Patenting Culture in Science: Reinventing the Scientific Wheel of Credibility

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This article discusses the emergence of a patenting culture in university science. Patenting culture is examined empirically in the context of the increasing commercialization of science, and theoretically within debates over scientific "credibility." The article explores the translation of academic credit into patents, and vice versa, and argues that this process raises new questions for our understanding of scientific recognition and of scientists' networks. In particular, the analysis suggests that scientists must move between two distinct social worlds to manage the rewards that academic and patent cultures carry.

Introduction

Typically, research on the locus of scientific practice has concentrated on the academic research community. The industrial context within which much of scientific research and development (R&D) is located and the growing interface between corporate and public sector research have received relatively little sociological attention. It is only recently that a number of contributions (Webster 1994; Etzkowitz 1993) have sought to explore what Cambrosio (1994) has called "inter-laboratory life," or the connections between the private and public contexts of the production and exchange of scientific knowledge. This article contributes to this new work by focusing on the emergent patenting culture in public sector science that reflects the

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general trend toward the increasing commercialization of university and government laboratory research (Mackenzie, Keating, and Cambrosio 1990; Bozeman and Crow 1991). The growing commercialization of science is said to pose a threat to the long-established conventions and norms of public sector, especially university, research (Seashore Louis, Anderson, and Rosenberg forthcoming). A commonly held view is that commercialization may compromise scientific impartiality by introducing the profit motive into the direction and evaluation of scientific knowledge claims (Brooks 1993; Krimsky 1991). Were this to happen, the normal processes of scientific reward would be undermined since claims would be less likely to be subject to the disinterested process of objective peer review.

The article examines how scientists determine what is patentable and how this differs from their traditional conceptions of novelty in science. It considers the implications of the patenting culture for the way scientific work is recognized and rewarded—the "cycle of credibility" through which scientists' reputation and position are secured—and suggests a new way of conceiving of the boundaries and networks between "public" and "private science" (see Rappert 1995). We thus paint a picture of the social world(s) of scientists whose credibility within academic and patenting networks is secured in different ways. Our analysis raises a number of criticisms of the approach most closely associated with network analysis in STS, the actor network theory (ANT).

Scientific rewards clearly depend on the dissemination and evaluation of scientific knowledge claims inscribed in scientific papers, conference presentations, grant proposals, and end-of-grant reports to funding agencies. Patents might also be seen as part of the dissemination process, and indeed, Narin (1994) argues that for bibliometric purposes, patents and papers can be treated in much the same way. A patent can thus be regarded as merely another form of scientific claim that generates scientific capital and, like a scientific article, brings its own rewards.

Earlier work on the forms and patterns of rewards in science has included Hagstrom's (1966) functionalist analysis of "the scientific community" engaging in "gift-exchanges," Bourdieu's (1974) image of a more competitive world of science characterized by competitive investments in "symbolic capital," and, as an extension of this, the concept of the "credit cycle" developed by Latour and Woolgar (1986). Latour and Woolgar argue that credit is more than simply recognition or reward for the work that scientists do; instead, "scientists' behavior is remarkably similar to that of an investor of capital" (p. 197). Scientists build their stock of scientific capital through making investments that will secure their *credibility* as scientists: "the receipt of reward is just one small part of a larger cycle of credibility investment"

(p. 197). The credibility of scientists is measured in terms of the trust and reliability *others* can invest in them: the more this is secured, the quicker the cycle of credibility turns and the stronger the stock of capital held by the scientist.

How would patents as a particular form of scientific investment fit into such cycles? Do they contribute significantly to scientists' credibility? Do scientists judge them to be successful or not to the degree that they can be converted into other forms of scientific capital in the credit cycle? Does failure of a patent claim based on a particular piece of scientific research necessarily weaken the credibility of that research, and vice versa? What counts as a *trust*worthy patent claim, and whose trust is to be secured? If it is found that there are differences in the way in which scientific investment in patenting relates to credit and credibility, can we simply incorporate patents into the reward system? If we cannot do so easily, might this suggest that there are different social worlds scientists occupy as they move between patenting and scientific research? Like Hagstrom (1966), Latour and Woolgar's (1986) account of credibility assumes a *singular* world for scientists insofar as "reward and credibility originate essentially from peers' comments" on their and other scientists' work (p. 198). As this article suggests, this network of peers forms only one social world, one that is much less significant as a source of credibility when it comes to investing in patent claims. The scientific capital or currency that patents generate may not be easily exchanged for other forms of capital that scientists seek to hold. Patenting requires engaging in a different form of investment with distinct criteria, and the sorts of skills and credibility needed for securing reward are different from those needed in academic research.

Patents, Competence, and Novelty

The research reported here is part of a project that examines the culture of patenting in the organizational contexts within which scientists work. It focuses specifically on how patenting works (or fails) in the context of public sector research. Our project began (in 1993) with the first national survey of all British universities' technology transfer offices. Fifty-seven institutions that replied to the survey (44 percent response rate) showed a wide range of patenting across universities. For example, whereas 572 patents were held in total, some universities had none, and one held as many as 60; 30 percent of the universities in the survey had no formal policy on intellectual property, and 60 percent of respondents said that patenting activity was *not* self-financing.

From these returns, we then selected ten universities that had varying levels of patenting activity in terms of filing and grants secured and that also had strong pharmacology and biotechnology research teams. These two fields were chosen because they were seen to represent, on the one hand (in pharmacology), a well-established research tradition in a mature field within which judgments about novelty and scope were guided by long-established conventions and, on the other hand, a newer field (biotechnology) in which novelty and scope of claims had yet to stabilize. We also checked whether these groups had links with industry. The overall intention was to secure respondents who were more likely to have engaged with the patent system and who might, thereby, have research experiences more akin to industrial scientists. We also visited all the research laboratories of one of the U.K. research councils to determine whether the universities faced similar problems as other public sector research institutions. In addition, we visited a smaller number (five) of corporations in the pharmaceutical and biotechnology sectors. Overall, we conducted in-depth interviews with fifty respondents: the majority of these (thirty-five) were from academic laboratories, but we also interviewed industrial liaison officers, patent agents, and examiners at the U.K. Patent Office. The results reported here relate specifically to the sample of university scientists.

