**(5): 1091-1121.

Miller, Jon 1996. 'Public Understanding of Science and Technology in OECD Countries: A Comparative Analysis'. Paris: Organisation for Economic Cooperation and Development.

Normile, Dennis 1996. 'Global Interest High, Knowledge Low', *Science* **274**(5276): 1074.

Pinson, Koppel S. 1934. *Pietism as a Factor in the Rise of German Nationalism*. New York: Columbia University Press.

Putnam, Robert D. 1993. *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton: Princeton University Press.

Roderick, Gordon W. and Michael D. Stephens 1972. *Scientific and Technical Education in Nineteenth Century England*. Newton Abbot, Devon: David and Charles.

Schofield, Robert E. 1963. *The Lunar Society of Birmingham: A Social History of Provincial Science and Industry in Eighteenth Century England*. Oxford: Clarendon Press.

Schwarz, Michel 1993. 'The Technological Culture: Opening the Political and Public Debate', in John Durant and Jane Gregory (eds), *Science and Culture in Europe*, pp. 203-209. London: Science Museum.

Shapin, Steven 1994. *The Social History of Truth, Civility, and Science in Seventeenth Century England*. Chicago: University of Chicago Press.

Toulmin, Stephen 1990. *Cosmopolis: This Hidden Agenda of Modernity*. Chicago: University of Chicago Press.

Turner, R. Steven 1989. 'Commentary', in Kathryn M. Olesko (ed.), *Science in Germany: The Intersection of Institutional and Intellectual Issues. Osiris* (Second Series), 5, pp. 296-304.

Weber, Max 1958. *The Protestant Ethic and the Spirit of Capitalism*. New York: Scribner's.

Webster, Charles (ed.) 1974. *The Intellectual Revolution of the Seventeenth Century*. London: Routledge and Kegan Paul.

Webster, Charles 1975. *The Great Instauration: Science, Medicine and Reform 1626-1660*. London: Duckworth.

Weiner, Martin J. 1981. *English Culture and the Decline of the Industrial Spirit, 1850–1980*. Cambridge: Cambridge University Press.

Williams, Raymond 1958. *Culture and Society, 1780-1950*. London: Chatto and Windus.