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## **History of Science Between the Sciences and the Humanities (\*\*)**

As indicated by the title of this paper, history of science is a peculiar scholarly activity for the reason that it is, at the same time, a humanistic and scientific area of learning. It is this peculiarity that I want to reflect upon, among other things. Before proceeding, allow me to mention a few points relating to my own career, not because they are particularly interesting, but because they may illustrate how a historian of science is in many ways professionally a split person with a leg — and presumably mind, too — located in both of the dominant cultures of our time, the humanistic and the scientific. Unlike most historians of science of the younger generation I have never received formal training in history, or in history of science, but came to the field with a training in physics and chemistry. After a long period as a teacher in these fields, doing history of science in my spare time, I have by now ended up as professor of history of science, being the occupant of a new chair in this field at the Faculty of the Humanities at the University of Oslo. I mention this because I am now, per definition, a 'humanist' in an environment which is very different from the one I used to be familiar with. In this position I witness at close hold the famous culture gap between the literary-humanistic world and the scientific-technological world. I also experienced this gap when I was associate professor at Cornell University, with a position shared between the departments of physics and history.

This situation of being split between two worlds has already caused me a great deal of trouble, personally and administratively, and I have been rather schocked to observe how deep the gap between the two cultures is and how difficult it is to bridge it. This paper is in part a personal, hence subjective (and even prejudicial),

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comment on some recent trends in the history of science, which is my excuse for bringing the author so immodestly into the introduction. With subjectivity and limited space follows a certain superficiality, I admit.

### *The Two Cultures*

When C. P. Snow back in the 1950s wrote his famous book about the two cultures,<sup>1</sup> he used as an illustration of how deeply the literary-humanistic culture has penetrated the notion of the educated citizen that ignorance about Shakespeare's characters would automatically be taken for an embarrassing lack of culture; whereas ignorance about the second law of thermodynamics was not only excusable, it was even considered good manners not to contaminate one's mind with such an abstruse scientific notion. I am sorry to say that, according to my experience, the situation has not improved over the years. We, whether being scientists or historians of science, have not succeeded in making the culture of science part of the generally recognized culture, and today the second law is as far away from the minds of the humanists as it was in Snow's days.

This is not to say that humanist scholars and liberal arts students are not interested in science at all, but the overwhelming majority of them are plainly ignorant and their interest is limited to the most superficial and rhetorical level. There is much *talk about* science and technology on the humanist campuses, but it is talk about science in the most general and uncommitted terms; it is dominated by theoretical discussions that do not relate to science proper, but to what philosophers, sociologists and literary critics of science may have to say about the matter in their most recent works.

An example: I recently attended a seminar on Heidegger's view of science in which the German philosopher's writings, and later commentators' interpretations of these writings, were discussed as if they reflected a deep insight in the nature and development of the sciences. When I objected that Heidegger evidently knew nothing about science, was not seriously interested in science, and had never bothered to study the history and philosophy of science, my objection was met with silence. The actual development of science was clearly seen as irrelevant to the discussion. In such an environment it will be taken for bad manners indeed if one asks about the changing roles of entropy in chemical theory.

If we turn to the scientists and engineers, things are different, but not necessarily better. Shakespeare is probably as well known among chemists as among anthropologists, and in general scientists have more humanistic culture than humanists have scientific culture. But this does not mean that scientists are

<sup>1</sup> C.P. SNOW, *The Two Cultures and a Second Look* (Cambridge: Cambridge University Press, 1966).

particularly broadly oriented or have been able to transcend the culture gap. It is simply a reflection of the general dominance of literary-humanistic values in modern society. When it comes to their own branches of knowledge, science and technology, scientists are — with some notable exceptions, of course — uninterested and unknowledgeable about the historical developments and the philosophical implications of the sciences. Moreover, the scientists are much less visible than the humanists in the debates which after all take place in newspapers and journals concerning the interaction between the two cultures or the social consequences of new developments in science and technology. It is unfortunately part of the education and socialization of scientists that they are encouraged to keep within their own world and discouraged to enter public debates.

The dominant position which literary-humanist culture enjoys is reflected with particular clarity in the students' choices of higher educations. In North America and many European countries fields such as philosophy, literature, theology, and cultural sociology are enormously popular. Physics, chemistry, and the engineering sciences, on the other hand, have increasing difficulties to recruit enough students to their expensive schools and laboratories; and this is spite of massive efforts, sometimes verging on propaganda, to attract students to these fields, supposed to be more useful for the modern society. This development is not necessarily a bad thing. However, I find it catastrophic if a large majority of our students can graduate without knowing a thing about science and technology — and I find it even more catastrophic if the bits of knowledge they are offered about these fields are the quasi-knowledge propagated by fashionable philosophers and literary critics.