Central themes of the research are the use and construction of concepts such as "novelty" and "scope," which are both defined as technical, legal terms but may also be understood in different ways by academic scientists who are patenting research work. We are interested in how this interaction between legal and scientific definitions of novelty—*and the distinct sense of "credibility" they carry*—affects the practice of scientific research and the increasingly important drive to push technology out of the laboratory and into companies. This article examines two aspects of the patenting process. We ask, first, how scientists acquire patents, by learning and applying what we call specific "sociotechnical competencies," and second, what scientists do with patents once they have been granted.

Exploiting Research to Produce Patentable Results

Translation of scientific findings into patents has to be understood as a *process* that involves a number of different social actors: scientists, local university-based technology transfer officers, patent agents, patent examiners, and, typically, companies that may be funding the research upon which the patent claim is based. Each of these actors judges the merits of the claim according to different local criteria: the scientific worth of the claim, its

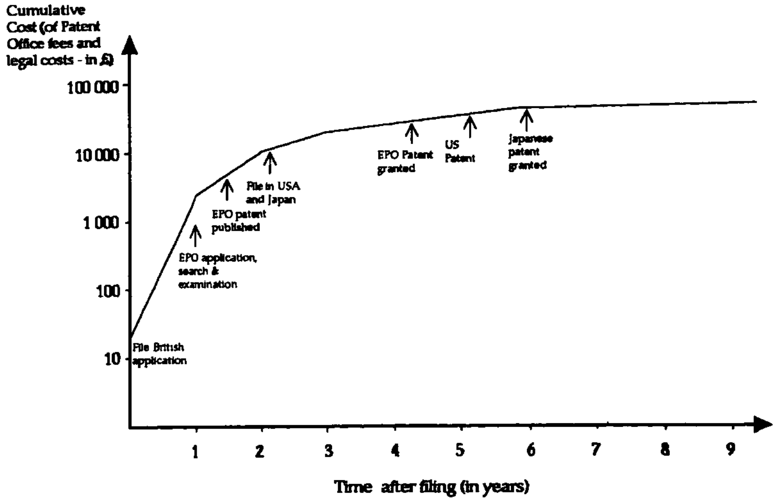

Figure 1. Costs of international patent filing.
NOTE: EPO = European Patent Office.

relationship to other existing claims, who holds existing patents in relation to the claim (e.g., other companies), the potential revenue it might bring, and so on. This indicates the range of different constituencies that need to be addressed in pursuing a claim. The list is not exhaustive. A wider constituency of international patent offices, international regulatory agencies and their policies (such as those associated with the European Commission's Biotechnology Directive), and groups opposed to patenting may all have a role to play in determining the ultimate career of the claim. Thus the identification and consolidation of claims as patentable is *never* a singular event—despite the "eventful" image of "discovery"—but rather an iterative *process*. Not surprisingly, it can take some considerable time to persuade others of one's claims (Myers 1995), and patenting can be exceedingly costly (see Figure 1). These financial costs of patenting are unlikely to be borne by individual scientists or even by their departments; it is much more likely that they would be met by a firm that had received licensing rights from a university. Nevertheless, to secure the needed financial support, scientists must present themselves as credible patentees.

If they are to have a chance of securing a claim to knowledge as a patentable claim, scientists must successfully complete a range of social and technical tasks. Failure to complete any one of these tasks could ultimately mean the collapse of the claim. From the perspective of Latour and Woolgar's

(1986) credibility cycle, these social and technical tasks of interpretation are crucial to being a "competent" or credible patent filer.

Sociotechnical Competencies

To secure patentable ideas and then the patents filed on them, research scientists must have access to a sophisticated and both materially and socially well-resourced *cultural infrastructure*. This infrastructure consists of the range of different interpretive skills, networks, information sources, and professional services that a scientist or group of scientists rely on. It will enable them to develop or draw on the sort of technical and social competencies (see Figure 2) they will need to negotiate the hurdles of patenting. We can distinguish two kinds of such competencies, although we are not suggesting that this categorization reflects hard and fast differences in the activities and skills involved.

First, scientists who are experienced academic researchers but unfamiliar with the patent system (see Myers 1995) need to acquire (through their own hard work or through purchasing someone else's services) competence in intellectual property issues. They must develop an understanding of legal terminology and practices and understand how to manipulate them. They must be able to distinguish between scientific and legal "novelty" and have the capacity to search patent literature, to formulate patent claims and relate them to a portfolio of sister claims, or to make interpretive judgments about wider conventions of being "skilled in the art." Such competencies also include the skills needed to produce a certain type of science-based text that can be credibly presented to the patent system. Such texts are similar in form but very different in content from articles submitted to journals. In Fujimura's (1987) terms, all these skills might be described as "production" work.

The other type of sociotechnical competence can be likened to Fujimura's (1987) notion of "articulation" work. Meeting the requirements of the patenting process requires changes in the experimental and social work of the laboratory. Scientists seeking patents must be prepared and able to provide an "embodiment" of the invention, work around existing patents, perform necessary research, and be willing and able to delay publication (in light of other restrictions on finishing a doctorate or producing a certain number of publications).

Fujimura (1987) shows that articulation and production tasks must be successfully completed *at different levels*. She argues that scientists will only succeed when they align the different demands made of them by their own immediate experimental practice, the wider laboratory, and the much wider "social world" (R&D managers, sponsors, and so on) that their work ad-

Sociotechnical Competencies.

