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Science as a Vocation in the 21st Century: An Empirical Study of Science Researchers

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Abstract

Max Weber's *Science as a Vocation* has long been part of the canon of science studies. In this paper, the key analytical categories that Weber uses to discuss scientific work are applied to some recent field work research carried out with academic physics and biochemistry researchers. The research, designed to investigate scientific communities, shows that professional scientists maintain a high degree of commitment to science through their understanding of science as a vocation. However, a number of structural factors surrounding scientific workplaces may threaten this in the future.

Weber's methodological writings, including *Science as a Vocation*, suggest that sociology proceeds by comparing complicated reality to ideal types. One source of ideal types is Weber's own writings on science. Ironically, contemporary scientists' motivations to being scientists conform almost exactly to the ideal type proposed by Weber, suggesting a degree of continuity in the project of science that is not matched by contemporary theories of the production of scientific knowledge. If we use the ideal types provided by contemporary sociology of science we will ignore key features of what it is to be a scientist, and how it is that scientific knowledge is produced. This paper proposes a consideration of structural and motivational factors in appraising the production of scientific knowledge in contemporary society.

Keywords: Weber, science, scientific community, sociology of work

Max Weber's famous lecture, *Science as a Vocation*, has long been part of the canon of Western sociology. However, its position has changed through the years since it was first published in 1919. Initially seen, particularly by American sociologists, as the starting point for the emerging sub-discipline of sociology of science (Parsons 1937; Barber 1962), *Science as a Vocation* has also been construed as a central contribution to the 'value-judgement debate' (Käsler 1988: 184), an account of rationalization that can be taken as a continuation of arguments presented in 'The Protestant Ethic and the Spirit of Capitalism' (Turner 1992: 99-100), and, as Lassman and Velody note, a treatise on the methodology and status of social science (Lassman and Velody 1989: xiv). Clearly this is a complex and influential text.

With this in mind, it may seem that the aim of this paper—to appraise Weber's lecture in the context of an empirical study of the vocation of *natural* scientists—is too literal an application of Weber's work. However, I would ask for the forbearance of the reader in this matter. Weber's text provides a range of useful insights into our understanding of *contemporary* scientific practice that deserve consideration. In addition, Weber's methodological strategy with respect to exploring science also provides us with important insights into the operation of contemporary sociology of science.

Weber does three things in his essay. First, he describes the external conditions of science as a vocation, primarily concentrating on the institutional organization of science in contemporary Germany and offering some comparisons to the situation in North America. Weber focuses on the rationalization and institutionalization of science, justifying this in a somewhat self-deprecating way as the 'pedantic custom' of political economists such as himself. He also describes the entry route and career path of recruits to the world of academic science, and notes the proletarianization of the intellectual through being transformed into a 'specialist' (Turner 1992: 100). Secondly, he goes on to discuss the inward calling for science that scientists possess, noting that this is what his audience really wants him to speak about. Here his focus is on the motivation towards a scientific career that scientists share. Finally he offers a discussion of what science actually is, and what role it fulfils in society. In this paper I intend to discuss some recent empirical research carried out amongst academic scientists and to utilize Weber's framework from *Science as a Vocation*, i.e. external conditions, internal conditions and, finally, some comments that relate these two things to what science, for scientists, actually is. The empirical material presented here was collected from a research project investigating scientific communities, and is based on interviews and observations carried out amongst two research teams (a group of biochemists and a group of physicists) working at a large provincial university in the UK.

We should note at this point that Weber's discussion of science need not refer solely to the 'hard' natural sciences. The translation of the German word 'Wissenschaft' to the English word 'science' does not do justice to the scope of Weber's vision: he was not concerned with restricting his subject matter to only the natural sciences. Rather, Weber sought to make generalizations about academic work as a whole.

> Within modern social science 'Science as a Vocation' has often been read as being of most relevance as an early contribution to the new sub-discipline of the sociology of science… It should be recalled that the term *Wissenschaft* has a much broader meaning than the English word 'science' (Lassman and Velody 1989: 164).

However, *Science as a Vocation* is primarily a discussion of the nature of the natural sciences and the relationship the individual scientist has to the project of natural science. It is therefore not wholly inappropriate to use *Science as a Vocation* as a tool for making sense of contemporary natural science. Conclusions presented here refer primarily to the natural sciences, but, with Weber, it can be suggested that such conclusions have a wider relevance.

Research in Higher Education

Researching other academics makes you think about what academia is, how 'academic' is defined and how inclusive or exclusive our conceptual schemes for making sense of contemporary Higher Education (HE) are. Most of the recent work that has looked at the current state of HE research and the position of researchers has been either purely quantitative (for example the Higher Education Statistical Agency's recent survey[1]) or has looked only at the arts and humanities (Harley and Lowe 1998). We should note that this area, i.e. the role, composition and motivation of academic researchers, has been under-researched for some 20 years. The 'scientific communities' debates of the 1960s and 1970s, best exemplified in the US by the work of Hagstrom (Hagstrom 1965) and in the UK by Cotgrove and Box (Cotgrove and Box 1970), largely disappeared as Sociology of Scientific Knowledge (SSK) and other modes of social analysis of science came to the fore.

