Enabling TRIPs: The Pharma -- Biotech -- University Patent Coalition.

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Abstract

The dominant player behind the Trade-Related Intellectual Property (TRIPs) agreement, as regards patents, was a handful of American pharmaceutical transnational corporations ("big pharma"). Given that TRIPs was exceptionally controversial, how was US big pharma uniquely enabled to command the entire trade diplomatic machinery of the US and, through that, enact global law in its favour? This paper explores one crucial factor in the enacting of TRIPs, namely the prior pursuit of domestic US patent reform, from which a highly integrated and powerful single-issue political coalition between US big pharma, the new biotechnology sector and academic life science departments was formed. This created the political context in the US in which patent issues, particularly those affecting the pharmaceuticals industry, came to be considered matters of state. But explaining both the success of this patent coalition and the subsequent success of the US-led international demands for TRIPs in turn demands appeal to analysis of the structure of the global economy and its transformation to one of neoliberal financialisation, from a watershed of 1980. The paper explores how the critical histories of each of the three sectors of the patent coalition are illuminated by analysis in the context of this structural change and the underlying connections between apparently disparate issues it reveals.

Introduction

The Trade-Related Intellectual Property (TRIPs) agreement of the World Trade Organisation (WTO) is currently at the heart of international regulation of world trade. But its signing in its current form is fundamentally baffling, for even its economic apologists admit it is in the economic interests of only a handful of developed economies (at least 'in the short term'), or rather the transnational corporations (TNCs) domiciled in these countries, particularly the United States.[1] How then did it come to be signed into international law by all the member states of the WTO when so many stood only to lose economically from doing so?

It is clear that the pre-eminent political agents for TRIPs, at least as regards patents, were the pharmaceutical TNCs, in particular those based in the United States (henceforth 'big pharma'). Big pharma thus not only entirely co-opted the machinery of the US state in international trade negotiations, but did so to the extent that the US Trade Representative (USTR) was prepared and able to overcome the strong objections of most other signatories of the agreement. But why was big pharma thrust to the position of exceptional political enablement? This paper argues that, while there are numerous well-sourced accounts of how TRIPs was effectively drafted and implemented by US big pharma, this kind of agential history overlooks some hugely important contextual issues without which it becomes hard to understand how big pharma achieved such a stranglehold over the machinery of US state trade diplomacy.[2] This opening up to context takes two stages. First, a critical history of big pharma reveals that global patent reform was not its only political demand at the time of TRIPs regarding which it was overwhelmingly successful. Domestic patent reform in the US was also pursued and in these demands it was supported by two other agents that were crucially affected: the fledgling biotechnology sector and the life science departments (above all molecular biology) of leading US universities. For two of the central demands of domestic patent reform were the extension of patentability to biological material and to publicly funded basic research, both of which mattered greatly to these agents. These political demands went hand-in-hand with the formation of a university--industrial (U--I) complex based on biotechnology, in a mutually complementary dialectic: the greater the success in domestic patent reform, the greater the coherence and power of the U--I complex and vice versa.

Both these political demands and the formation of the U--I complex were overwhelmingly successful. The political successes, however, cannot be explained just in terms of the coherence of the interests of the three parties to the complex, for this reckons without the countervailing interests resisting its formation. And in each case, substantial controversy and political conflict accompanied the proposed changes. Yet all three parties have experienced extraordinary commercial successes and on remarkably similar timelines, from a watershed of 1980. There is thus a striking parallel between the three developments matched by their participation in each case in the U--I complex. The question thus arises: 'what explains these parallels?'

This takes us to the second stage of unfolding the context of TRIPs with a turn to the particular structural context of these developments, in order to explain the conditions that enabled the emergence of such exceptional political agency. Such a structural analysis reveals the various demands regarding patents to be perfectly consonant with the structural imperative for the global primitive accumulation of knowledge along three dimensions: extensive spread of capital into new areas of the globe by TRIPs; intensive spread within already-capitalist societies into new technological capabilities by biotechnology; and intensive spread into the social relations of the production of knowledge through commercialisation of the university. Thus while the political agency behind TRIPs was big pharma, its capacity to take over the state's agenda for international trade diplomacy regarding patents was built upon the domestic political success of a much broader coalition, a U--I complex in the life sciences, and this success in turn was possible due to its unique complementarity with structural imperatives.

The paper proceeds as follows. The first section presents brief critical histories of each element, showing how their individual economic interests led to the pursuit of business relations with the other two parties and to the complementary demands for patent reform to facilitate the formation of the U--I complex. The necessary conditions for the formation of a highly integrated political coalition were thus in place. The second section then briefly outlines the controversial nature of each of the patent demands. This is followed by consideration of their total success and overnight change in fortunes from 1980. By placing these histories in a novel juxtaposition, they are given new and important significance. This is particularly so once set in the

context of the final section, where comparison of the demands with the structural context is shown to explain the extraordinary success in each case. The paper concludes with consideration of the implications of this analysis for the ongoing commercialisation of the university.

Critical history 1: transnational pharmaceutical corporations

The pharmaceutical TNCs at the heart of the TRIPs negotiations and the formation of U--I coalition, such as Pfizer, are one major element of a huge, complex and global industry. While these TNCs are based in a number of developed countries, the majority are domiciled in the US. The rise of the US pharmaceutical industry occurred in particular with the production of penicillin during the Second World War. The development of industrial fermentation processes for production of antibiotics, and the establishment of cartels, served to propel the American companies to dominance (e.g. Dutfield, 2003; Liebenau, 1984; Swann, 1988). By the 1970s, pharmaceuticals was thus a major, profitable sector of the US economy, with profits throughout the decade, at 10%, approximately twice that of the average for the economy as a whole (see Figure 1 below).