1. Production work
    - Using legal terminology and making judgments in light of it
    - Searching patent literature
    - Writing patent examples and helping formulate claims
2. Articulation work
    - Performing new experiments to embody a patent claim
    - Planning research around existing patents
    - Altering or delaying publication to avoid damaging patent applications

Figure 2. Competencies required for successful patenting.

dresses. She does not, of course, relate this process to the social world of patenting. In patenting, we find not only that scientists must engage with different social worlds but also that the "alignment" process is rather different. Fujimura's model assumes (in a way that is similar to ANT) that scientists can enroll the support of those from other social worlds through translating their claims to scientific novelty into scientific facts at each "level" so as to align successfully the distinct "levels." But when scientists in our study translated scientific claims into patentable claims, they were *not* thereby aligning the worlds of scientific experiment and patenting. The determination of novelty and credibility in the first was not easily translated or exchanged for novelty and credibility in the second. Instead, scientists moved between distinct social worlds.

Determining Novelty in Science

The most important technical competence of research scientists involved in patenting is the ability to recognize and distinguish between scientific and legal versions of the novelty of their work. Even the most well-developed and funded industrial liaison office is unlikely to be able to monitor scientists' work for patentable inventions, certainly not to the extent that company R&D managers do. This limitation stems partly from the lack of specialist technical and market knowledge across the wide range of research areas that would be necessary to monitor university research and partly from the traditional distrust of central university administration. Typically, therefore, scientists carry the primary responsibility for recognizing and developing a patentable invention.

Although Eisenberg (1987) discusses disclosure and enablement in some depth, she pays scant attention to novelty and nonobviousness after initially recognizing their importance. On the surface, the black letter law of patenting and the rhetoric of scientific norms appear to treat novelty in similar terms. However, judgments of the novelty and nonobviousness of biotechnology patents have been crucial in causing and deciding disputes. The comments of the scientists we interviewed also suggest that scientists perceive the legal concepts of novelty and nonobviousness very differently from the way they judge the originality of academic work.

The legal concept of novelty in patenting is quite a simple one. For an invention to be novel, it must not have been publicly disclosed by the applicant or anyone else before the patent application has been filed (or one year prior to the filing in the United States, where a system different to that operated under the EPO exists; the rest of this discussion relates to the first-to-file system since it is under its auspices that all of the scientists that we spoke to would file their initial claims). Disclosure includes any sort of publication (an article in an academic journal, a patent, a newspaper article, or book), a conference presentation, a commercial use of the invention, and any form of oral disclosure not covered by a confidentiality agreement (for example, see warnings in *Bio/technology* about the dangers of disclosure while chatting on a coach on the way to a scientific meeting; Williams 1994). A patent application is "tested" for novelty by searching (usually using keywords) through electronic databases of academic publications and patents (published and unpublished). When scientists in U.K. universities first started to patent their research, their unfamiliarity with the system meant that a number of applications were turned down because they had published their findings before filing a patent application. However, it is now rare for such an application in the biological sciences to be disallowed because of failure to meet the novelty requirement.

This does not, however, mean that the issue of originality is unimportant in the examination of patent applications. Nearly all patents are initially referred back to inventors, and many of the patent examiners' queries ask whether the invention disclosed in the application meets the requirement of being nonobvious, a concept closely related to originality. In judging whether the patent makes an inventive step and thereby fulfils this criterion, the patent examiner assesses the claims not only in relation to the letter of the law and to prior court rulings but also, and more specifically, in relation to an imaginary character, the "person skilled in the art." To be inventive, a patent application must demonstrate how its contents enable others to repeat a procedure or make an object that would not have been an *obvious* extension of the existing knowledge or practice (prior art) available to someone with a reasonable knowledge of the field at the time the application was filed. The person skilled in the art is someone conversant with all the relevant publications and experimental procedures of a specialism but without any capacity to engage in original thought (that is, not someone most scientists would be keen to employ or take on as a student).

Making judgments about the mental capacity of someone skilled in the art is a difficult task, even for experienced examiners, since the conception of the person skilled in the art not only must change to accommodate different technologies relating to different patent applications but also must be firmly grounded in the time of the patent application. Owing to delays in the processing—especially of biotechnology applications—patent examinations or legal disputes may take place months or even years after the initial application has been filed. Research will have moved on considerably since that time, but the examiners must avoid using hindsight. They must base their judgments on what prior art was available at the time of filing (patents and scientific publications are cited by examiners in their search reports that accompany published patents and correspondence with applicants) and avoid being inventive themselves in its interpretation. As one examiner commented, "You have to avoid being an inventive examiner. You have not to look at things with hindsight; you have to look at the situation there and then."

Although the legal arena of patenting is more bureaucratic than the invisible college of the scientific community, *interpretation* of the tacit "rules" is just as important in this arena as the laws themselves. In talking to scientists about their experience of patenting, we wanted to find out how they dealt with this mixture of definitive law and flexible interpretation and how they integrated the requirements of patenting with the requirements of academic institutions and communities concerning the production and publication of original or "novel" research.

The scientists we spoke to generally believed in gradual advancement of knowledge in small steps and did not evaluate research programs simply in terms of the march of intellectual history. New genes were sequenced, novel strains of bacteria were isolated from newly acquired samples, improved and ingenious methodologies were developed, and reviews of previous work led to more perceptive theoretical insights. Although some advances were seen as more significant than others (and therefore easier to get published), they were all considered novel and contributing to progress in the field. This complicated notion of progress in science makes it very difficult to generalize about the matter in which these differing types and conceptions of scientific novelty are relevant to patenting. However, most of the scientists we spoke to recognized that there was a difference between their conceptions of what novelty was in terms of academic science and what it meant for the legal requirements of patentability.

The criteria of novelty and nonobviousness in the patent system were generally seen as *less* stringent than the standards by which originality is judged in academic science. One scientist felt some embarrassment at being a named inventor on a patent that she regarded as obvious:

> I am in bit of an awkward position because I had to be an inventor on this because I suggested they do it, but it is so obvious from the literature and it is so derivative that I am absolutely surprised it issued.