### *History of Science: a Cure?*

After this rather gloomy and admittedly subjective presentation of the culture gap I want to turn to history of science and ask if this field of scholarship can and should serve as a possible bridge between the two cultures. Sarton strongly believed so, and the idea served as a basis for history of science during the wars; however, it largely remained an idea. Yet the idea is persuasive: history of science is by its very nature bi-cultural, being the historical (and hence humanistic) study of the development of the sciences. It is important to stress that history of science is different from the sciences, and that its subject is the sciences and the scientists, not nature — a point to which I shall return.

It is a fact that for a period of some 2,500 years a distinct activity called science has evolved as a study of nature and that this activity through most of its development has been closely related to other cultural, ideological, economic, and political developments. It is also a fact that science has become increasingly more important to society and that the number of scientists has increased continually since the Scientific Revolution during which modern science really took off. It is *not*

a fact that science is the mother of invention, but on the other hand it is beyond dispute that in general science (whether 'pure' or applied) has contributed greatly to the advance of technology and in some cases even provided the basis for entire industries. So it would be difficult to deny that science has been, and continues to be, a powerful cultural force that has thoroughly shaped our material and spiritual situation. For this reason alone history of science ought to be a prime field of interest to humanists and others concerned with how the world has become to be what it is. But science is much more; it is also, and perhaps primarily, a way of determining ever more reliably how nature works. So, at least, most scientists believe.

Now some philosophers argue that although science has increased quantitatively, institutionally and socially, scientific knowledge has not necessarily progressed and that, cognitively, science is not a superior or unique way of obtaining objective knowledge about nature. With regard to my argument for history of science this much-discussed question is somewhat beyond the point, but let me mention anyway that I find it difficult to take it seriously in its simple form. One doesn't have to indulge in philosophical discussions over notions such as correspondence, theory-ladenness and meaning-incompatibility in order to see how ridiculous the claim is. All what one has to do is too look at the cognitive level of science in, say, the sixteenth century and compare it to the present level. What knowledgeable person can seriously claim that we do not know more about chemical compounds and their reactions today than Boyle and his contemporaries did? And yet, strange as it may seem, this kind of radical claims are defended by a growing school of postmodernist scholars, for whom the notion of progress in science is nothing but ideology. Postmodernism, as well known, is high fashion among humanists and also has found support among some historians of science.<sup>2</sup> Needless to say, it is not the kind of fashion which facilitates communication with the scientific communities. More about this later.

But this was a digression. The important thing is simply the recognition that science has played an enormously influential role in the history of humankind and that presently its role is as great as ever. In spite of our culture being literary and humanistic, our social and material world is, paradoxically, very much the product of science and technology. So given this long and interesting development, given the importance of science both as a producer of knowledge and a contributor to

<sup>2</sup> For an example of radical postmodernism, see D. HARAWAY, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (New York: Routledge, 1989). A useful survey of postmodernism and history of science is provided in T.Y. CAO, «The Kuhnian revolution and the postmodernist turn in the history of science», *Physis*, 30 (1993), 477-504. For a caustic and enjoyable attack on postmodernist science studies, see P.R. GROSS and N. LEAVITT, *Higher Superstition: The Academic Left and its Quarrels with Science* (Baltimore: The Johns Hopkins University Press, 1994).

technology and welfare (yes, welfare!), the history of science ought surely to be a key element in any kind of history and not merely an appendix to the so-called real history. Universities invariably include departments or institutes for literary history and art history, and also often for the histories of religion and the musical and visual arts. These subjects, interesting and worthy as they undoubtedly are, are considered natural in the humanistic landscape, contrary to the history of science and technology which has to fight to gain its proper recognition as a humanistic study of the greatest cultural and productive force ever. This is ironic, but it is the situation.

### *Humanist Histories*

It is instructive briefly to compare history of science with history of literature and history of religion. On the one hand, these fields have a lot in common, both as regards their substances and, especially, their methods. They are all historical studies of cultural phenomena which go back to time immemorial — religion being the oldest, science the youngest — and during the course of time they have interacted in important ways. The interaction forms a natural link between the histories of science and religion in particular, less so between the histories of science and literature. From a methodological point of view the three fields share their foundation in historical method and source criticism, although of course with some differences as well. For example, the historian of literature makes full use of hermeneutic methods, which is less common in the history of science, where the historian can to some extent substitute experiments and objective knowledge for interpretations of meaning.