In recent years, the term 'scientific community' has been left unanalysed, although the term has a common sense usage that designates the people who work in a set of pursuits that are generally construed as being scientific. I felt that this was worthy of analysis in itself and designed the research project to investigate the usages and meanings that scientists associate with the term 'scientific community'. However, an additional aim was to investigate scientific work and how scientists themselves make sense of their work, their workplaces and their careers. To do this, the research project involved a large amount of participation in the workplaces of the two research teams selected for inclusion.

Data Collection in Laboratories

Field work for the project took place between November 1999 and June 2000, and involved semi-structured interviews with volunteers, and

1. 'Characteristics of research active staff' (Unpublished study by the HEFCE Analytical Services Group, March 2000).

observation in workplaces. Two research teams were selected for comparative purposes: a group of physicists and a group of biochemists.

The choice of research teams was deliberate. My research was designed, in part, to revisit the scientific communities debate that was initiated by the work of Hagstrom (Hagstrom 1965) who defined a scientist's membership of a scientific community as being largely dependent upon the exchange of information with other scientists through publication, attendance at international conferences, collaborative work relationships and other forms of communication. To follow Hagstrom's approach it was therefore necessary to speak to scientists who were publishing extensively and who were involved in a range of collaborations. Both research teams chosen have a good to very good reputation amongst other academic scientists[2] and in the international arena.[3] In addition, both teams had ongoing collaborative research links to other research teams across the globe: a number of interviewed physicists were either seconded to their current team from another institution for the purpose of collaborative research, or had deliberately chosen to come to this university to study in the research unit due to its reputation. In biochemistry, the team was involved in a large collaborative project with a research group in Japan and a research group in the USA. It is also worth noting that both research groups included a number of non-UK nationals. In the case of the physics team this was at all levels: lecturers, postdoctoral researchers and PhD students.

In all, 26 interviews were carried out with the members of the two research teams, representing just over half of the total number of team members. In addition, a large amount of data was collected through participating in the everyday working lives of these scientists.

The two research laboratories included in this research were similar in a number of important respects, despite representing very different scientific disciplines. They were complex workplaces with a large amount of activity taking place in tightly defined and spatially restricted areas. This meant that they both required a high degree of co-operation between participants to function efficiently. However, the most significant obser-

2. This was judged by informal discussions with colleagues at the university where the research took place. These informants were contacts made by myself through membership of a trade union (the Association of University Teachers [AUT]).

3. This was judged by asking the research team members to identify other leading research groups in their area of research. The question format generally used was 'how would you rank this research team against other teams involved in similar research?' Additional material on this topic was gained through extensive discussion with respondents about their career trajectories and which institutions it would be best to work in.

vation made was that both workplaces, despite having a number of relatively inexperienced workers, provided the researchers with a high degree of autonomy and a low degree of supervision: researchers had almost total control over their individual day to day activities, whilst having goals set for them by supervisors. In contrast to other workplaces where workers are supervised closely to achieve productivity targets, these workplaces achieved productivity targets, and often excelled them, with little or no supervision. To investigate how this was achieved I will consider working conditions and motivations of these workers or, in Weber's terms, examine the external conditions and the inward conditions of scientists. Much of Weber's work focuses on the tensions between the external constraints imposed on an individual and the inner motivations that allow the individual to resist and manage such external constraints or compulsions (Weber 1949: 26-27). Weber's pessimism on this point is well known (Hennis 2000b: 80), and we can read *Science as a Vocation* as referring to the emergence of a spiritless *Berufsmensch* suitable for capitalism.

External Conditions

By 'external conditions' Weber means the ways in which science as a vocation is set up in 'the material sense of the word'. For Weber, this entails an examination of the position of graduates, and their induction into a career pattern that begins with being a lecturer and ends with the individual becoming a professor. Weber notes the problems associated with this career pattern: novices are expected to work for little, or even no money, face a high degree of insecurity and are subject to the whims of supervisors and senior colleagues (Weber 1989: 3-4). A very different career pattern, in terms of structure, is currently the norm for graduates entering careers as academic scientists in contemporary UK HE. However, we should note that the current pattern is a fairly recent invention.

HE in the UK has undergone dramatic changes in the past two decades. This is an obvious point, one may think, but an important point to make given that there has been little study of scientific communities in the UK since Cotgrove and Box's 1970 study. In general terms, the UK HE system of the post-1945 years did not significantly change in terms of its form, function or ethos until the Thatcher government 'reforms' of the 1980s. This is not to ignore the postwar expansion of the tertiary education sector, particularly in the 1960s. Rather, it is to emphasize that UK universities between 1945 and 1980 were characterized by a professional culture that was set apart from business and economic imperatives (Robins and Webster 1985). This was replaced by dramatic businessoriented interventions in the UK university system, coupled with swingeing cuts (the Thatcher government cut £100m from university budgets immediately on coming to power in 1979). The changes in orientation of the university system in the 1980s resulted in the 1988 Education Act which brought about the abolition of the polytechnics and their conversion to universities in 1992, the expansion of access to HE to provide a highly qualified workforce, the forging of closer links with business and enterprise and the reorientation of university research towards prospects for commercial exploitation (Slaughter and Leslie 1997: 42).

The most significant change in this period was the increased separation of teaching and research in UK HE. Whereas, previously, senior teaching staff in universities had received research funds attached to their posts, all research funding, particularly in the sciences, was to be administered by external agencies. No longer would senior academics have a research budget: they would have to 'compete for funds targeted to strategic goals in technoscience areas' (Slaughter and Leslie 1997: 43).