All the scientists recognized that the concept of the "inventive step" was difficult to locate within their social world. Two reasons were cited. First, "discoveries" are legally nonpatentable. So although coming across a new, naturally occurring species, disease, or chemical entity might be considered a significant advance in science, in patenting terms it would carry no reward. It would not count as intellectual property to which one could secure legal rights (unless one could show how the effort of purification or preparation of this discovery made it into a product of human labor). Second, patenting judgments are based on a *universalistic* notion of a virtual scientific community sharing a common stock of knowledge, whereas scientists' own judgments are based on a sense of *specific* communities, which, although geographically dispersed, are local in the sense of being based on subject specialties and interests. As Star (1986) wrote, "Each actor, site or node of a scientific community has a viewpoint, a partial truth consisting of local beliefs, local practices, local constants, and resources, none of which are fully verifiable across all sites" (p. 46).

Unlike the judgment of novelty by the "partial truth" of a specific scientific community, novelty in patenting is judged against all possible forms of publication: as members of specific communities, scientists would probably only expect to read what they are sent by colleagues or find in their department libraries. Similarly, patenting judgments about nonobviousness are made against the baseline of someone skilled in the art, who can draw on all the relevant literature. This combination means that the decision characterized as universal actually applies only to someone with peculiarly good access to publications and active involvement in whatever research project one cares to name. In the social world of science, as one of our respondents noted, it would be ridiculous to consider an invention as nonobvious if only a handful of people had ever had the inclination or opportunity to provide a solution to the question at hand: "[Something is only really inventive if] you ask ten people and only one person comes up with the solution. They get round it by essentially only asking one person."

How scientists relate to the patent system depends on the sort of judgments they make about the virtual community of science, represented by the invisible skilled-in-the-art person, and whether they perceive intellectual property rights as something awarded only to major advances or to seemingly petty advances. Scientists who had the least involvement with patenting thought that only major advances can be patented:

> Basically the question is that there has never been anything that I'm really convinced that is absolutely wonderful. . . . There are a lot of people working in the field so you read their papers, and they read yours, and you make a little step forward on the basis of that. So there's nothing like the invention of PCR, that's such a fantastic idea which you say I must patent it. If something like that happened, and you say this is going to revolutionize molecular biology, then you obviously would patent it.

This view of patenting is perhaps not surprising given the tendency in the science press to characterize scientific breakthroughs as revolutionary or "eureka" events. Such events play a central part in the rhetoric surrounding milestones in research. For example, this is how Kary Mullis described his own work on Polymerase Chain Reaction, a widely used molecular biology technology:

> a revelation came to me one Friday night in April 1983, as I gripped the steering wheel of my car and snaked along a moonlit mountain road into northern California's redwood country. . . that was how I stumbled across a process. (Mullis 1990, 36)

The patent system generally deals with incremental changes. Yet the impression often given in the reporting of patenting in journals such as *Nature*, *Science*, and *New Scientist* mirrors the "breakthrough" story of Mullis's (1990) account. Such reporting has focused on major advances and disputed patents in the area of biotechnology. In *Nature*, five biotechnology patents accounted for over half of the news items dealing with individual patents (as opposed to changes in patent law, etc.) between 1974 and 1992. Although pharmaceutical patents are not so widely publicized, the rhetoric surrounding the need for strong patent protection of new chemical entities reinforces the association between patenting and single, distinct, immensely important inventions.

Scientists with experience of patenting recalled that initially they had also thought patents were associated with major advances in science, though they now believed this to be a naive view. Remembering his early experience, one scientist claimed,

> [the main reason for not proceeding with the patent application was that] we couldn't convince ourselves that what we'd report would be regarded as new in scientific terms.

It might seem surprising that those who thought that patenting requires less originality from the scientist also found it more difficult to present their work as inventive in patenting terms than to write scientific articles. This admission, however, merely confirms that when scientists make patent claims, they must move between distinct social worlds.

The experienced difficulty is not just the shock of the new: even those who are fully conversant with the patent system still perceive a definite boundary between patenting and the rest of their work as academic scientists. They have not ended up integrating the distinct audiences of the "invisible college" of science and of the virtual universe of patentable knowledge *that has no "membership" status even when one participates in it*. There is no one unified process of evaluating and presenting their work in these two arenas. The differences are expressed not only in the scientists' initial feelings of unease at venturing into new territory but also in the mental, literary, and discursive actions that scientists undertake to facilitate their movement. Unlike in the alignment process described by Fujimura (1987), translation here works across two very different social worlds that are relatively independent of each other. This helps explain why in some specific areas, a translation or exchange of "credit" between the two is closed off.

Some scientists coped with these two worlds and managed their contrasting conceptions of novelty and audience by treating the experience (and perhaps the rest of their scientific and administrative work) as a game. Different rules apply to patenting than to academic publication, but one is not transgressing any sort of ethical code by conforming to these rules. Moving between the different games, one is merely doing what is necessary to remain a player. Others were less cynical but still maintain a sense of two distinct cultures:

> When I go into a legal way of thinking then I use novelty (2) instead of novelty (1). I think people can cope with that. It's just a question as to whether *lawyers* will agree amongst themselves as to what constitutes novelty. (emphasis added)

For this scientist, the credibility of claims is *not* judged by the constituency of scientific peers but by "lawyers" represented as having their own local debate about what, according to their criteria, can be credibly considered novel. This particular scientist also said that he had come to be seen by others in the laboratory as someone to whom they could turn for advice on legal issues such as patenting. His status as an advisor was not due to any prior laboratory experience in dealing with intellectual property rights but to the fact that he had worked for his *church* in helping lawyers draw up an agreement with another church about shared use of a building. In this case, patenting was firmly perceived as part of the legal rather than the scientific arena, and *any* experience of the law was regarded as helpful to the uninitiated in the world of the laboratory.