The nature of pharmaceuticals, as a 'knowledge-intensive' business, also makes it particularly suitable to transnational activity, because the most important advantages of such operations over their local competitors will typically be technological or knowledge-based.[3] Accordingly, by the 1970s it was already a thoroughly multinational industry.[4] The transnational spread of research and development (R&D) of drugs upon which the major players depend was also growing though predominantly in other developed countries (Kuemmerle, 1999).[5]

One of the stimuli for moving such operations overseas, however, was the visibility from the 1970s of the increasing costs of R&D, a trend continuing to the present (Drahos & Braithwaite, 2002: 59). While a drug in the 1960s averaged $5 million to develop, by the mid-1970s this had grown to $25 million and today the figure is considerably higher again, probably over $100 million.[6] A major cause of this was the increasing regulation of drugs (particularly following the thalidomide scandal) in the major developed country markets (Dutfield, 2003: 97). However, increasing costs were also compounded by a diminishing rate of discovery from the traditional

processes of screening of synthesized chemicals (Drahos & Braithwaite, 2002: 59; Dutfield, 2003: 96).

The prospects for the US industry seemed to be further jeopardised by the growing competitiveness of other pharmaceutical firms, both the other TNCs based in Western Europe and Japan and a growing generics industry in the developing countries. With the rising costs and competition, therefore, drugs now had to be 'sold worldwide, since no company can fully exploit a patented product, recouping the research & development costs solely in its own home market, even in the two largest national markets, the USA and Japan' (Dutfield, 2003: 168). US big pharma was thus seeking new markets to maintain profits, cheaper production and new R&D processes that would break through the threatened exhaustion of the pipeline.

There was, however, a crucial factor complicating this process, namely the exceptional dependence of the pharmaceutical industry on patents. On the one hand, big pharma sought global markets for realisation of profits commensurate with the rising costs of R&D; but on the other, without patents the growing technological capability of local competition threatened merely to exacerbate the problems of profitability because reverse engineering and imitation was increasingly likely.

There is little doubt that the pharmaceuticals industry 'stands alone' regarding its dependence upon patents.[7] The reasons for such dependence are also relatively straightforward. The pharmaceutical product is very expensive to develop (as we have seen) but a major part of this expense is the regulatory process of clinical trials, which do not produce an advantage built into the product that is easily appropriated.[8] Furthermore, many pharmaceuticals are relatively easy to reverse engineer (Richards 2004: 141). In particular, by the late 1970s local competitors in the developing countries were gaining the necessary technological capability for such reverse engineering. This was compounded by patent reform in these countries, specifically aimed at fostering such a national industry by weakening drug patents. The resulting fall in market share of big pharma in these countries, set against the (long-term, as we shall see) need for expansion of markets into these very countries to recoup the growing costs of R&D, thus made patents <u>even more</u> important for the profitability of the TNCs.

Yet we must not overstate the importance of these developing country markets for these TNCs. The US still today remains the most important market, and sales in the developed world continue to dominate massively those in the developing world. Patent reform within the US itself was thus also of great importance to big pharma. In the context of a generalized anxiety in government circles about the declining competitiveness of American industry, this profitable TNC industry was well placed to receive a favourable audience from government over its concerns. Yet the dwindling pipeline could have easily undermined this position if it had allowed pharmaceuticals to be plausibly cast as a mature and declining industry, for the traditional free-trade sentiments on Capitol Hill would have baulked at supporting protectionist measures.[9]

Big pharma, however, could claim two particular competitive advantages that greatly strengthened its political hand: its central association with the 'technology of the future' and with a US asset of unassailable superiority. In short, in addressing its pipeline problems, big pharma could call on its connection, respectively, with biotechnology and with the source of this 'technological saviour', American university basic research in the life sciences, particularly molecular biology. The huge importance of these two factors was noted at the time by Kenney (1986: 33):

> In nearly every current statement of the present economic malaise, the university is looked upon as the source of new technologies which are to spark sustained long-term recovery.

Biotechnology was the primary example. The credibility of this claimed link, however, and the subsequent formation of a complex of big pharma and these university departments, mediated by biotechnology, depended upon the reception of big pharma's advances from these other two parties. It is to these that we now turn.

Critical history 2: biotechnology

Faced with the prospect of a declining output of new drugs, by the late 1970s pharmaceutical (and chemical) firms were looking for new alternatives. With the underlying similarities in biomedical subject matter and the historical experience of

the enormous success of applying organic chemistry in industry, the emerging research in biotechnology was quickly latched onto as the 'obvious' next step, the technology that would resolve the US's (and the globe's) economic woes (Drahos & Braithwaite, 2002: 59; Dutfield, 2003: 148).

While the term 'biotechnology' originally referred to fermentation (Bud 1998), the biotechnology arousing such excitement arose from a number of seminal breakthroughs in molecular biology, the first and most important of which was the discovery of recombinant DNA (rDNA) techniques by Cohen and Boyer in 1973. These discoveries emerged in relatively quick succession predominantly in molecular biology departments in leading US universities and it was quickly apparent that they were 'transform[ing] radically the knowledge base and the opportunities for innovations in biotechnology' (Orsenigo, 1989: 36).

The historical connection of big pharma with universities meant that it was the first industry to recognize the significance of these developments (Orsenigo, 1989: 85). Molecular biology, however, was not a department in the life sciences with strong historical links with industry. Nevertheless, it was a discipline that was particularly compatible with the demands of business for profitable biological commodities because it had been developed from the outset as a biological discipline that would contribute to social control (Kay, 1993 & 1998).

While its programme was not initially concerned primarily with commercial applications, its uniquely reductionistic viewpoint, reducing 'life' to the interaction of a number of molecules, adapted easily to the imperatives of the production of appropriable, and so isolatable, biological commodities (Kay, 1998: 35; Kenney, 1986: 9). The social structure of the discipline also facilitated an easy fit into relations with industry: the use of high-technology apparatus along with the large budgets and responsiveness to funding imperatives this entailed, as well as the hierarchical organisation of the laboratories, all meant the discipline had significant experience of working in an appropriate environment (Kenney, 1986: 12).