The differences between the three historical fields of inquiry are mostly related to their different subject-matters. The subject of history of religion is essentially the thoughts which people over the time have had regarding God, supernatural concepts and other things called religious; and the subject of history of literature is of course literature, that is, basically, the words put on print in non-technical books and articles. Historians of science too deal with the thoughts and actions of a certain group of people, the scientists, but the knowledge claims that this group makes is of a very different nature from those studied by historians of literature and religion. Scientists endeavour to discover the real structure of the physical world, to produce true and objective knowledge, and, in spite of all philosophical debate, it is evident that they have succeeded remarkably well. Much better, in fact, than theologians and writers, who have greatly enriched our lives and cultures but can scarcely be said to have produced a progressive system of objective knowledge — but then, of course, nor is that what they aspire to.

Put in a nutshell, the difference is reflected in the fact that past writers, such as Shakespeare or Henrik Ibsen, are still being discussed and analysed as living

parts of our own culture; the thoughts of past religious thinkers, such as Thomas of Aquinas or Paul Tillich, are similarly seen as relevant for today's theologians. Although they are history, they are not just history. Contrarywise, our interest in Galileo and Lavoisier is purely historical. They are studied by historians of science, but no physicist will benefit professionally from reading Galileo and no chemist from reading Lavoisier. The reason is of course that the pioneering achievements of a Galileo and a Lavoisier long ago have been superseded by other achievements, have been incorporated in the ever-changing and ever-progressing course of science. What we know today in physics and chemistry has simply made the contributions of Galileo and Lavoisier superfluous from a present and pragmatic point of view. Although modern scientists and engineers may benefit culturally and personally from reading the old masters, from a professional point of view they are as irrelevant as Ibsen and Shakespeare.

Add to this that historians of literature and other humanist branches of culture have a relationship to their subjects (the writers etc.) which is rather different from the one that historians of science have to the scientists. The historian of literature is an active part of the literary life, a critic who is taken seriously and contributes relatively independently to the literary tradition and ongoing debate. The same cannot be said about the historian of science.

The comparison illustrates a relative weakness of history of science, namely that past science is relegated to history and seems to have no direct bearing on the modern practitioner of science. Given the relative indifference to science of traditional humanist scholarship this threatens history of science to become a scholarly field without an audience except that of the historians of science themselves. Is that necessarily a sad scenario? After all there are many smaller fields of scholarship that live happily in such situations, including many branches of history which deal with cultures that have disappeared long ago. My answer is that history of science does not deal with a lost culture or a minor episode in history and for that reason it cannot afford the luxury of academic insulation. It deals with the development of a monumental tradition in history which is as alive as ever. One would therefore like the field to have a broader audience and to relate also to people outside the narrow field of scholarship.

The problem I am referring to is, broadly speaking, whether history of science should be an autonomous field of scholarship or a more pragmatic branch of learning which is open to a larger audience and in part justified by the services it can render to external groups. The establishment of history of science as an academic and professional discipline during the 1950s and 1960s carried with it the view that history of science is in no need of external justification, but is justified by itself, so to speak, and only responsible to high academic standards of scholarship. The eminent historian I. B. Cohen dreamed in 1961 about "the time when historians of science will be so numerous that they may produce scholarly works which need satisfy only the members of their own profession, the only requirement

being that of high standards”.<sup>3</sup> That time arrived some ten years later and today history of science has indeed become a mature and professional field of scholarship which does not need to be sanctioned by external groups. ‘History of science for its own sake’ has in many ways been a necessary and valuable movement and has undoubtedly led to much excellent scholarly work and a deepened understanding of the development of the sciences. But it is not necessarily a movement appropriate for the 1990s.

### *Against Purism - with Modifications*

There is reason to take a critical look at the purist and hyper-professional kind of history of science which typically manifests itself in a dozen professional journals and in expensive, scholarly books mainly bought by libraries. There is nothing wrong with this kind of scholarship, but it may be problematic if the purist view dominates the field and excludes other, more pragmatic motivations and styles of doing history of science. Methodologically speaking, purism is a good thing, but from a wider point of view it is not. It may well be the obsession for high scholarly standards and professional purity which has prevented history of science to play a more successful role as bridge-builder between the two cultures than it actually has. The problem is of course that purism and disciplinary autonomy are typically accompanied by a narrowing of focus as well as of audience, a disregard for syntheses and larger questions, and a fear for leaving the safe ground of the newly won independence and academic respectability.<sup>4</sup> If history of science is simply justified for its own sake and if the only norms are those defined by its professional peers, how can it then intervene in the broader intellectual debate and become a discipline which is not only respectable but also useful to other than its few practitioners?