Today, research in UK HE is carried out by three distinct groups. Lecturers in UK universities are (generally) expected to be producing research for their institution and this is part of their contract of employment. In recent years, the pressure to produce has increased dramatically for this group, largely through the introduction of the HEFCE run Research Assessment Exercise (RAE)[4] (Harley and Lowe 1998). The second group are PhD students, studying for a degree and working under the supervision of members of the academic staff. The third, and by far the largest, group are full-time researchers who are almost invariably employed on short-term contracts (typically lasting for the length of the funding secured from a research council) and working under the supervision of a lecturer (usually, but not always, employed on a permanent contract). The researchers are referred to, institutionally, as Contract Research Staff (CRS), although many of those that I interviewed did not use, or even recognize, this term and preferred to call themselves 'postdocs', a shortening of their formal job titles of 'postdoctoral research assistant' or 'postdoctoral research fellow'. For the sake of clarity I will use the term CRS to distinguish this group from the other two researching groups:[5] PhD students and lecturers.[6]

4. The RAE provides a mechanism to distribute funds to UK universities. Simplifying to the extreme, it measures the level of research activity in a department according to a five point rating, then allocates funding according to how many 'research active' members of the department there are.

5. There is also a fourth group involved in research: technical staff. Technicians facilitate the construction and maintenance of experimental equipment and are sometimes involved in completing experiments themselves. Technicians are rarely involved

There is a career progression structure visible here: academic scientists will start their careers as PhD students, usually immediately after completing their undergraduate degrees, will then find employment as CRS in a postdoctoral capacity and will finally become lecturers, responsible for supervising PhD students and running research projects employing CRS. This was the pattern that all the lecturers I interviewed had followed. There is an obvious discrepancy here: there are a small number of university lecturers in science compared to a very large number of CRS so, clearly, only a small proportion of CRS actually manage to get to the end point of this career structure, a point to which we will return.

In the research laboratories in which I carried out my study there were representatives of all three groups but demarcation between individuals in terms of institutional status was not always clear. For example, in a number of cases I found PhD students instructing CRS in the use of equipment and materials and in most cases I found that everyday supervision of PhD students was not carried out by lecturers (the formal / official supervisor) but by CRS. Further, with regard to publication and dissemination of scientific knowledge, all participants in a piece of research (i.e. lecturers, PhD students and CRS, sometimes even technicians) would be credited.[7]

The subject of contract length is pertinent to constructing an outline of the external conditions affecting academic scientists. Not only is there a fairly obvious point of social status and ascription of status being attached to the length of the contract an individual may hold, there is also the issue of natural justice and the co-operative and communal nature of research. Since 1975, the number of researchers employed on temporary contracts in UK HE institutions has increased by 200 per cent. In terms of academic staff as a whole, CRS now make up one third of the total, and in a number of HE institutions they make up over 50 per cent of the academic staff

in writing research papers and reports, but it is worth noting that one possible career route in academic science research involves a transition from technical staff to CRS. One participant in this research was currently attempting to make this transition.

6. The naming of different groups involved in research will always be somewhat arbitrary as the names applied locally will depend on local convention and custom. In this paper I want to distinguish three groups from each other and have relied upon the 'official' categories that are used by external agencies such as funding councils. In the labs that I worked in participants would often distinguish between 'academic staff' —meaning lecturers—and 'postdocs'—meaning CRS. This is not a useful analytical designation: CRS are also academic staff, according to their contract of employment.

7. The subject of name order on papers was nowhere near as contentious as I thought it would be.

employed.[8] Effectively, CRS are responsible for the production of scientific knowledge: they carry out most of the experimental work, write most of the papers and supervise PhD students, training up the next generation of CRS. Yet they are consistently treated as being less a part of an institution than lecturing staff, have little or no career structure available to them[9] and receive wages that are much lower than lecturers.[10] In addition, they are under-represented in terms of trade union membership (none of the CRS I interviewed were members of a trade union[11]) and are, accordingly, often poorly represented in negotiations with management concerning terms and conditions of service, career structure and promotion.

At this point we should note that Weber's analysis of the ways in which the scientific establishment of his day organized its hierarchy is little different from contemporary practices. He noted that it was often the insecurely employed *Privatdozenten* who would be responsible for producing much scientific research, and also responsible for training the

8. Figures from Dr Colin Bryson, Nottingham Trent University (personal communication).

9. Many CRS I spoke to noted that even when they did manage to get another contract after the end of a period of research their pay would return to a point lower on the salary scale than at the end of their previous contract.

10. In pre-1992 HE institutions the salary scale for researchers on grade 1A (i.e. postdoctoral CRS) starts at £16,675 and ends at £25,213. Researchers appointed to this scale will (normally) receive an increment rise on their pay every year, with the final point of the scale being a bar that requires a formal promotion process to be completed. In contrast, the lecturers salary scale starts at £18,731 and ends at £30,967, although to reach this point lecturers must pass from A to B grade. In principle, CRS who achieve promotion will eventually achieve exactly the same pay as lecturers: both lecturers' and researchers' pay scales currently end at £36,740 (top of Senior Lecturer for lecturers, top of Grade III for researchers). In practice, this will be very difficult for researchers to achieve: they would need to be immediately rehired at the end of each contract at the same point where they finished, and would need to be continuously employed in this way for 20 years. Given the constraints on research council funding, and the high level of competition for research contracts—a factor that encourages lecturers to make bids that include the lowest staff costs—such an outcome is unlikely for most CRS. It should be noted that there are a small number (about 3 per cent) of CRS on permanent contracts. These are mainly CRS who have been 'in the system' since the early 1970s when permanent contracts were the norm for researchers. Having permanent contract status allows such CRS to bid for their own funds from research councils.