The 'new' biotechnology was thus arising from autonomous developments at the level of 'basic research' in molecular biology. Indeed, those interested in developing such

biotechnology found it to be exceptional as a new technology in its dependence on 'basic science' capabilities and the publicly-funded research conducted in universities (e.g. Rosenberg & Nelson, 1994: 343; Orsenigo, 1989: 2). It followed that the major barrier to entry into, or rather development of, a biotechnology industry was access to the relevant scientific expertise located in universities and the need for the creation of links between industry and these individuals and their departments (Orsenigo, 1989: 40 & 49). In short, for this biotechnology to be successfully developed, the creation of a university-industry complex was necessary.

This did not mean that biotechnology entrepreneurs would necessarily welcome the advances of big pharma. Not every start-up in a new technology wants dealings with the existing big players because if it can successfully develop the technology without such assistance, efforts to provide it will be legitimately treated as attempts to protect existing market positions. But this was not the case for biotechnology. For the very centrality of the basic science meant that development of successful commercial products was neither founded on a relatively unsophisticated scientific base nor a straightforwardly appropriable process, taking place at the level of technological tinkering. Unlike computers, biotech could not be developed by enthusiastic individuals in their garages. Biotechnology thus actively sought large external investment, without which it was impossible to launch, and big pharma was an obvious source of such financial support. Furthermore, with biotechnology's strengths lying in research, the established capabilities of these large firms in development and marketing promised a synergy of business operations to both parties (Kenney, 1998: 137, 1986: 207). In soliciting biotechnology as a potential solution to its pipeline problems, therefore, big pharma found a willing partner.

The particular political goal of big pharma, recall, was patent reform. It was crucial for this political strengthening, therefore, that the interests of biotechnology entrepreneurs were compatible with big pharma's not merely economically but also regarding this domestic political demand. Biotech, however, also clearly stood to benefit from patent reform. This again arises from the exceptional central role of 'basic science', because such science, as high-level knowledge relatively disembodied from technical know-how, is relatively easily appropriated by competition. Biotechnology start-ups are thus exceptionally secretive (Kenney, 1986: 177). They

are also high risk and extremely research intensive, with R&D expenditures commonly as high as 50 per cent of sales, so that such threats of imitation jeopardise the whole business plan (Dutfield, 2003: 153). Furthermore, the level of activity meant that such technological lead times as did exist were quickly shortened considerably. While a business can always resort to trade secrets in the absence of patents, so that it is difficult to argue that patents were 'necessary' for the development of biotech, the added security of patents was evidently enormously attractive to biotech start-ups. Big pharma's interest in patents was thus matched by a similar interest from biotech.

For patenting to be possible in biotech, however, two particular changes in the law seemed to be necessary. First, it was unclear that biological materials were patentable at all in that they could fall foul of restrictions on patenting scientific discovery rather than invention.[10] Secondly, given the location of this biotechnological research in university departments, the illegality of the patenting, and hence private appropriation, of the results of publicly funded basic science research in universities was a major problem.[11] Without these changes, providing the 'legal certainty' required for assurance to potential investment, biotechnology and the formation of the U--I complex necessary for its development was significantly less assured. For their own economic interests, therefore, both big pharma and biotech actively sought such domestic reform. Its success, however, depended on whether one final player, the relevant life science university departments, would accept the radical transformation in norms that such legislative reform would institute.

Critical history 3: the privatisation of US university research

Federal funding of science ballooned during the Second World War (e.g. Mowery et al., 2004; Mirowski & Sent, 2002). The massive 'success' of converting basic research into crucial technologies, such as the atom bomb, and then the scare of its Cold War rival's launching of Sputnik, meant that this funding continued and indeed increased consistently in the following decades. At the beginning of the 1970s, however, the percentage of federal funding of university research began to fall. By 1980, dire economic circumstances were increasing the calls both for slashing the science budgets of what was easily branded a cosseted and politically radical elite and for the universities to prove their contribution to the faltering national economy. With

the new Reagan administration duly obliging with threats of such cuts and with high inflation eroding the real value of what funds were in fact delivered, the universities found themselves compelled 'to compete increasingly for external dollars that were tied to market-related research' (Slaughter & Leslie, 1997: 8).[12] Biotechnology was unsurprisingly the focus of this move because the most striking scientific breakthroughs of the period were occurring in molecular biology. Furthermore, the percentage of federal research funds devoted to the life sciences was large and growing, so that research in this field was plausibly presented as a national competitive asset for commercial exploitation.[13]

Amongst biology faculty, while there were mixed reactions regarding the embrace of commerce, there was widespread acknowledgement of the possibilities of funding their research through the establishment of such links. From a purely academic perspective of seeking to preserve the funds necessary for their research programmes, therefore, relations with industry were often welcomed. But for such links to be established, patents over research findings were often needed in order to attract investors with the promise of exclusive ownership of the resulting product. Patents also offered the potential of direct licensing income for the departments, again an attractive prospect given the financial constraints of the time.

Patents, however, were particularly important for such technology transfer given the nature of biotechnology (Williams 2000). Biotechnology straddles the conventional distinction between 'basic' and 'applied' research, thereby problematizing it and stretching economic arrangements premised upon it to their limit.[14] Given this liminal nature, the development of basic research programmes will in many cases be the development of a technology. Yet this process may be both difficult and very expensive, with the proto-business plan suggested by the original basic research result being only a 'proof of concept'. In the climate of the time, there was little chance that public funds would be available for these projects, but for such investment to be forthcoming from the private sector, the resulting product had to offer the prospects of a profitable commodity.