I want to argue for a history of science which is not narrowly academic, but is more pragmatic, more tuned towards actual problems, and even more applied. This is far from a novel call, of course. Thus John Pickstone has recently emphasized the need for translating our scholarly knowledge to wider audiences and for a more relaxed attitude to one of these: “Because HSTM (History of Science, Technology and Medicine) has often been subservient to scientists, technologists and physicians, both intellectually and in terms of academic politics, many historians of STM seek

<sup>3</sup> I.B. COHEN, «History of science as an academic discipline», 769-80 in A.C. Crombie, ed., *Scientific Change* (London: Heinemann, 1961), p. 773.

<sup>4</sup> For a philosopher’s recent discussion of this issue, see T. NICKLES, «Philosophy of science and history of science», *Osiris*, 10 (1995), 139-63. See also C. HAAKFORT, «The missing syntheses in the historiography of science», *History of Science*, 29 (1991), 207-16, and the special issue on «The Big Picture» of *British Journal for the History of Science*, 26 (1993).

independent stature by cutting those links and aligning themselves with other kinds of historians. Thus by concentrating on one period they extend their linkages with fellow historians, and they distance themselves from HSTM predecessors whom they see less as fathers than as 'stepfathers' — the Sartons and Singers who seem now so hopelessly Whiggish and so uncritical of the scientific enterprise".<sup>5</sup>

Of course history of science should not be made more popular and accessible for any cost or under any circumstances. For example, it may be argued that a certain kind of pragmatic history of science has indeed flourished during the last decade when courses in science studies (or, more often, science and technology studies) have been established at many universities. This has to some extent been at the expense of more traditional courses in the history and philosophy of science, which have often been absorbed, in reduced versions, in the new courses or units. Science studies is largely an amalgamation of history, philosophy and sociology of science and technology, in general with an emphasis on the social and political aspects of contemporary science and with a strong presentist and pragmatic inclination. This is not the place for a closer analysis of programmes in science studies, so suffice to mention that history of science typically has a relatively weak position in such programmes and often enters merely as cases for sociological analysis.<sup>6</sup> The kind of history of science included is normally limited to social, economic, ideological and other external aspects of science, whereas intellectual or internal aspects are either ignored or given low priority. Moreover, the historical perspective is usually limited to the twentieth century. After all, what has ancient or medieval science to tell a modern or postmodern society?

The science studies version of history of science has the advantage that it appeals to many students and is often relevant for science policy and the research bureaucracy. However, it is not real history of science, but only a small part of history selected to serve other goals than the historical analysis of past science. Personally I find it unacceptable to exclude older science and especially to pretend that a knowledge of the history of science can be obtained without studying what scientists in the past actually thought and did, that is, without caring about the content of science.

<sup>5</sup> J. PICKSTONE, «Past and present knowledges in the practice of the history of science», *History of Science*, 33 (1995), 203-24, on p. 206.

<sup>6</sup> The weak position of history of science is reflected in a new, authoritative handbook which includes 37 authors from the science studies area. None of the contributions deal primarily with history of science. S. JASANOFF, G.E. MARKLE, J.C. PETERSEN, and T. PINCH, eds., *Handbook of Science and Technology Studies* (Thousands Oaks, CA: Sage Publ., 1995).



### *The Historiographical Triangle*

All the same, while science studies go too far in employing a pragmatic notion of history of science, traditional history of science goes not far enough. The important thing is simply that history of science should not be, and in the long run cannot afford to be, an insulated dialogue between professional historians and the past, but that it has an obligation to open up for a wider audience and address questions that are currently considered important and to which the historian of science may possibly contribute. These may be philosophical, social, pedagogic or broadly cultural questions relating to science, or they may be political such as participation on advisory boards dealing with science and technology policies.<sup>7</sup>

It has often been pointed out that the traditional anti-Whig ideal is neither realistic nor acceptable and that historians should aim at more than just understanding the past and share their findings with fellow specialists. History of science is an affair with three kinds of actors, namely the historian, the past science, and the modern audience, and it would be a serious mistake to ignore the latter actor. Not only does he, as a taxpayer, pay for our academic curiosity, it is also he we would like to convince that science is an important part of our cultural heritage and an endeavour as human and exciting as any branch of the humanities. For twenty-five years ago Hooykaas noted that the historian “must possess a power of imagination sufficiently great to ‘forget’ what became known after the period he is studying”. He then added, no less importantly, “he must [also] be able to confront earlier views with the actual ones, in order to be understood by the modern reader and in order to make history something really alive, of a more than purely antiquarian interest”.<sup>8</sup>

What I unoriginally argue is, then, that historians of science should apply a greater deal of their knowledge and talents to write for a non-professional readership than they normally do. Historical writings about science have always had a considerable public appeal, but much of it has been written by scientists or journalists with (in some cases) little real understanding of the development of science, and most scholarly works by professional historians are decidedly not for the average citizen. There are good examples of popular or semi-popular works written by historians of science, but there could be many more, both directed to the public at large and to more special groups such as teachers, scientists and students. In particular, we still need a good, modern textbook in history of science, suitable for introductory courses at university level.