Scientists involved in patenting not only have to think differently about novelty but also have to change some of their activities. Clearly, they have to write up their research for a new type of audience, using legal terminology with which they may be unfamiliar. They have to position their work in relation to that of their colleagues and peers differently from the way they do so in a scientific article. One of the respondents explained:

> Papers are written in a more scientific way—in that your references are made to papers and you have to explain other people's work and discuss it with relation to your work, whereas a patent is just a write up of *your* work.

In scientific articles, citations to earlier work can be used to lend support to the direction of thinking and experiment reported in the article. They can position the new research as the next logical step for all concerned. In a patent, on the contrary, such contextualization of claims might lead to the work being seen as obvious and not patentable. One scientist explained why it had taken a long time to decide whether his invention was patentable. His "invention," as he discovered, was a melange of discrete findings:

> In the BTG[1] patent the novelty was taking three completely different, separate, possibly published situations and linking them together to create a new system. It wasn't the type of novelty of sitting down with a piece of paper and saying, here is a type of chemistry that nobody has ever thought about before.

The ideal way to use citations in patents is to recognize work that the applicants know the examiners will be likely to find and that can lend support to certain assumptions or techniques. These references, however, cannot be too closely related to the disclosed invention because they should not jeopardize the patent claim. A "credible" claim in this context is built by constructing nonobviousness.

Changes in the scientists' practice are not limited to their patent writing activities. Literature searches may need to be improved and new experiments performed to support the patent claims or dispute those of others. Such activities may be needed to support a current patent application or to improve the possibility of obtaining patents in the future. One laboratory made relatively large investments in staff time and equipment to perform work that would not have been necessary if patenting were not a goal:

> It has been one of the stumbling blocks of the [new technology transfer activities] whether or not it should be associated with a reduction to practice

> laboratory and I think we decided that we didn't know basically whether that was a good thing to do, [but] it is a very expensive thing to do.

In general, although both for patenting and for academic research scientists develop what is initially *articulation* work into *production* work, there is still a divide between the concepts, actions, and constituencies—the social worlds—associated with patent production work and those associated with academic production work. Scientists translate the novelty of academic production into patent production by trying to map scientific novelty claims onto the patent system: the experiences this gives them—especially with regard to the amount of articulation work they have to perform—will determine the process of translation. In the biosciences, for example, academics have traditionally had little experience with commercializing their research; now they are increasingly given the opportunity, or are expected, to take part in technology transfer. As they become more familiar with the practice and rules of the patent system, they adjust the claims of novelty that they make. Or, as one bioscientist put it, "now I keep it to the clean and simples."

When scientists have established themselves as credible patentees—whether on the basis of "the clean and simples" or by patents of more ambitious scope—to what extent can they use the credibility established through a patent in the world of academic research? If so much translation was required to enter the distinct social world of patents in the first place, is it possible then to use the currency and credibility of the patent in the very different context of academia? Scientists do use patents within their research environment—the world of the laboratory, their peers, their universities—but in a way that has much less to do with enrolling others and more to do with *controlling* others. Holding patents is not so much a means of enhancing the credibility of scientists in their research world but a means of defending prior investment in the area.

Exploiting Patents in Academia: Controlling Scientific Research

To illustrate these processes in more detail, we can return to Fujimura's (1987) account of the social world of science and examine the relations between Fujimura's three levels: the laboratory, the institution, and the wider corporate world.

Within the Laboratory

As sources of scientific and technical information, one would expect patents to serve in the laboratories as resources for experimental and theoretical work. However, very few of the scientists we spoke to used patents as a source of information for their research work. Even scientists who had patents taken out in their names had never considered using patents in this manner. In its attempts to educate researchers about the patent system, the U.K. Patent Office's promotional material often stresses that much of the information that appears in patents is never published elsewhere and could, therefore, serve as a potentially important source of information. For a number of reasons, our interviewees were skeptical about these claims.

Patents are much more difficult and more expensive to get hold of than articles, particularly papers sent by colleagues or given out at conferences. Offprints, preprints, or references sent by colleagues are often the principal way in which scientists keep in touch with recent research. Industrial scientists were sometimes sent copies of patents, but generally speaking, scientists were not exchanging patent offprints in the same way as papers. One scientist involved in collaboration with research groups in several countries said that she had never seen the other groups' patents or requested copies of them, even though they had swapped materials, results, and articles.

Patents are classified and located according to a complicated system with which most researchers are completely unfamiliar. Given the constraints of time and limited resources available to academic scientists in the United Kingdom, they are not likely to have time to invest in learning new skills. Even when scientists do get hold of patents, the information they contain does not always leap off the page. Patents differ from academic publications in a number of ways: they make different types of statements, use a different mode of referencing, and have a different balance between methodological and theoretical content (Myers 1995). The different format and the use of legal terminology may make scientists initially uneasy about reading patents, although this is not a permanent barrier. Scientists adapt to reading patents as they had to adapt to reading journal articles after learning from textbooks. There are, however, more long-lasting barriers to understanding. One scientist, referring to a patent he was currently examining, said that it was "deliberately obscure and I think the reason it was obscure was because the thing doesn't work." Another researcher, when asked whether she used patents as a source of information said, "Having written patents and knowing the way you write them is to make it impossible to reproduce the work, no."

Some people referred to the extreme length of some patents, which was designed to discourage people from reading them. These comments contrast sharply with the justification of the patent system as a means of promoting disclosure and dissemination of information that would otherwise be kept secret.

As a result of these sorts of disincentives to use patents, the first time many scientists come face to face with a patent is when they have to write one themselves. Previous patents in the field are used as guides as to what sort of language is expected and how information should be structured. In some cases, an education in the patent system can seem to be rather like a crash course in strategic lying. The language used in a patent application would be taken as a lie in any other context. As one scientist commented:

> You had to take it as a joke really, you had to say this will do this. . . and write it in the present tense, and just be over the top in the way you would never be in a publication.