11. Most of the CRS I interviewed had heard of the Association of University Teachers (AUT), the trade union that represents their interests, but few had considered joining. Many were actually put off by the name ('that's the union for university teachers' was a common response) and most considered that the union would not represent their interests adequately.

next generation of scientific researchers, albeit through the somewhat different route of providing basic tuition courses for undergraduates. However, Weber misses a key point here, one which Norbert Elias makes quite clearly:

> At first glance, the hierarchic order of offices, rank, salaries etc. in these academic institutions may not seem so very different from that in economic, military, administrative, or other organizations with a firmly instituted office hierarchy… As an advance in knowledge, though, scientific innovation cannot easily be routinized… There are other distinguishing characteristics of these establishments. A junior member may surpass in inventiveness, imagination, and power of scientific discovery some or all of the higher ranking members of a department (Elias 1982: 4-5).

Elias identifies a significant problem for the understanding of scientific hierarchies: our understanding of bureaucracies and routinization may help us to understand some of the structural processes taking place in a given setting, but will not help us to explain the ways in which hierarchies are understood by participants.[12]

As noted above, there is some confusion in defining who is actually a researcher.[13] Although I found no specific instances where an individual was unsure whether or not they counted as being a researcher, external agencies and universities themselves have great difficulty, and exhibit a certain amount of confusion, in doing this. At times, institutions will define their researchers as being 'research active staff', that is largely lecturers who have been returned in the RAE. Certainly, these people are involved in research: it is part of their standard contract of employment. However, they are by no means the people responsible for all, or even most, of the research carried out. In contrast, universities will describe CRS as being 'researchers' but will choose whether or not to include them in the measurement of research activity in an institution,i.e. the

12. See Whitley 1982, for an extensive account of the development of the university system of science research. Whitley notes that 'by organising research around the training process, and developing formulations and procedures which permitted trainees to produce valid knowledge claims, the academic professionalization of science developed both a hierarchical structure for conducting scientific research and a style of research which enabled original knowledge to be produced by such hierarchies' (1982: 320).

13. My definition of CRS is based upon contract type and grade: for my purposes I define anyone who was on a research grade of employment as being CRS. My adoption of 'CRS' as the term to describe those who are neither PhD students nor lecturers, but who are carrying out research in a particular department, may not be congruent with official designations provided by employers or funding bodies. However, it does have an advantage in that it is a verifiable term and it also reflects the reality.

RAE. The reasons for this are complex: the RAE rules allow any member of staff on an academic contract to be included in the RAE. Each person so included will have their publications and other research activities considered when assessment is made of the department's overall research rating. From this perspective it would appear to be in an institution's interests to include as many CRS as possible so as to reflect the total amount of research taking place and to maximize benefit from HEFCE funding allocation. However, CRS when included in the RAE are accounted for in a different way to lecturing staff. HEFCE, who administer the RAE, consider that CRS staff have already received research funds through the research council that is funding their research project, therefore HEFCE remunerate institutions for CRS entered in the RAE at the rate of 10 per cent that of a full-time lecturer. Even so, it could be assumed that this is better than nothing and that institutions should include such staff. At this point, institutions must make a decision concerning the publication record of each individual in a department. The RAE rules do not allow the same publication to be counted twice for individuals at the same institution (e.g. jointly authored papers), but they do allow for lecturers in receipt of research grants[14] to incorporate research publications produced by members of their research team to be counted to the lecturer's overall tally of publications, even if that lecturer has not authored the publication. Thus institutions are allowed to exclude CRS, but re-allocate their publications to another individual in their research unit. This could be beneficial to institutions in that it allows the work of CRS to be used to bolster the research profile of a lecturer that can then be returned at 100 per cent instead of the 10 per cent a CRS would get.[15] Clearly, local 'political' and tactical considerations will be taken into consideration when deciding who will be included in an institution's RAE submission.

There is no such confusion over definitions of 'researcher' in external funding agencies. HEFCE only define 'researcher' as being 'research active' lecturers who are returned in the RAE. This leads to some quite bizarre effects. The recent survey of characteristics of research active staff

14. It is worth noting that of all the UK funding councils, only the Economic and Social Research Council (ESRC) allows CRS to be grant holders. The ESRC is responsible for disseminating government funds for social science research. No natural science or engineering research funders allow CRS to bid for research grants.

15. However, it is worth noting that 20 per cent of CRS in the UK are not funded by research councils: many of these are working in the 'new' university sector and are employed and funded in their work by their own HE institution. These CRS are still subject to the '10 per cent rule' outline above.

carried out for HEFCE[16] is hard to understand if one is familiar with the operation of scientific research in universities. Quite simply, the exclusion of CRS from such a survey makes it look as if almost all research carried out in UK HE is done by lecturers employed on full-time permanent contracts. Such a definition hides a major problem of job insecurity in HE research. This institutional approach to defining who is a researcher perpetuates an insidious myth, namely that CRS are the 'underlabourers' of the 'real' scientists, that is, the lecturers who are doing all the 'real' scientific research work. This was not the case in the research teams I studied and the CRS I interviewed were acutely aware of the need for them to generate their own publication records and to produce their own research to maintain their position in a labour market that is characterized by job insecurity.