<sup>7</sup> For arguments in favour of such use of history of science, see J.L. HEILBRON, «Applied history of science», *Isis*, 78 (1987), 552-63 and L.R. GRAHAM, «Why can't history dance contemporary ballet? or, whig history and the evils of contemporary dance», *Science, Technology & Human Values*, 34 (1981), 3-6.

<sup>8</sup> R. HOOYKAAS, «Historiography of science, its aim and methods», *Organon*, 7 (1970), 37-49, on p. 45.

Elizabeth Knoll, a former university press editor with a PhD in history of science, has recently argued the same point and emphasized that there are pragmatic as well as intellectual reasons for historians of science to widen their scope. "Where are the ambitious and accessible books that bring this subject to a broad, educated public?" she asks, well knowing that there are very few of these books. And, when they exist, they are often written by journalists or other authors outside the profession of history of science.<sup>9</sup> The elementary point is that books, in order to have a broad impact, have to be read by many people; and monographs by historians of science typically sell 400 copies in their lifetime (according to Knoll). They are usually "very well written, deeply researched, imaginatively and seriously thought out — about subjects that interest a very, very few people with high IQs and limited book budgets".

If we really mean that history of science is an important subject and a possible means to bridge the gap between the two cultures, we just have to take the wider audience as seriously as we take our professional colleagues. This is no easy task, but it is possible and it does not necessarily imply prostitution or the sacrifice of good scholarship. David Lindberg's recent history of ancient and medieval science can serve as a model.<sup>10</sup> Another, more remarkable example is Kuhn's famous work about revolutions in science,<sup>11</sup> which is not only remarkable because of its enormous impact but also because it was based on good historical research and nonetheless succeeded to become a best-seller, read by hundred of thousands with no prior knowledge of history of science at all. That we may have our doubts about Kuhn's picture of the development of science, or rather the way it has been interpreted by many of his readers, is a different matter. The point is that it is possible for the historian of science to contribute to a shift in people's conception of what science is and thereby to intervene in the broader intellectual and cultural process in which science is embedded.

### *History and the Scientists*

One particular audience to which history of science traditionally have had close links, is the community of scientists, but these links are now widely seen as suspicious or problematic by many historians. What was once a stable marriage is

<sup>9</sup> E. KNOLL, «Where are the trade books by historians of science?», *History of Science Society Newsletter*, 24: 3 (1995), 8.

<sup>10</sup> D.C. LINDBERG, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450* (Chicago: The University of Chicago Press, 1992).

<sup>11</sup> T.S. KUHN, *The Structure of Scientific Revolutions* (Chicago: The University of Chicago Press, 1962).

now close to divorce. Scientists study various aspects of nature and are sometimes interested in knowing how their predecessors conceived these aspects. The modern chemist will typically focus on how the modern notion of the chemical bond evolved during the nineteenth and early twentieth century, and he will be interested in this development because he is interested in the result of the development, in how nature works. How science works is considered less important. The attitude is nicely encapsulated by Yakov Zel'dovich and Igor Novikov, two eminent Russian astrophysicists, according to whom "the history of the Universe is infinitely more interesting than the [history of the] study of the Universe".<sup>12</sup>

While scientists tend to emphasize history of *science* rather than *history* of science, many modern historians and science analysts have no interest in the content of science. They may argue that science (or 'technoscience') is just another knowledge system which has no epistemic superiority over, say, those of the Inca civilization, Gothic cathedral builders, or Australian Aboriginals.<sup>13</sup> Or, if closer to history of science, they may argue that interest in science is neither necessary nor an advantage; for history of science should not deal with the things of science, but solely with the scientists and their relations to society. From that point of view it is rather an advantage not to be interested or competent in modern science, for then the historian can approach his subject with a more objective and neutral mind, avoid anachronisms and distortions of the past, and better perform a critical analysis of past science on its own premises. According to Paul Forman, history of science is still intellectually subservient to science and in desperate need of independence, that is, a divorce with science and its practitioners.<sup>14</sup>