One scientist in our sample used patents as a teaching aid for undergraduate students. They had to examine a patent in their area of study to see what information it disclosed and, more important, what further information one would require if one wanted actually to reduce the patent to practice (thus fulfilling one of the legal requirements of the patent). In this exercise, students were taught not only to recognize methods and theories but also to discover the deviousness of the scientific and legal professions. This scientist acknowledged that he was trying to teach his students that,

> Just because it's been printed and granted by the U.S. patent office doesn't mean to say that it contains anything that is scientifically sensible.

At the level of the laboratory and experimental research, then, patents are not used to enroll peers but, rather, to keep them away. As the above quotations reveal, patents are occasionally constructed as claims that *resist translation*. But even if a claim made in a patent is not "scientifically sensible," everyone recognizes that it can serve as a means of professional control.

Within the Institution or Scientific Community

Both the law and the industry regard patents as a tool for controlling relations between institutions. However, we found that scientists also used their patents *within* scientific institutions, both at the meso level (within their university or the international research community in their specialized area of research) and at the micro level (in their laboratories). Scientists were asked whether they ever used patent claims to demarcate areas of professional or commercial interest. Researchers who had experience in patenting did think that it could be used to help secure their credibility among members of the university with responsibility for commercialization. Several scientists said quite explicitly that a "credibility factor" was involved in patenting. The importance of this factor depends on how links with industry and their potential to generate income are viewed within particular subdisciplines and institutions. One industrial liaison officer said that,

> Some of the big professors would use that as a bargaining tool in another area, use their patent portfolio, use their contact with the pharmaceutical companies in particular, the fact that BTG are just about to sign a deal with somebody. . . . they would push that out as a kind of "look at how much money I am about to make for the university."

One scientist we interviewed had been involved in an institutional debate about how much significance should be attached to activities such as patenting and academic-industry relations in her university. She had argued that not enough credit was given for this work. The increasing importance of patents in a wider range of institutions suggests that patents will also play a greater role in the internal politics of specialisms and universities than they have before.

The Relation to Corporate Links

At the macroeconomic level, the patent system is supposed to facilitate technology transfer in two ways: by granting monopoly rights as an incentive for companies to innovate and by requiring the disclosure of information. The patenting activity of the scientists that we interviewed did not seem to fit into this pattern. Actual products or processes that could be used by consumers were rarely a major theme in our discussions with scientists. For scientists, patents formed part of their links with industry; they were not primarily vehicles for technology transfer. Although some of the scientists had earned substantial sums of money for further research work, through the licensing of patented inventions, others had not been successful in earning money on patents and had only modest hopes of doing so in the future. For many scientists, patents were part of the payoff for the industrial sponsors of their work. Rather than initiating a process of technology transfer, patents were then the result of such activity. Patents do, however, also play a role in the earlier stages of this process when scientists try to attract industrial funding. Here, patents worked as a marketing tool. They indicated that academic scientists were sensitive to the industry need for proprietary knowledge and that they were competent, not only to produce scientific knowledge but also to secure it for commercial use:

> It really is what one is looking at the patent for. It's advertising, it's window dressing, it's to allow you to go to the next stage, to raise funding, to allow you to indicate seriousness in what you are doing.

Companies often use patents as a source of strategic information about their competitors, and they employ information scientists to review and process new patent literature and to carry out specific searches. Most academics in our study did not use patents for these purposes, although some scientists were involved in the monitoring of patents on behalf of their industrial sponsors. For example, they were reviewing competitors' patents in terms of their practical feasibility. Only one scientist said that he reviewed the patent literature in the area to get an idea of "who is working on what and what their approaches have been." Another way in which companies use patents is as a bargaining tool in negotiating licensing or other deals. They may keep spare patents or try and patent in areas of interest to competitors to try to block their work or to have something to swap. Some of the scientists most involved in commercial activities did recognize this practice and tried to use their patents to negotiate the best possible deal with sponsoring companies or to protect their freedom to follow their own research agenda:

> the only reason I would be interested was to make sure that what I do, nobody tells me I can't do something. If you have a patent then that's it covered; nobody can come along later and tell you what you've done belongs to them.

In external relations, then, patents did not appear to serve so much as a channel for the dissemination of information but as a device used to control competitors.

In summary, scientists *do use patents* to maintain and further their position in the credibility cycle. Scientists use patents to initiate and maintain connections with outside bodies such as companies; they use patents to further their position within university academic hierarchies; and they use them in their own laboratories to help in writing their own patents. Scientists do not necessarily see patents as the vehicle for technology transfer, but they use patents with great effect to enable them to carry on with their academic research programs. Within the scientists' credibility cycle, patents do not serve as sources of information or as a means of cementing *academic networks*. They are not a way to *enroll* other academic actors.

Discussion

Our analysis of the emergent patenting practices within academic research science shows that although both in the world of academic research and in the world of patenting, scientists are rewarded for "novel" contribution, the meaning of novelty and the form of rewards are different in these two social worlds. As scientists cross boundaries and move from the localized network of their specific research world to the virtual universe of "state-of-the-art" knowledge in the patenting world, they engage in translations that are initially experienced as problematic and that require a different form of production and articulation work than is the norm in academia.

ANT has sought to explore the construction and the exchange of scientific knowledge in networks of heterogeneous actors, who enroll each other to stabilize or black box particular understandings of nature. The human actors in scientific institutions continually have to create and invest credit to sustain and advance their own involvement in the processes of science. This approach implies the existence of a singular world in which actors translate interests and engage in the enrollment of allies. Our work suggests that when research scientists engage in patenting, the processes at work are different from those that operate in their purely academic work.

The patenting arena calls for distinct forms of production and articulation work, and it is not simply part of the scientists' heterogeneous network as ANT might declare were it to consider patenting. Scientists—even those most experienced with patenting—are not *members* of the patenting world in the same way in which they are members of their research world. In this sense, they are not "enrolled" within the world of patenting. How, then, can we summarize some of the key differences in the way novelty, reward, and credibility operate in the distinct worlds of patenting and research?