Job Security

Given the high rate of temporary employment in academic science work, it was to be expected that job security would be identified as a significant issue for professional scientists when considering their working lives. Unlike other occupations, where job insecurity may be a result of a lack of qualifications (e.g. temporary workers in white collar jobs or unskilled manual workers) or are the norm for alleged business reasons (such as zero-hours contracts being offered in fast-food catering or the informal economy) and can be implemented due to the lack of a need for trained or skilled workers, professional scientists have very high entry level qualifications, and the projects that they are involved in require a high degree of commitment over a period of a number of years. Achieving a PhD requires a minimum of 3 years full-time study and work in a specific area and this in itself requires the achievement of at least a 2i undergraduate degree.[17] All the CRS I interviewed had achieved this: all were employed on temporary contracts. Therefore I expected a degree of dissatisfaction with the level of job insecurity at work. This was not strictly the case.

Almost all CRS respondents noted that their job was not secure and most respondents saw job security as being an important consideration

16. 'Characteristics of research active staff'. Study by the HEFCE Analytical Services Group, March 2000.

17. Such a degree classification is the second highest level possible in UK undergraduate degrees, where grades are assigned in the following order: first class, second class division 1 (2i), second class division 2 (2ii), third class, fail.

for them when looking for future employment.[18] However, many respondents did not feel that job security was something they could do anything about and, although they were concerned about job security, they recognised that being CRS meant that job security would always be a problem. Many also recognised that they were trading risk for future benefits, as this biochemistry CRS explained:

> If I had a choice between a secure but boring post and an exciting but temporary position, I think I would go for the temporary position with the exciting work because usually there will be options further down the line and the most important thing is your c.v., the work that you have done and your publications. That will make you a stronger researcher and make you a more viable asset for obtaining a more permanent position in the future.

Other CRS did not share this opinion and expressed a strong preference for finding a permanent contract as soon as possible. In some cases, the attitude expressed concerning job security was related to personal factors:

> INTERVIEWER—Is job security important to you?
> Physics CRS—Currently it isn't but that is because I and my girlfriend are independent. It would be different if I were married with children. But right now I don't care much about it.

Although there was variation in attitudes towards job security, no discernible pattern emerged between, for example, male and female respondents, or EU and non-EU respondents.

In summarizing the external conditions that face scientists there are some striking features, namely, that working conditions are hard,[19]

18. Table 1: Attitudes towards job security—All respondents/CRS respondents

	All respondents		CRS Respondents	
	Is your job secure?	Is job security important to you?	Is your job secure?	Is job security important to you?
Yes	9	17	1	8
No	12	0	11	0
Don't know	0	2	0	0
Not really	0	5	0	4
Not asked/ no answer	5	2	1	1

n = 26 (nCRS = 13)

19. All respondents said they worked a minimum of 40 hours per week in the lab.

remuneration is relatively poor, job security for most researchers is almost non-existent and for CRS there is no obvious structure to career progression. Given these external conditions, we will have to find fairly robust ways of explaining why it is that scientists are willing to persist in their work and why they choose to embark on such careers in the first place. In interviews, most respondents who were not full-time lecturers identified these external conditions as being issues that concerned them, although to varying degrees. In addition, most respondents considered their job to be stressful either always or some of the time. We can conclude that there must be some major positive benefits to temper these negative aspects of being a professional scientist. To investigate this I will now turn towards the inward conditions that drive individuals towards choosing such a career.

Inward Conditions

> In our time, the internal situation, in contrast to the organization of science as a vocation, is first of all conditioned by the fact that science has entered a phase of specialization previously unknown and that this will forever remain the case. Not only externally, but inwardly, matters stand at a point where the individual can acquire the sure consciousness of achieving something truly perfect in the field of science only in case he is a strict specialist… Only by strict specialization can the scientific worker become fully conscious, for once and perhaps never again in his lifetime, that he has achieved something that will endure. A really definitive and good accomplishment is today always a specialized accomplishment. And whoever lacks the capacity to put on blinders, so to speak, and to come up to the idea that the fate of his soul depends on whether or not he makes the correct conjecture at this passage of this manuscript may as well stay away from science. He will never have what one may call the 'personal experience' of science. (Weber 1948: 134)

Can Weber really be correct? Is it true that scientists are going to be driven from the inside by a passion for science and that they will exclude other concerns in favour of this? We can imagine people enjoying their work, being dedicated to it, even thinking that it is very important. But what Weber is describing here is single-minded devotion.

In the interviews, respondents were asked why they went to work and had a job, and what they liked or disliked about their work. As would be expected a wide range of responses were offered. To simplify these I have collected responses into three categories.

Three said they would spend a minimum of 60 hours in the lab. All reported that they frequently worked at home in addition to their normal working day.

1. Those respondents who identified job satisfaction or enjoyment of work and financial reward as their primary motivation.

The largest group (10 of 26 respondents) fell into this category. Here are a few examples of the ways in which these respondents described their motivations towards work:

> Getting the money, you have to have that first. But I really enjoy designing and building things.—Physics CRS.