Such attitudes are not uncommon today, when many historians of science have never had a scientific training and are brought up in an atmosphere where science has an ambiguous reputation and is seen as a social construction rather than a grand project uncovering the secrets of nature. According to many modern historians of science, it is important to keep a critical attitude to science and not to bow to the authority of scientists, for without such an attitude history of science will inevitably degenerate into a self-congratulatory narrative which is subordinate to the interests of the scientists and not an independent search for historical truth. There can be little doubt that some historians and sociologists, who held such views, are not only not interested in science, but also lack insight in science, and that this lack of knowledge influences their views as a rationalization for not dealing with the

<sup>12</sup> Ya.B. ZEL'DOVICH and I. NOVIKOV, *Relativistic Astrophysics* (Chicago: The University of Chicago Press, 1983), preface.

<sup>13</sup> H. WATSON-VERRAN and D. TURNBULL, «Science and other indigeneous knowledge systems», 115-39 in S. Jasanoff et al., eds., *Handbook of Science and Technology Studies*.

<sup>14</sup> P. FORMAN, «Independence, not transcendence, for the historian of science», *Isis*, 82 (1991), 71-86. See also FORMAN, «The discovery of X-rays by crystals: a critique of the myths», *Archive for History of Exact Sciences*, 6 (1969), 38-71.

content of science. However, it would be too easy to dismiss the non- or anti-scientific attitude as simply a reflection of historians' lack of scientific insight. It is a widely held attitude in modern history and sociology of science, shared also by some scholars with an excellent knowledge of science and who cannot be accused of being scientific illiterates.

At any rate, how should we judge this situation? Is it possible, or preferable, to do history of science without dealing with the content of science and without paying attention to the scientists?<sup>15</sup> This is a complicated question, consisting of several layers. For one thing, it is of course quite possible to make interesting and valuable studies of the development of science without having much knowledge about, or interest in, science; namely if one deals with those aspects of science that are generally termed 'external', that is, institutional, social and political aspects of science. Although in some cases a knowledge of science may be advantageous, in general it is unnecessary, and in fact a good deal of the best of such history has been written by historians with no background in science at all.

While this is unproblematical, it is also important to emphasize that social and institutional aspects of science are only parts of science and that it would be wholly unsatisfactory not to deal also with internal developments, with which I mean the theories and experiments such as they are typically presented in research publications. When it comes to this second aspect, things are obviously different. If we want to find out how the theory of relativity was created, there is no other way than to study the research literature, the manuscripts and the letters that Einstein and others wrote; and to understand these sources it is absolutely necessary to master physics and mathematics to a level that requires a scientific training. Of course, in the end it is a political question whether such internal or conceptual history of science is judged valuable and interesting. But if it is, if the genesis and development of scientific ideas is considered a central part of history of science, then scientific competence cannot be dispensed with.

The question of the involvement of contemporary scientists in history of science is a rather different one. First, scientific competence should not be equated with professional scientific skills in the sense that only scientists are able to penetrate the technicalities of past scientific literature. The important thing is that the competence is acquired, not that it comes from a formal scientific training; in many cases it is quite possible for the historian to acquire the necessary background by his own, hard work. What matters is not so much whether history of intellectual science is done by scientists or historians, but rather that it is done at all, and that by people who are willing and capable of acquiring a double set of competence: not

<sup>15</sup> N. REINGOLD, «Science, scientists, and historians of science», *History of Science*, 19 (1981), 274-83, and M.A.B. WHITTAKER, «Science, scientists, and history of science», *History of Science*, 22 (1984), 421-24. H. KRAGH, *An Introduction to the Historiography of Science* (Cambridge: Cambridge University Press 1987), pp. 111-19, 150-58.

only the necessary technical-scientific competence, but also the equally necessary historical insight.

There is another, more practical aspect of the question of scientists' involvement in history of science, which is not concerned with the scientist's role as contributor to the field but with his role as recipient or audience. I find it problematic to alienate scientists from the history of science for a variety of reasons, one of them being that we, the historians of science, to a large extent write for the scientists, who are a key audience and without whom much science history simply would not be written because there would not be an audience for it. Moreover, to keep the scientists out of the good company, as many historians would prefer, would mean that we give up the possibility of instructing and educating the scientists about how their sciences have developed. If we are dissatisfied with scientists' supposedly primitive notions of the nature of science, their failure in appreciating the historicity of science, and their simplistic, linear view of how science has developed, should we then stop communicating with them? Of course we should not, we should reinforce our efforts to write good history of science which appeal to the scientists and tell them a better version of science and its history.