Institutional Context

There is an important difference in the institutional contexts within which academic and patent production work takes place. Academic status and credibility depend on the production and articulation of knowledge claims that are negotiated with other scientists in local and broader networks. According to Lynch (1985, 264), "what counts as a notable finding, a definitive anatomical entity, a thing's attributes, a procedure of measurement, an adequate display of data, and a plan of methodic action" is secured through interaction with others. Publications and their "inscriptions" are circulated and evaluated among participants and serve as a "social glue" (Knorr-Cetina

1995, 155). The institutional relations within the university facilitate this process and require scientists to engage in academic production to secure research status for themselves and the university, thereby to assure themselves of research funding.

Patenting production cannot be easily mapped onto this set of institutional relations. Scientists find that they must engage with a distinct group of individuals—such as patent agents and industrial liaison officers—and organizations—such as spin-off firms, large corporations and the patent office—with whom they have legal and contractual, rather than collegial, relations. Nevertheless, the demands these actors can place on the scientists can be as great as those of scientific peers. For example, patent production requires scientists to expend intellectual energy and material resources on searching existing patent literature and on experiments that provide a demonstrable "embodiment" of the patent claim. The institutional relations here are distinct from those characteristic of the academic network, not only because different work has to be done but also because different actors judge its merit and set the terms of how and when it is to be delivered. The "social glue" that secures the research network among academics *may* be in jeopardy here because a key feature of patent production is to preempt sharing one's ideas freely with other people. We have a few examples of scientists reporting that the need to secure patents has led them or research groups they have collaborated with to abandon or put on hold such collaborations until the patents are issued. Balancing the distinct institutional demands of the university and the patent system can be problematic. Credibility in one may undermine the credibility in the other.

Enrollment

Engaging with the patent system means engaging with a different set of actors, whose enrollment is open to question. The notion of "enrollment" in ANT assumes that significant others can be enrolled not merely by translating one's claims into those acceptable to them but crucially also by translating *their* ideas into one's own. According to Knorr-Cetina (1995, 159),

> How do I persuade someone to accept my proposal, my method, my invention? By convincing them that it is in their interest to adopt my offer, by redefining ("translating") their interests such that they converge with mine, and thereby by "enrolling" a heterogeneous crowd of "actors" into a network of associations that stabilise the technical object.

As we have argued, scientists do translate their scientific claims into patents. And they do rely on securing the support and expertise of specific actors who are part of a (qualitatively) different network. However, the stabilization of the technical object—here, the patent—depends on the judgment of some actors who are not enrollable in the sense assumed by ANT. The most important in this regard is the virtual actor—the person skilled in the art—with whom one cannot negotiate but whose "voice" is articulated through judgments of patent examiners (and, possibly, the courts). Scientists construct various mental images of this person—from a postdoc with two or three years research experience to a senior scientist one might expect to employ as a defense witness in a patent dispute. These constructs did not necessarily conform to those of the patent examiners. The collective expertise of the person skilled in the art accumulates over time, but this may only be "discovered" during a patent dispute in which the judge might declare that an unpublished patent application constituted prior art for a new claim under consideration by the court. Moreover, a scientist's control over his or her *own* status as *scientific* actor—clearly assumed by ANT's notion of strategic interaction with other scientists—can suddenly be removed by a court's declaration that previous academic production by the same scientist must be regarded as prior art, *even if that scientist insists that this is not the case.*

Moreover, the world of patenting within which scientists operate is a network of actors linked by distinct "social glue." Social ties in this world are based on distinct modes of interaction through which patents, facts, and their novelty are constructed. Although ANT declares that networks are heterogeneous, we believe that it understates the sense of heterogeneity. It is not enough to recognize the variety of social actors that comprise complex networks; one must also recognize that this variety means something: actors do have locales, senses of belonging, and reference group memberships that cannot easily be translated from one part of the network to another.

Time Scale

Time scales over which patent claims are developed and evaluated are different from those associated with academic production. How is the speed at which the credit cycle turns affected by the competing demands of patenting and academic publication? If patenting sometimes causes delays in publishing, does patenting have a drag-effect on securing professional credibility within local research communities? Such problems may be most acute in cases of patent dispute that have to be resolved through the courts and that can be subject to especially long delays (we have come across a case that has lasted twenty-nine years; Swinbanks 1994).

Furthermore, scientists need to develop a sense of timing needed to decide when to file for a patent to ensure that it will attract sufficient industrial interest without preempting the possibility of a stronger patent claim filed later when further work had been conducted. A similar dilemma confronts scientists who must decide on the timing of their academic publications to ensure that their ideas are disseminated early enough to claim priority and to attract support. However, in contrast to patents, academic articles do not preempt later versions of the same research whose publication can result in similar (or even higher) returns—hence the phenomenon of the so-called self-plagiarized papers.

Textual Differences

Patents and articles also differ as texts (see Myers 1995; Packer and Webster 1995). Articles aim to build on existing work and to disseminate new research findings that can be explicitly linked to the contribution of other members of a scientist's network. Patents must declare novelty and nonobviousness with regard to earlier work. Do these different practices affect what gets cited as part of the academic and the patent claims? Are the citation practices similar or different, and when patent examiners cite earlier "art," is this convergent with the invisible college that the scientist would regard as his or her reference group?

There is evidence that the preparation of texts as part of academic production is influenced by the preparation of texts for patent production. That is, scientists in our study report being more guarded about the speculative claims they might be tempted to make in the conclusions to their academic articles lest these compromise the potential scope and novelty of patents they are drafting at the same time. Thus entering the patent arena may influence the process and content of the dissemination of results within the academic arena. Eisenberg's (1987) belief that patenting can demand as much—if not more—disclosure than articles only makes sense if scientists would actually use the two arenas as equally available sources of information. The evidence presented earlier suggests that they do not.