The simultaneously basic/applied nature of biotechnology, however, presents the business risk that while development of the actual technology will be very expensive,

once successful, public accessibility of the original business idea will render market entrance relatively easy, not least through facilitating reverse engineering. In these circumstances, private enterprise will only take up these risks on the guarantee of some exclusivity in order to be able to recoup and profit from their sizeable investment. But it follows also that patents are necessary for the continuation of such research in universities at all. In the absence of an artificially created scarcity of knowledge as produced by intellectual property rights (May & Sell, 2005), the traditional 'open science' publication of such knowledge will result in it being stillborn, as a published business plan for an enterprise the particular competitive advantage of which is its private and secret knowledge. The only alternative is not to disclose at all, but this is to exclude 'basic scientists' from the game altogether, which takes place instead purely at the level of trade secrets. And, indeed, a 'major factor' in the entry of the university into the biotechnology business was 'fear of losing lead researchers' to pursue their research in private enterprise (Orsenigo, 1989: 83).

It must be emphasised that the scenario discussed above is a limit case and that the traditionally recognised means of the appropriating knowledge in the transformation of scientific research into profitable technologies – where lead times and tacit knowledge provide the competitive advantage, so that the avenues of open science remain perfectly acceptable, if not preferable – are by no means obsolete, even in the case of biotechnology (Colyvas et al., 2002). Nevertheless, such limit cases were more likely than ever for biotech, and especially in its early days.

University administrators thus began to lobby for this change (Slaughter & Rhoades, 2004: 20). Furthermore, the typical argument for the policy in government circles was just such a case of 'university inventions that were embryonic pharmaceuticals' but which would not be developed without a patent (Nelson, 2001: 15; Colyvas et al., 2001: 62; Mowery et al., 2004: 177). The economic and political complementarities between the university and big pharma on this score were thus explicit.

The patentability of public research, however, was not the only patent reform in which the universities and life science departments had an interest. For they also supported clarification (if not change) of the patentability of biological materials. Indeed, as Kenney notes (1986: 257), it was the universities who had most interest in such

reforms. While such a move was certainly important to biotech start-ups and pharmaceutical TNCs alike, they could rely on trade secrets to some extent in the normal course of pursuing profitable business. Yet such action is unavailable to universities for 'the university is not constituted as an institution that sells products in the market. If the university cannot patent inventions it would have nothing to sell because the university cannot use its inventions to become a company' (ibid.).

Mutual complementarities

For each of the three parties necessary for the successful creation of a university-industrial complex of biotechnology, we have found their specific and autonomous economic interests to be complementary. But this also gave rise to a mutual compatibility and interdependence of political needs, because the successful creation of such a U--I complex was conditioned by the necessity of reform to the patent system to allow for such relations to be established and such reform had to be supported by all parties. In each case this single-issue political support was readily forthcoming. As such, the successful formation of such a complex was not merely the creation of an economic sector but also of a political agent of considerable breadth and coherence focused on domestic patent reform. But, as regards TRIPs, it was also the case that the successful emergence of this patent coalition transformed the domestic political landscape, greatly strengthening big pharma's political leverage at the level of the US state machinery to pursue a regime of strong, global patent rights that would cover pharmaceuticals and biological materials in particular.

We have already seen that TRIPs was a highly controversial development. Perhaps we might expect, then, that those reforms strengthening big pharma in its demands for TRIPs would be relatively uncontroversial, for the success of a demand besieged on all sides by controversy would be, prima facie, unlikely in the extreme. Yet the other patent reform demands were also highly controversial and vulnerable in two ways: first, regarding explicit and vociferous political opposition to the changes; and, secondly, regarding the hyped or at least essentially unproven claims of the official economic case for the proposed reforms. Indeed, the economic justification of the proposed reforms not only was unproven at the time, but is increasingly exposed to substantial criticism.[15]

Yet not only were the reforms successful, but the success of the demands of each of the three agents was overwhelming and simultaneous, from a watershed of 1980. How did this occur? The explanation of this success set against the level of controversy attending it demands recourse to the coincidental political enablement from the socioeconomic structure. For considerations of structural context alone can explain the dramatic turnaround in the fortunes of the various parties. Before turning to this, though, let us consider a brief summary of the controversies attending the various dimensions of the proposed patent reform in order to show the level of the objections and obstacles that had to be overcome.

Parallel developments: controversial demands

First, as we have mentioned above, TRIPS was the result of a straightforward political strong-arming in which the substantial objections of numerous developing countries, particularly India and Brazil regarding the potentially penal effects on economic development of redrafting property rights in favour of TNCs, were overridden (e.g. Sell, 2003; Drahos & Braithwaite, 2002; Shiva, 2001). Secondly, as regards biotechnology, from the time of the initial rDNA successes, there was considerable debate about the regulation of these technologies with national and local government threatening serious limitation of the use of rDNA techniques for reasons of safety (e.g. Kenney, 1986; Krimsky, 2003; Wright, 1994 & 1998). Finally, the increased connections between academe and industry that biotech involved were and continue to be contested, with numerous scholars and commentators expressing serious misgivings over the effect of such commercial ties along a number of dimensions: e.g. on the scientific 'neutrality' and so status of the university as a knowledge-producing institution; on research agendas; and on the likelihood of greater obstructions to the free flow of scientific findings.[16]

But the cases for these reforms were not particularly strong either, being couched in terms of the so-called 'linear model' of academic 'basic science' giving rise to applied science or technology, which then produces economic growth. This was then supplemented by the argument that, because knowledge is a 'public good', unless there is some intervention there will be a market failure. Patents, by creating property rights over such knowledge products, are one way to resolve this problem (David, 1993). Yet both elements of this argument, linear model and market failure, have been

seriously criticized, both generally and in respect of biotech. In fact, most industries do not depend greatly upon 'basic science', nor upon patents for innovation. Nor do they depend upon the patented results of basic research for its dissemination and commercialisation.[17] Channels of open science are generally deemed much more important, suggesting a much more complex role for the university as regards its contribution to economic growth than the policy rhetoric allowed. Furthermore, in direct opposition to much of the discussion of the time, far from being an easy development and a safe investment, the 'obvious' next step, biotech was a highly uncertain and risky technology (Orsenigo 1989).