> To pay the mortgage [laughs]. I enjoy it here, I'm an active member of the sports centre and in my time here I've thoroughly enjoyed it. It's a nice environment working alongside very intelligent and nice people, that's the truth of it. They're all good guys.—Biochemistry technician.

> I enjoy what I do, I'm happy with what I am doing, it challenges me mentally. Obviously to earn money, to make a living, but I believe in enjoying your work. You spend so much of your life at work then if you are not happy at your work you're not happy with your life.—Biochemistry CRS.

> Money to survive. But also I need something to do—I don't want to just vegetate. I would say that I work to live rather than live to work. But I do enjoy it.—Physics PhD.

2. Respondents who identified job satisfaction, but did not identify money, as being their motivation to undertake scientific work.

5 of the 26 respondents (3 PhD and 2 CRS) fell into this category. They were pressed on whether or not they really would carry out their work if there was no financial reward at all:

> I'm not doing this for going to work and having a job. I'm doing this because I want to do this, I want to work in science and getting paid is a bonus. OK, I could complain about not getting paid enough but I'm not in it for the money. If I was I wouldn't be doing this. And the other thing I like is, well not here, but other places there is a freedom to be yourself mentally, work how you want, have your own ideas. I don't like the team obsession here, but it will look good on my c.v. But it stifles individuality and individual ideas.—Physics CRS

> I really enjoy it. Money is not an issue here. I do it because I really enjoy it. But, of course, I would like more money [laughs].—Physics CRS.

> It's not for the money [laughs]. I would be bored at home all day. I like social interaction, talking to people, seeing people. And I do enjoy the work that I do—I couldn't sit at a computer all day inputting data.—Physics technician.

3. Respondents who offered another explanation of their motivation. These responses varied in form, but most clustered around some aspect of intellectual challenge, achievement or duty. In all, 5 respondents offered responses of this sort and some examples will help to illustrate these:

> INTERVIEWER—Why do you go to work and have a job?
> Sometimes, when I have a project and an idea I want to go to work to check if my idea is viable or not. Most of the time it's an intellectual challenge, maybe like a sort of game.
> INTERVIEWER—It's not the money?
> Oh no, not at all! I'm too young to think about money, and I'm not married, I don't have any responsibilities, I just have enough for me and that's enough.—Physics PhD.

> It is a duty to use my talents. I enjoy it very much and am very very very happy when I come here to work. If I have too little work I become nervous, I like to be busy, but busy in science.—Biochemistry PhD.

> INTERVIEWER—What are your main reasons for going to work and having a job?
> To advance the frontiers of the subject, definitely.
> INTERVIEWER—If you won the lottery would you still come to work?
> I would still have the responsibility so I would come to work tomorrow. I'm not sure if I would keep doing this job, I might use the money to negotiate a different kind of contract so I could do the stuff I want to do and not the stuff I don't want to do. But from a lifestyle point of view I would be quite tempted to get a cottage in Scotland with the family. Science is not my only reason to live by a long way… Money is a motivation for going to work, but not specifically this job.—Physics lecturer.

In addition to the above explanations for going to work, most respondents identified the social aspects of their job as being of great importance to them. This was confirmed through participation in the everyday work cultures of these labs: workers really did spend almost all of their time together, socialized with other lab members after work and at weekends and would spend their break periods discussing each other's work and theories. These were very close-knit occupational communities, with some research team members sharing accommodation, transport to work, leisure activities and friends.

> Ladies and gentlemen. In the field of science only he who is devoted *solely* to the work at hand has 'personality'. And this holds not only for the field of science; we know of no great artist who has ever done anything but serve his work and only his work (Weber 1948: 137).

Weber suggests that scientists are dedicated to their work and their working lives, they are highly motivated and committed to their colleagues. This is supported by the interviews carried out with scientists. But is this enough to explain individuals' involvement in science?

Weber's account looks to scientists as being obsessed, single-minded devotees who have no other concerns than the self-set and limited goals of a particular specialized branch of science. Weber notes the limitations of this: given the level of specialization, no scientist can produce a piece of work that will stand the test of time and last for generations of other scientists to follow. Indeed, we can see Weber predicting Kuhn (1970) on this matter in the ways that he describes the progressive accumulation of scientific knowledge: 'Every scientific "fulfilment" raises new "questions": it *asks* to be "surpassed" and outdated' (Weber 1948: 138). Weber does move a little bit further than just this explanation—he asks whether the restricted goals of science are the vocation of scientists, or if it is not the case that the vocation that scientists are attracted to is that of progress itself (Weber 1948: 140).

At this point it may be worth noting again that Weber's account is not based on fieldwork or even discussions with academic or professional scientists. We can be sure that Weber would have known a good number of academic scientists, but we have to wonder whether these would have been faculty staff and professors at his university, rather than more junior staff (*Privatdozenten*). In any case, the structural landscape of science is very different from the one in Weber's day. However, the point remains of interest: given that today the tangible benefits of being a scientist are diminishing relative to other career possibilities (by this I mean pay, conditions, job security and, most crucially, social status[20]) we need to find further explanations for the continuing popularity of academic scientist as a career option. Following Weber's lead, perhaps what we should be doing is looking at what scientists think science is, rather than just concentrating on how they are motivated towards their work tasks. However, it is worth pointing out that it will not be possible to disentangle these two threads. Scientists make sense of their work by reference to inward conditions and by reference to what they think science is: likewise, scientists make sense of what science is by reference to their own work and motivations towards it.