We should aim at intellectual independence, but not accept the myth that contact with the scientists automatically lead to corruption or subservience. Interest and competence in science does not preclude a critical attitude to science. Pickstone has expressed it well: "Historians of STM may well be critics of modern science, but they undercut their own case and squander their expertise if they refuse to engage with STM sufficiently closely to discriminate between its various social and cognitive forms, or fail to give due account of the technical details and technological powers which have been STM's promise as well as its threat".<sup>16</sup>

It is generally agreed that the best form of history of science should involve or synthesize both intellectual and social aspects, but it is a consensus which is more rhetoric than reality. With some notable exceptions the old distinction between internal and external history of science is very much alive, only has the latter approach become dominant in professional circles, now reappearing under the name 'contextualism'.<sup>17</sup> However, it is important to be aware that social, external, eclectic, or contextual history of science cannot stand alone and that in many cases it needs intellectual or internal history in order to discern what were social influences and what not. If we do not have an understanding of the intellectual or cognitive aspects of science we will not be able to construct a contextual history either; for the various contexts — social, economic, etc. — are contexts of something, or surrounding something, and what this something is can only be

<sup>16</sup> PICKSTONE, «Past and present knowledges», p. 206.

<sup>17</sup> S. SHAPIN, «Discipline and bounding: the history and sociology of science as seen through the externalism-internalism debate», *History of Science*, 30 (1992), 333-69.

discovered by penetrating into the intellectual heart of science.<sup>18</sup> As historian of physics Stephen Brush has pointed out, the best studies of the social aspects of science are precisely those whose authors are willing to immerse themselves in the life of the laboratory, not as anthropologists visiting from an alien culture but as participant-observers.<sup>19</sup>

### *Historiography of Chemistry*

Until now I have commented on various historiographical issues in a very general way, without distinguishing between various periods or various sciences. It will be appropriate to end with some comments on the present state of historiography of chemistry.

Chemistry, and more specifically the period including and surrounding the Chemical Revolution, was of course a central topic in the revival of history of science that took place in the 1950s; since then there has been an increasing interest in many areas of chemistry, involving both intellectual, social and industrial aspects. History of chemistry certainly has a great past, but compared with some other sciences its presence and future may seem more bleak. There are obvious lacunae in the historical writings, the most serious being the almost total absence of good histories of post-war chemistry. Whereas there are good, scholarly accounts of developments in modern physics, geology, biology and astronomy, there is not a single book which analyses the important changes which has taken place in chemistry since the end of the Second World War.

Moreover, modern chemical sciences have completely failed to become integrated in cultural history in the same (limited) way as other sciences have, and they remain invisible both to the historians and the general public. Students and scholars of the humanities will have opinions — sometimes even knowledge — about modern developments in physics, biology and cosmology, but be as indifferent as ignorant about chemistry; and if they have an opinion, they will tend to identify chemistry with a rather dull science which mainly produces pollution, hazardous wastes, and food additives. Most educated persons know about Einstein, have heard about the Big Bang, and are vaguely familiar with Watson and Crick's double helix model, but ask them to mention an important postwar chemist or a conceptual innovation of modern chemistry, and they will be silent. And so will many historians of science. Chemistry has no modern role model, no charismatic

<sup>18</sup> Let me unmodestly mention the example of hydrogen's fine structure, an intricate scientific question which reveals, when analysed in depth, the interplay between social, ideological and scientific factors in the early Weimar republic. In this case, the context can only be understood by understanding the physics. See H. KRAGH, «The fine Structure of hydrogen and the gross structure of the physics community, 1916-26», *Historical Studies in the Physical Sciences*, 15 (1985), 67-127.

<sup>19</sup> S.G. BRUSH, «Scientists as historians», *Osiris*, 10 (1995), 215-31, on p. 229.

leaders like Richard Feynman or Stephen Hawking in physics; and if they exist, as in the case of Ilya Prigogine, they tend to be identified as physicists.

The uneasy relationship between scientists and historians of science which I have just dealt with, is perhaps more serious in chemistry than in most other sciences. As William Jensen, a chemist as well as a historian of chemistry, has recently pointed out, there is a deep gap between modern scholarship in the history of chemistry and what chemists are interested in.<sup>20</sup> Chemists are probably neither more nor less interested in history than their colleagues in other sciences, but traditionally they have been less inclined to enter into discussions with historians and other outsiders, and for this reason, among others, they remain almost invisible in the historical — and, more broadly, humanistic — landscape. Part of the reason for the unsuccessful relationship can undoubtedly be located in most chemists' attitude to history — that it is an excellent source of diversion and entertainment, a nice hobby that may even have some educational merits, but not more than that. There are chemists who think otherwise, of course, but they are few and not of the same caliber as their great predecessors such as Hermann Kopp, Wilhelm Ostwald, Marcelin Berthelot, Pierre Duhem, and James Partington.<sup>21</sup> Nor is serious interest in history widespread among chemists, such as indicated by the fact that the American Chemical Society has a membership which exceeds 140,000, whereas the Society's Division of the History of Chemistry can enroll only about 700 members, less than a half percent. By comparison, in 1995 3,344 members of the American Physical Society were also members of its Forum for History of Physics, corresponding to 8%.