Finally, big pharma's plea for strong patents in developing countries as being necessary for its profitability as a business model is belied by the fact that still in 2003 91 per cent of sales and 98.8 per cent of R&D expenditure was associated with developed countries, and in particular the US, where patents were already strong before TRIPs.[18] Indeed, the CEO of Pfizer and architect of TRIPs himself admitted that losing market share in developing countries in the 1970s had very little impact on profitability (Drahos & Braithwaite, 2002). The astronomical estimates of the costs of developing new drugs have also been seriously questioned, undermining the central plank in the argument.[19] To be sure, drug development is a very expensive business. But realistic estimates of costs set against the very small contribution of developing country markets to big pharma's profits make the argument for TRIPs, even (if not especially) in the case of pharmaceuticals, highly problematic.

Parallel developments: Extraordinary successes since 1980

Success of TRIPs and Pharma

The most astounding success of big pharma is, of course, orchestrating TRIPs itself, an unprecedented agreement providing strong patent rights on a global scale and in particular to the industries (of pharma and biotech) for which such provision is most controversial. Indeed, such was the success that a key player in the big pharma negotiations, Jacques Gorlin, was moved to state that the agreement was '95 per cent' of what they wanted; the ominous remaining 5 per cent referring to compromise on compulsory licensing and a limited provision for a public health emergency carve-out (Drahos & Braithwaite, 2002).

But pharma has also prospered spectacularly in the last 25 years, from the 'watershed' of 1980 (Angell, 2005: 3) when profits in the industry took off (see Figure 1). The industry's profits were a healthy double of the average throughout the 1970s, but from 1980 this ratio has grown to an average 2.4 for the 1980s and 3.3 for the 1990s.[20] In 2002, in the midst of recession, profits for big pharma at ($35.9 billion) were greater than profits for all of the other 490 companies of the US Fortune 500 combined ($33.7 billion) (Public Citizen, 2003b).

[**Figure 1 about here**]

Nor has this increase in profitability been the commensurate 'reward' for increased innovation in the industry, which has been falling throughout the period. Of the new drugs approved in the US between 1989-2000 only 15 per cent were of the highly innovative class that provide a significant improvement over existing drugs (NIHCM, 2002: 9). Rising prices thus reflect not the remuneration of increased innovation but the costs and successes of numerous other tactics, particularly marketing and legal 'strategy'. As regards the former, official figures on expenditure by big pharma on marketing are now consistently significantly greater than R&D, and this despite the fact that much marketing to the medical profession is reclassified as 'education' (Angell, 2005: Ch.8).[21] As regards the latter, the most important tactic for maintaining profits is to prolong patents. For instance, firms can get 'a new patent and FDA approval for a trivial variation of their blockbuster and promot[e] it as an "improved" version of the original' (Angell, 2005: 183).[22] Patents are thus routinely prolonged for years after their theoretical expiry date.

A third major means by which big pharma maintains its profits is by political lobbying on a massive scale in a runaway positive feedback loop: the profits afford further penetration of pharma lobby activities into government, which in turn produces legislative action to further bolster its profitability. This is particularly marked in the US. There the industry already has influential ears in government at all levels with many high profile contacts and a 'revolving door' between government and lobbying (Public Citizen, 2001a, 2002, 2003a and 2004). But the huge numbers of professional lobbyists it employs at great expense (reaching nearly 1000 lobbyists at over $140 million in 2003) redoubles its access to the political machinery. Evidently,

such expenditure must be both affordable and value for money. The profitability of the industry assures the former, but the latter is also amply in evidence with legislative decisions in its favour too numerous to list exhaustively, including the extension of monopolies and tax breaks (Angell, 2005).

This almost unchallengeable power is ripe for abuse and evidence of such malpractice is rife and growing. Given the seriousness of their products for human health, perhaps the most important abuse is the rigging and bias of clinical trials; something that can be done 'in a dozen ways' and is now 'rampant' (Angell, 2005: 95). The result has been a number of highly excoriating reviews in the leading medical journals of the New England Journal of Medicine, JAMA and the BMJ, but few active political steps at reform (Bekelman et al., 2003; Bodenheimer, 2000; BMJ 2003 respectively). This is to list only the most egregious example, because the purpose of this paper is not primarily to expose or condemn the pharmaceutical industry.[23] Yet these abuses have yet to be brought in check, providing further evidence of big pharma's extraordinarily privileged political position.

Biotech success

Turning next to biotechnology, the most remarkable fact about its development is that despite the strong uncertainty associated with it, discussed above, 'attempts to exploit it commercially immediately followed the scientific discoveries' (Orsenigo, 1989: 2, my emphasis). The trigger was the success, in autumn 1977, of expression of the somatostatin gene in E. Coli, which led to take off in TNC and venture capital investment in small biotech and genetic engineering firms (Wright, 1998: 93).

At this time the regulation of rDNA techniques remained exceptionally high profile in formal political debate, and, indeed, seemed very likely (ibid.: 91). Yet in November 1977, the US Senate Subcommittee on Science, Technology and Space saluted the 'extraordinary progress towards the construction of organisms that make therapeutically useful hormones' (quoted in ibid.). The statement was merely a harbinger of a much more profound shift in the debate, in which 'the "real" risk was now defined as that of losing out on a novel field with immense commercial impact' (ibid.). This culminated in regulations being relaxed twice in 1980, and again in 1981

and 1983, in effect totally dismantling controls on rDNA experiments (Kenney, 1986: 26-27; Wright,1998: 97).

In this context, and providing the background to these changes, there was a 'gold rush' of IPOs (initial public offerings of shares) in the first biotech companies to be floated on the stock market.[24] For example, in 1980 Genentech's IPO was the fastest rise of any stock 'in the history of the New York capital market' (Bud, 1998: 5, Kenney, 1998: 136, 1986: 156). While a tailing off in numbers of IPOs followed, up to 1983, this was in the context of a deep recession and hence a weakness of market conditions for IPOs (Kenney, 1986: 137). When the economy recovered in the latter half of the decade, so too did IPOs. Similarly, that there was a shake out of the sector is not nearly as remarkable, given the background economic conditions of the time, as the lightness of this effect on biotech. 'Business failures were at all-time highs, yet biotechnology expanded into the recession' (ibid.: 175).