Science and Scientists

Science has become a contentious term in recent years. Scientific knowledge, as a privileged form of human knowledge that provides access to 'the truth', has been under sustained assault from a number of different directions. Scientific progress is contested by many, from environmen-

20. I would suggest that some scientists define their work as being 'morally contestable' in that they felt a significant amount of social concern or even opprobrium surrounding their work. In particular, biochemists explained to me that they were careful in describing their work to other people for fear of being associated with the negatively comprehended genetic modification debate. They would, for example, often not mention to others that they were involved in cloning.

talists and eco-feminists to relativists and religious groups (Irwin and Wynne 1996: 8). Scientific institutions, through their associations with governments and business organizations, have become tarnished by the perceived use and abuse of power. Where Weber was capable of seeing science as a progressive, albeit limiting, force that provided rationalization and progress, science today has a more dubious reputation.

This account, although heavily truncated, would be accepted by many involved in social studies of science. But it isn't accepted by most professional scientists, nor could it be: without having to go as far as Weber, we do need to see science as a whole retaining some form of a coherent and progressive project to start explaining the levels of commitment that scientific workers show. For professional scientists there is more to science than simply completing tasks in a lively and co-operative atmosphere. So, what do scientists think science is?

In interviews, scientists offered a wide variety of definitions and understandings of science. However, four broad themes emerged.

1. Those who defined science by identifying its goals and its methods. 20 out of 26 respondents offered a definition around these themes. Some typical responses illustrate this:

> To me, science is the attempt to understand nature.—Physics lecturer.
>
> Science is discovery, it is the willingness to want to understand more.—Physics lecturer.
>
> The definition changes with time, but right now I would say it is the study of things that we don't know about, the study of nature.—Physics PhD.
>
> I will probably be very conventional in saying this but I would say it is trying to understand better what is around us.—Physics CRS
>
> It is for discovering and understanding us and the world that we live in and the things that are around us.—Biochemistry technician.
>
> The study of things around you, natural phenomena around you.—Biochemistry CRS.

2. Those who could not offer a definition of science. 3 respondents fall into this category. For example:

> INTERVIEWER—What is science and what is it for?
> I really don't know. I always think of myself as a life scientist, having come from biology, and that's the study of life. But I really don't have a definition.—Biochemistry CRS

3. Those who qualified their answers by linking their definitions of science to the concepts of progress and improvement. 6 respondents offered such replies. The following comments are typical:

From a scientific point of view, science is the application of logic and reason to solve problems. You form an idea about something or a null hypothesis and you perform experiments to prove or disprove that hypothesis and it is through logic and reason. That's a very scientific view. I'd like to think that the overall aim of science is to improve the quality of life for people in the world. That's my aim. The scientific community as a whole, that should be their aim. Improving the life of people in the world through whatever means, medically, or food or technology, whatever.—Biochemistry CRS

To me, science is the attempt to understand nature. It fundamentally advances our knowledge of the world and this improves civilisation, and it improves technology that supposedly improves the quality of life.—Physics lecturer.

[Science is for the] Edification of the human race. You can take that in both ways, both the joy of knowledge and the joy of technology.—Physics CRS

4. A final theme linked science to making money. Two respondents did this:

INTERVIEWER—What is science and what is it for?
The knowledge of all things. We are naturally inquisitive, but unfortunately it is more and more about making money.—Physics CRS

INTERVIEWER—What is science and what is it for?
It's the search for knowledge, finding out why things happen, how things are arranged. But also it is to solve problems, in medical research it is there to provide cures or vaccines. It is a helpful tool, that is there to improve the quality of life. It can also be a huge waste of money, and some science is just people tampering with things for the sake of tampering with things. Like that mouse with an ear on its back, that is horrendous, and cloning, I don't understand why they do that. Science is very commercial, and a lot of science is there to develop an idea and make loads of money out of it.—Biochemistry PhD.

Overall, the definitions of science gathered from respondents were, largely, normative. They hold with the ways that science has been 'traditionally' defined by social scientists such as Merton (1957). In particular we should note the continued relevance of Merton's definition of the institutional goal of science as 'the extension of certified knowledge' (Merton 1957). In addition, we can see strong traces of the scientific worldview, which sees that 'everything is in principle knowable and that the world is a causal mechanism, the working of which can ultimately be explained' (Schroeder 1995: 233).[21] The definitions of science from these

21. For Weber, according to Schroeder, it is this point that marks the 'double-

scientists present an inclusive picture of a wider project for science that includes all of those involved in research, and offers no particular hierarchy of knowledge,[22] assuming that all research so included has been carried out 'scientifically', that is according to the principles of normatively defined scientific investigation. In all the interviews carried out there was not a single trace of any form of doubt about the status, rationality or truthfulness of science. Strenuous effort was made to engage scientists in discussions of, for example, the 'ideological' status of science or the possibilities that knowledge is a constructed artefact or that scientific work was a response to an agenda being set elsewhere. Whilst some scientists did accept that there were some financial considerations that were driving their research, they did not find this particularly problematical. However, the possibilities that science did not produce a thing called 'objective knowledge' were politely laughed at. Indeed, most scientists, when such issues were raised, could not make any sense of such a frame of reference, simply could not appraise such claims.