Jay Labinger, a practising chemist, has recently addressed the question of why scientists are absent in the science studies programmes. As mentioned, science studies cannot be identified with history of science, but they include elements of history and have similar problematic relationships to the scientific communities. As Labinger notes, in spite of the emphasis on interdisciplinarity that permeates the new science studies, in practice they exclude scientists; the interdisciplinarity seems to be limited to social and humanist studies — history, sociology, anthropology, philosophy, literary theory, psychology etc. One reason for this unhealthy compartmentalization is undoubtedly the extreme relativism and anti-science attitudes of many science studies scholars. "Trying to convince scientists to do something based on the premise that they are all wrong is not likely to be very successful", as Labinger tersely puts it.<sup>22</sup>

<sup>20</sup> W.B. JENSEN, «History of chemistry and the chemical community: Bridging the gap?», 262-75 in S.H. Mauskopf, ed., *Chemical Sciences in the Modern World* (Philadelphia: University of Pennsylvania Press, 1993).

<sup>21</sup> C.A. RUSSELL, «Rude and disgraceful beginnings': A view of history of chemistry from the 19th century», *British Journal for the History of Science*, 21 (1988), 273-94.

<sup>22</sup> J.A. LABINGER, «Science as culture: a view from the petri dish», *Social Studies of Science*,

Part of the reason for chemists' lack of serious interest in the history of their science is simply that a career in chemistry, like in any other science, is driven by research productivity, and that history does not count when it comes to peer prestige and job applications. (One of my Danish colleagues, a professional chemist who also has written many excellent papers on history of chemistry, applied for some years ago for a professorship in chemistry and wanted to include also his historical writings; he was advised not to do so, for, as he was told, not only would these be judged irrelevant, they would probably have a negative effect on his candidacy because they would signal a person who was unable to distinguish between real chemistry and historical hobby work). Of course the career pressure does not exert a narrowing influence only in chemistry; it is a quite general phenomenon which is also important in history of science, where a young scholar cannot hope to get tenure if he does not publish a particular kind of articles and books which live up to internal standards, but will be seen as irrelevant by outsiders. As historical work does not count in the chemist's career, so does scientific or pedagogical work not count in the career of a historian of science. All this is unfortunate, but that's the way it is.

But if the chemists' attitude to history is one explanation of the communication gap, so is the historians'. The tendency towards purism, methodological autonomy, self-centeredness, and a literary-critical style which characterizes so much of professional history of science alienates the field from working chemists and offers them stones for bread. Most historians of science simply do not write the kind of works which appeal to chemists or which teachers can use in courses.<sup>23</sup> So historians of chemistry are as guilty as the chemists in the divorce between the two fields.

However, there may be light ahead, and I want to end in a more optimistic note by recalling that recently some historians of chemistry have descended from the ivory tower and produced valuable and useful textbooks in history of chemistry, books that will appeal to chemists as well as to historians and which are also well suited as textbooks.<sup>24</sup> Then we can only hope that teachers of chemistry will also make use of this possibility.

25 (1995), 285-306, on p. 301, with comments by H. M. Collins, S. Fuller, M. Lynch, T. J. Pinch, and others.

<sup>23</sup> The perplexing question of the relationship between science education and history of science has been discussed more in physics than in chemistry, but most of the problems are the same in the two fields. See, e.g., H. KRAGH, «A sense of history: History of science and the teaching of introductory quantum theory», *Science & Education*, 1 (1992), 349-63; S.G. BRUSH, «Should the history of science be rated X?», *Science*, 183 (1974), 1164-72; and H. SIEGEL, «On the distortion of the history of science in science education», *Science Education*, 63 (1979), 111-18.

<sup>24</sup> W.H. BROCK, *The Norton History of Chemistry* (New York: Norton & Co., 1992). B. BENSUADE-VINCENT and I. STENGERS, *Histoire de la Chimie* (Paris, La Decouverte, 1993). For a different kind of modern history of chemistry, less likely to appeal to chemists but more likely to appeal to humanists, see D.M. KNIGHT, *Ideas in Chemistry: A History of the Science* (London: Athlone Press, 1992).