The result of all this business interest is a significant biotechnology sector: in 1998, there were 250 public and approximately 1000 private companies (Thackray, 1998; Arundel, 2000). Yet this growth in the sector has occurred in the context of relatively few successes. Only 54 biotech-derived therapeutics and vaccines had been approved in the US by late '90s, including a rush in 1998 (Senker, 2000: 58). And while many of these products are 'of significance for health and for agriculture, their economic impact is far more limited than the impact of computerisation in 1970' (Arundel, 2000: 84). In short, biotech remains, over 20 years after initial investment excitement, a business that, while undeniably up-and-running, is built largely on expectation.

US patent reform since 1980

Since 1980, there has been a host of patent and drug legislation, all of which has favoured the U--I complex (Slaughter & Rhoades, 2002). Each of these acts of legislation provided a major boost to the U--I complex, in particular the Bayh--Dole Act, which allowed patenting of university research (e.g. Economist, 2005). We will discuss university patenting in more detail below. Here we focus on a number of other developments in patenting more generally. The legal development of greatest importance for biotechnology in this regard was, in fact, a judicial and not a legislative change: the judgment of the Supreme Court in *Diamond v. Chakrabarty*

[1980], which provided an indubitable legal authority to the patentability of biotechnological commodities.[25]

A second change of enormous significance was the establishment in 1982 of a separate court circuit dedicated to patent litigation. A specialised court for patent litigation is staffed by patent lawyers who are inevitably more attuned to patent issues than those of other economic interests or imperatives, such as competition policy. The result has been a significant strengthening of patentees in such litigation, and hence of patents generally (Jaffe, 2000: 549). For instance, while nearly two-thirds of adjudicated patents were found invalid by the courts between 1921-1973, between 1982-1985 this fell to 44 per cent (Boyle, 1996: 134). More recently, Waldfogel (1998) notes that the chances of successful defence of a patent have risen to 84 per cent in cases lasting 3 months and 61 per cent of those lasting one year.

This development has been complemented by a widely observed weakening in the standards of both the novelty/non-obviousness and utility tests by the patent authorities (e.g. Barton, 2000; Cohen & Merrill, 2003; Jaffe, 2000; Merges, 1999). Whatever the cause of this, patents are now not only stronger, but also more easily granted in the first place. It is thus predictable that there has been a massive growth of patenting in the US, again since the early 1980s.[26] Between 1985 and 1999 the number of new patents granted per year doubled (see Figure 2) (Gallini, 2002: 131; Kortum & Lerner, 1999). The growth of patenting is particularly noticeable in biotechnology. For instance, the number of patents in the patent class of 'molecular biology and microbiology' increased over ten-fold between 1985 and 1998.[27]

[**Figure 2 about here**]

University patenting and privatization

We discussed above how patenting has ballooned since 1980, but this is particularly marked for universities. Thus, while patenting increased through the 1970s, it exploded in the early 1980s: university patents more than doubled between 1979-1984, again in 1984-1989 and again in 1989-1997 (see Table 1). Similarly, between 1980 and 1997 university patents per dollar more than tripled (Jaffe, 2000: 541). This growth was concentrated in the largest 100 universities, which tripled annual patent

output from 1984 –1994 (Gallini, 2002: 131). The growth of patenting, however, has not been limited to these leading institutions, but has spread across the entire education sector. Thus in 1965, 30 academic institutions received patents, growing to 150 in 1991 and over 400 in 1997 (Jaffe, 2000: 541). Similarly there was an eight-fold increase in university technology transfer offices between 1980 and 1995 (Cohen et al., 2002: 4). As the universities had hoped, this has been lucrative, though only for a few universities.[28] Licensing revenues grew to $222 million in 1991 before trebling to $698 million in 1997 (Mowery et al., 2001).

[**Table 1 about here**]

As is the case in the economy generally, the growth of such university patenting has also been 'disproportionately concentrated in technological classes related to health sciences' (Jaffe, 2000: 541).[29] At Columbia and Stanford Universities, both major protagonists and beneficiaries of the change, by 1995 biomedical patents accounted for more than 80 per cent of their substantial licensing revenues (Mowery et al., 2001: 107).

Increased patenting is merely one element of a broader change in the funding of basic science in the university through the proliferation of U--I relations. It must be stressed that this was not a black-and-white change from a golden age of public sector 'purity' to a dark age of private sector 'corruption', a point rightly emphasized by Mirowski & Sent (forthcoming). Industrial links were strong in the US university system before the Second World War and remained so even at the height of the Cold War 'open science' regime. Nevertheless, this continuity has been accompanied by a fundamental discontinuity, namely 'the extent of these ties and the intensity of their effects' (Wright, 1998: 94).

The overall funding of academic science shifted considerably from public to private sources in the period from 1970, with the percentage of federal funds falling through the 1980s (though actual amounts grew consistently) (see Figure 3).[30] On the other hand, there was a growing, if still small, percentage of industry sponsorship, from a low of 2.6 per cent in 1970, growing slowly to 3.9 per cent in 1980, then mushrooming to approximately 7.0 per cent in 1990 (a nearly 5-fold increase in

nominal dollars), where it remained for the rest of the decade (NSF, 2006a; Cohen et al., 2002; Narin et al., 1997). Once again, however, this scenario was intensified in biotech, where industry funding was already over one third in the mid-'80s (Blumenthal et al., 1986a & 1986b).

[**Figure 3 about here**]

Orsenigo (1989: 77) thus notes the 'explosive rate of growth' of U--I relationships in biotech, the 'most striking feature' of which is 'the direct involvement of scientific institutions and industrial scientists on the one hand, and the systematic, targeted nature of the ties on the other.' Most of these relationships were with 'only a limited number of companies (mainly chemical or pharmaceutical corporations)' (ibid.: 81). Similarly Krimsky (2003: 31) calls the growth in U--I relations in the 1980s 'unprecedented' and 'a fact specifically evident in biotechnology'.