There are a number of explanations that we can offer for this strong, almost unshakeable, faith in science. Most obvious is the fact that most of these scientists had not been exposed to ideas that call into question the nature of scientific knowledge. Their cultural tastes were diverse, but few claimed to have read any philosophy or sociology of science. Those few who had were quite dismissive of such approaches to the world. For example, one biochemist, when asked to describe what he thought science is said, after much laughter, 'To be honest I don't think it matters at all, it is just the sort of thing a sociologist would ask.' Scientists did not see the social critique of science as threatening science in any way. They did not consider that social studies of science would undermine the project of science, or that these should not be carried out. Far from it: all those involved in my project were supportive and helpful. But they did see science as being under threat from two directions. First, they thought that media representations of science were very poor and that these served to present a distorted picture of science as an all-knowing and all-powerful set of disciplines. The threat here came from the generalization of false expectations concerning the benefits from science for the wider public. The interviews are replete with examples of this, such as the

edged' nature of the project of science: 'it robs the world of meaning while being unable to replace it' (Schroeder 1995: 233).

22. It is interesting to note that 6 of the 26 respondents specifically stated that sociologists and other social scientists were also scientists by their definition, i.e. they should be included in a general definition of science. Of these 6, 5 were non-EU nationals who had only recently moved to the UK to work.

furore surrounding genetically modified (GM) foods and mad cow disease (Bovine Spongiform Encephalopathy [BSE]). The second threat came from the demands put on science by economic imperatives and industry in general. Perceptions of these threats varied: from the contraction of 'blue-skies' research to the dangers of global economic instability. Scientists who identified the economic threats to science (6 respondents) agreed that the problem was the external setting of the agenda of science and argued for greater autonomy to be given to science. For example:

> Science is not working in a good, proper manner because the driving force for all things is money. Money directs science to certain problems… Science nowadays is serving money, not money serving science.—Biochemistry CRS.

A further explanation for the formation of these normative views of science can be found in the tight-knit nature of these work groups. Patterns of association were very close. Few respondents identified that they had any friends or acquaintances who were not also scientists.

However, this affirmation of a normative view of science needs to be put in the context of general societal views of what science is. By this I mean that whilst the attitudes of scientists towards science make it clear that they felt 'pulled' towards science, we need to recognize that there may also be a social valorization of science that 'pushes' people towards choosing science as a vocation.

Science as a Vocation in the 21st Century

From the interview material presented here we can see that the inward motivation or calling of scientists is remarkably similar to that described by Weber: scientists maintain a high degree of motivation towards their work and to their collectively held view of what science is. Science, for those interviewed in my research, is a vocation. It is, of course, other things too. Most notably for Weber, science is a double-edged project; at once both progressive and disenchanting. As Schroeder notes, science is seen by Weber as being an ominous project that while providing inevitable progress will also presage a 'mechanical petrification in modern society' (Schroeder 1995: 227).

Weber's *Science as a Vocation* is, as noted above, a complex text that does not limit itself to a description of the external and inward conditions of science. It is itself an object lesson in the application of Weberian methodology to the social world. In *Science as a Vocation* we can see Weber applying a set of ideal types to particular cases in an attempt to impose some order and meaning on a complex set of events and action. Given this, it is unsurprising that Weber's description of science fits so neatly with his other work that investigates the rationalization of the social world. However, it is worth noting that a similar methodological process is visible in much of contemporary sociology of science, that is, the application of ideal types to specific cases which produces results that clarify, and occasionally problematize, contemporary scientific practice. Yet such approaches that focus on the process of knowledge production in science, or focus on the product itself, despite using a similar method to Weber, are using different categories of ideal types. Contemporary sociology of science approaches tell us that science is a set of practices, a way of orienting ourselves towards the world, a form of knowledge.[23] What they ignore is that science is also a vocation, and that scientific knowledge itself is a product of the adoption and articulation of a vocation. Contemporary studies of science frequently occlude the external and inward conditions of science, indeed they rely on such an occlusion. Were they to not avoid such issues their studies would perforce have to shift focus away from the construction of scientific knowledge and move towards a consideration of the construction of scientific work relationships in the context of a workplace environment that reproduces key instabilities, and key imperatives, of contemporary capitalism.

In *Science as a Vocation* Weber locates science in an ideal-typical construction of work and organizational practices. Further, he locates scientific vocations in an ideal-typical construct of science as an intellectual activity that is central to capitalist society. Weber's work reminds us that we have to place science in the context of work if we are to understand why it is that scientists will produce knowledge in the way that they do. We need to have a grasp of the inward conditions that motivate scientists, the ways in which scientists themselves are making sense of their project and, perhaps most importantly of all, we must have some understanding of the external conditions of science that pattern and structure the vocation of scientists. The interplay of these three factors is what gives science and scientific institutions their character and, ultimately, lead to the production of the objects of scientific knowledge.

When we apply Weber's scheme we will begin to recognize that the character and structure of UK HE science may be vulnerable. Those responsible for producing the scientific knowledge that many see as the driving force behind technological change are not the people who are receiving the rewards of a sci-tech revolution. Rather, they are receiving job insecurity, lack of institutional recognition and relatively low pay. Whilst the calling of science may still explain the continued allegiance of

23. Most notable examples of such an approach are Latour and Woolgar 1979; Pickering 1984; Pickering 1992; Latour 1987; Golinksi 1998.

scientific workers to their profession, given the range of assaults from other social institutions we must begin to wonder how long this state of affairs will remain.

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