Scientists have an ambivalent attitude toward patents as sources of information. Some regard them as useful devices for teaching: students might obtain from them knowledge about methodologies for experimental work. Others believe that patents hide as much as they reveal and that even their methodological precision that is ostensibly required by the law can be suspect: some have found it impossible to reproduce the detailed experimental procedures inscribed in the patent text. But this occurs also in academic research (Collins 1985), in which without tacit knowledge, no amount of text-based instruction will enable successful experimental replication of earlier work.

Boundaries and Their Implications for Reward

Our argument that scientists can translate academic production into patent production through rethinking notions of novelty and inventiveness has implications for our understanding of how scientists are rewarded. The credit-cycle model developed by Latour and Woolgar (1986) assumes that scientists work within one academic—even if heterogeneous—network. We have sketched some important differences between the social worlds of academia and patenting.[2] Given that scientists translate their work across the boundaries of these worlds, are the rewards of one social world also transferable to the other?

Income from patents can obviously be used to sustain academic research through the royalties it generates, although typically the amounts are small compared with endowments, contract research grants, or governmental funding. Through a process of translation, the less tangible rewards of one world are also convertible into rewards of the other: we saw this, for example, in the translation of texts and in the defensive use of patents to demarcate academic areas. Moreover, some scientists were prepared to put patents on their curricula vitae and were favorably disposed toward new recruits who had patents, along with traditional scientific publications. In its recent advice to universities relating to the research assessment exercise in March 1996, the British funding council, the Higher Education Funding Council, took basically this position on patenting. Panels responsible for assessing submissions will be asked to regard patents as indicators of the utility to and exploitation of research by industry. Against this, however, the primary task of the panels is to review submissions on the basis of four best "quality" outputs of researchers in different fields. Whether a researcher would risk submitting a patent as his or her best output remains to be seen, but given our earlier argument about the distinct networks and audiences for patents, we suspect that such submissions would be unlikely.

These examples illustrate the translation of credit between the two social worlds, but the qualitative difference between the two social worlds reemerges when we examine how *failure* in one world is kept relatively insulated from the other. For example, if a scientist's patent is ultimately refused by a patent examiner or a court, this is *not* regarded by academic parties as questioning the quality of the research lying behind it. Unlike the rejection of a publication, the rejection of a patent claim does not then damage the status of a scientist in his or her invisible college. Nevertheless, academic scientists acting as witnesses in patent disputes that go to court *can* feel professionally threatened by barristers for the opposition who challenge their judgment: such disputes, orchestrated by the gladiatorial dynamics of the courtroom,

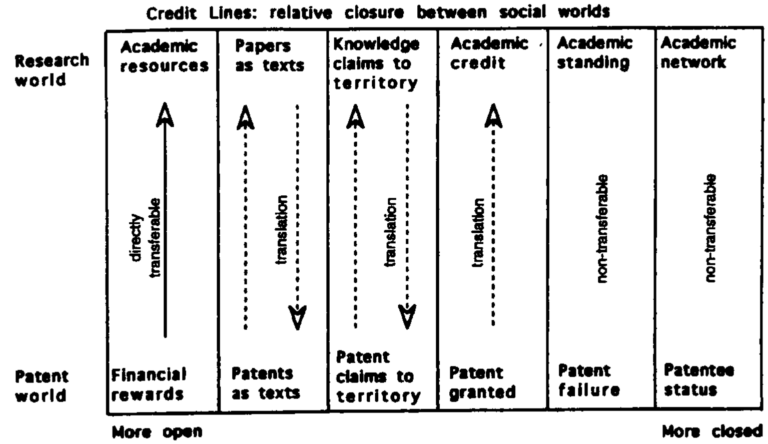

Figure 3. Translating credibility between social worlds.

can pose difficulties for scientists who enter them as though they were operating in an academic context, in which, as Lynch (1985) has shown, interaction is based on a mutual desire to secure agreement.

The transfer of rewards (or failures) from the social world of patenting to the social world of academic research has been summarized in Figure 3.

Conclusion

We have shown how the social worlds of academic and patent production are distinct and how scientists translate novelty between the two, and we have suggested a number of key differences between them in terms of context, actors, timing, texts, and rewards. We suggest that ANT needs to acknowledge the qualitative difference between these social worlds and networks. Without such a distinction, we fail to capture the dynamics of the interaction and the boundaries between these arenas. Although scientists can move between the two worlds and cross boundaries, doing so is often problematic and requires a range of sociotechnical competencies that a tradition of engaging solely in academic production does not provide. As scientists develop new competencies for patenting, they also confront the uncertainties of engaging with a world that evaluates novelty differently than they are accustomed, is held together by a distinct "social glue," and affects the academic credit cycle by bringing new rewards—such as stronger likelihood of securing new industrial research—and new costs—such as holding back on the dissemination of new knowledge claims and delaying or forgoing the reputation this brings. Some might suggest that there are two credit cycles: one for academic and one for patent production. Indeed, inasmuch as industrial scientists also produce patents, one could argue that they also engage with the discrete credit cycle of patenting. However, while acknowledging that there *are* discrete features of the patent system of reward, we would prefer to incorporate these specific dynamics of the patent system within the broader credit cycle of scientists precisely because *they have to map it onto their more central activity as professional scientists*. In doing so, they mediate the effects of patenting by, for example, using a patent to fend off potential competitors, especially private companies, in order to carry on *as before*. In this example, scientists used the novelty of science to translate into a novelty of patenting that could then be used, in turn, to secure additional scientific novelty. The story of academic patenting is both richer and more complicated than the conventional ANT perspective allows.

Notes

1. British Technology Group (BTG) is a technology transfer company that used to be publicly owned and used to have right of first refusal on the commercialization of all government-funded research in universities. It lost these monopoly rights in 1985 and was privatized in 1992.

2. The notion of distinct social worlds within which scientists seek distinct forms of recognition and reward has also been explored recently by Rip (1994), who has looked at the social world of research councils and the relationship this has to the social world of academic science. Like us, he sees them as separate reward structures that impinge on scientists' credit cycles, although his analysis does not go on to examine the implications this has for ANT.

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