Success of the Coalition

In search of means to boost their respective finances, big pharma, biotechnology entrepreneurs and university life science faculty and administrators all committed themselves to the development of biotechnology and the formation of U--I relations necessary for this to occur. We have seen above how both of these have been extremely successful. Thus we can have little doubt that this biotechnology U--I complex has indeed been created, creating a synergistic mutual dependence between the various parties, in which the huge capabilities of big pharma to develop and market products is matched with the unique research capacities of the biotech firms (Kenney, 1998: 140, Ronit, 1997).

But the forging of these links has also assured the inextricability of the fates of university life science research and the pharmaceutical industry, providing the latter with a potential trump card in political wrangling for the foreseeable future.[31] The major political success of the coalition was domestic US patent reform, but the success of biotech itself was also utterly dependent on the social acceptance of the privatization of publicly funded research (Kenney, 1998: 135), acceptance that has been politically achieved with bipartisan support in Congress (Slaughter & Rhoades,

1996). The formation of a U--I coalition by these agents thus marks a watershed in the domestic political landscape regarding patents.

This is not to argue that pharmaceuticals, biotech and university life sciences are now an indissoluble unity. They remain clearly distinct with their own institutional imperatives and interests. Yet pharmaceutical research remains overwhelmingly dominant in biotechnology.[32] And the pharmaceutical industry has provided the 'protective niche' necessary for the development of this fundamentally risky and radically novel technology (Arundel, 2000: 86). The success of this process is apparent in the fact that even failure (Bud, 1998: 4) and continuing controversy, flaring up again from 1996 (Bauer & Gaskell, 2002), have had only relatively superficial impact on the hopes surrounding biotechnology.

The role of patents in this success cannot be overstated. For they have been crucial in the management of commercial relations between university and industry upon which biotechnology has been built (Williams, 2000: 68 et seq.). Nor is this due to commercial interests perverting the development of the technology to its nefarious ends. Rather, as we have seen, given its nature on the basic/applied science boundary, for university research to be possible in this form of biotech, in the context of a capitalist economy, patents (though not patent reform) were needed.

The penetration of commercial relations and patenting into these departments, therefore, has not been something driven by the pharmaceutical industry so much as thoroughly exploited by it, in particular by using the political power this presented it to orchestrate patent reform not only within the US but also strengthening IPRs across the globe in its favour. To repeat, even domestic patent reform was not necessary for the development of biotech. Patents were already available to an extent and, in any case, are not always needed for technology transfer even in biotechnology (Colyvas et al., 2002: 65). The outcome of these trends, however, is an increasingly proprietary regime of science funding (Rai & Eisenberg, 2003: 291; Orsenigo, 1989: 96). But this also has significant repercussions for the global political economy. As Williams (2000: 69) puts it:

> the most immediately apparent feature of the socio-economic relationship between patents and the emerging international political economy of biotechnology lies in the manner in which the state-sponsored patent system has led to increasing commercial dominance of a number of key sectors in the global economy.… The availability of strong patent rights in the field has promoted unprecedented corporate control of the life sciences.

As we shall see in the next section, it is this outcome and the fact that the interests of these agents were such that they would pursue it that together explain their unique political enablement and, in turn, that of big pharma regarding TRIPs.

Primitive accumulation along 3 dimensions: the unique enablement of the coalition

There can be little doubt that each of these developments was highly controversial in its own right and yet was extraordinarily successful, on remarkably similar timescales, in instituting various patent reforms. What, then, can explain these puzzling observations? Not recourse to the exceptional coherence of these agents alone, for this reckons without both the level of opposition they faced and the weakness of each of them as regards their cases. Nor can such purely agential analyses explain how, despite the continuity of growing patenting and U--I links in life science departments in the late 1970s, suddenly the social constraints to this process fell away, allowing its explosive growth from 1980 (Mowery et al., 2001: 104).

But neither can a purely 'cynical' explanation, which latches onto the fact that the dramatic turnaround in fortunes was associated with the recognition of money being at stake. For such an analysis does not address the crucial question of why there was money at stake. Given the highly risky nature of biotechnology, discussed above, it would seem at first to be a particularly unattractive investment. That there was money to be made from biotech, therefore, was only because of a widespread sense that people were willing, and indeed eager, to invest in it. But then this itself demands explanation and simply pointing to financial greed cannot furnish this.

We must, therefore, turn to an analysis of the context in which these developments occurred, and in particular to the condition of the structure of the global economy, if we are to be able to explain why, despite being a risky bet, finance (especially in the

US) believed it was a sure-fire winner. In arguing thus, I refer to the argument made by Arrighi (1995, 2003, 2005a, 2005b) inter alia that the global economy underwent a fundamental structural change in 1980, triggered by the monetarist revolution of Reagan and Thatcher, from a cycle of strong growth spread across the economy and led by productive business to one in which the economy is dominated by the financial sector ('financialisation').[33]

The fundamental driver of this process is the relentless accumulation of capital, which takes the form of the penetration of the capital relation of waged labour into ever more areas of social life around the globe. This shift was the culmination of a process that had seen the political economic space of the post-war period reach its limits in the 1970s and then trigger a political crisis that was only averted with a radical reassertion of the power of global capital. This took the form, as it has in previous cycles, of the balance of power between the productive and financial sectors of the economy moving sharply in favour of the latter. The control of finance capital over the economy (as an 'historic bloc') in turn allowed it to orchestrate both the radical restructuring of productive enterprise and a round of appropriation into private hands of a new set of resources upon which the global economy will (or at least has in past cycles) eventually be able to begin a new cycle of productive growth ('primitive accumulation').[34]

What resources capital seeks to appropriate in these phases is conditional upon the existing extent and nature of the global capitalist economy. In every case, however, capital must expand both outwards, into new social realities inhabiting other areas of the globe, and inwards, intensifying its penetration into the already capitalist societies. The expansion of capital, however, changes societies, and hence is met with resistance. Its expansion in any given round of primitive accumulation is thus both enabled and constrained by its extent.

Developments in the global economy are currently characterised by two buzzwords: 'globalisation' and the 'knowledge economy'. On the analysis offered here, these two capture (albeit unwittingly in many analyses) the nature of the present round of primitive accumulation: extensively in the further transformation of non-western economies into capitalist ones and intensively through the transformation of the social

relations of the production of knowledge. As regards the latter, this is because the societies at the core of the global economy are not only already thoroughly capitalist as regards the social relations of production, but they are also capitalist as regards the social relations of the production of culture. For capital to expand yet further into these social realities, therefore, it must transform social relations of production of a kind even further removed from the material reproduction of society. The invocations of a 'knowledge economy' or 'information society', whatever their failings, capture the essential nature of this change: the expansion of the capital relation into the social relations of production of knowledge.

One further dimension needs to be explained. Capital transforms not only social relations but also the material constitution of societies and it does this by the introduction of new technologies that offer profitable manipulations of material reality not hitherto known to be possible. Furthermore, this process is crucial for the continued growth of the economy, for it is novel technological possibilities that afford the profitable transformation of the economy (employing waged labour in the production of surplus value in new conditions) in the Schumpeterian (1976) 'gales of creative destruction' characteristic of capitalist growth. Given that these technologies must be commercially developed in a social milieu, the discovery of such possibilities also opens up a new sphere of socioeconomic life into which capital can expand. Each cycle, therefore, is characterised by a novel technology that percolates through the economy and thoroughly transforms it, and society in the process. Furthermore, economic problems start to appear when the possibilities for profiting from such transformation using existing technologies begin to decline. At this time, therefore, in the absence of profitable opportunities from exploitation of presently-familiar or 'normal' innovation processes, new technologies will start to attract increasing interest as potential ways to provide new commodities to overcome this stagnation.

The greater the impasse from the exhaustion of the 'normal' development of existing technologies, the greater will be the effort required to develop the 'next' technology. Yet such effort will not be forthcoming until there is sufficient concentration of finance to invest in it. This condition is satisfied during a financialisation phase, but at this time finance's economic power is such that it can also compel the placing in private hands of the necessary resources for the technology's profitable development,

including through political reform of the law, redrafting property rights to its benefit. Primitive accumulation thus also takes the form of the development of a new technology that affords the expansion of capital into a wholly new sphere of manipulation of physical reality in the production of profitable commodities.

In the present case, the possibilities for the exploitation of material reality have already been thoroughly consumed in a number of ways: mechanically, electrically, chemically etc… The new technology must inevitably take its lead from the existing state of scientific knowledge. It is apparent that the discipline that attracts the most attention in this regard is (molecular) biology, and that the technology therefore touted as the 'technology of the future' is biotechnology. We see, therefore, that the hopes pinned on biotechnology arise immediately from the structure of the global economy at that time. The exhaustion of the political economic space since the Second World War and of the possibilities for chemical and electrical products meant that for the global economy to continue its necessary expansion, it needed to find a new and radical technology. But was this biotechnology? And if so, why?

To answer this question we must return to consider the other two dimensions of primitive accumulation mentioned above: globalisation and the commodification of knowledge. Together, these structural imperatives demanded the 'globalized construction of (knowledge) scarcity' (May, 2006: 53). But this is precisely what big pharma sought in TRIPs, strong global patents, and for biological commodities in particular. And we have seen that biotech is exceptional in its dependence upon 'basic' science, thus making it uniquely relevant to the 'knowledge economy'. To be sure, as regards the extensive spread of capital, big pharma's pursuit of TRIPs is merely one element of a broader neoliberal assault, including the International Monetary Fund's structural adjustment programmes (Stiglitz, 2003) and other WTO trade talks. Nevertheless, TRIPs stands alone as the aspect of this package concerned with the construction of the 'knowledge economy'.

But once we acknowledge that big pharma's political power in the US regarding TRIPs was built upon domestic success in the formation of the U--I complex, we can also see that the complementarities go even deeper in this case. For the prime targets for moves to commodify knowledge production are clearly the leading universities in

the world, which are concentrated in the United States and part of the same U--I coalition that includes big pharma. Again, patenting figures across the university show that the biosciences have not been the only departments to experience a marked increase in their connections with commerce (e.g. Mowery et al., 2004). But we have also seen that they do stand alone in the intensity of this development and this due to the exceptional dependence of biotechnology both on patenting and on 'basic science' research.

Each of the three dimensions (globalisation, commodification of knowledge and pioneer technology) thus shows a unique compatibility with the demands of the three parties to the U--I biotechnology complex. Furthermore, we have seen above how each of these parties' success took off in 1980, the year of the structural shift of the monetarist revolution. Similarly, as regards the importance of the context of financialisation, observers have also pointed to the central role of finance in the trajectories of the various parties. The importance of the demands from Wall Street for high profit margins in order to maintain share prices has been singled out as a major factor in the futile production of patented and branded me-too drugs by big pharma (NIHCM, 2002: 4 & 15). Kenney (1998: 135, 1986: 133) is also unequivocal that without a large venture capital sector, developed in particular on the back of the growth of computers in the 1970s, biotechnology would have struggled to launch itself. In short, therefore, it was because of the total support of the historic bloc of finance capital that the patent coalition was so successful, but this level of support in turn is explained only by the unique two-fold fit of the patent coalition with each other and with the structural imperatives of the global economy.

With the coincidental support of these structural imperatives, each of these three agents found that the mutual complementarities of their economic interests in the formation of strong links with the other two and the political implementation of their united wishes for US patent reform were mutually reinforcing. For their initial interests succeeded in eliciting patent reform that thereby facilitated the deeper integration of their interests in the formation of the U--I complex, which in turn presented a stronger political front for exacting yet further patent reform in their favour.

Conclusion

As big pharma obtained the domestic patent reform it sought, it became an even stronger political player, thus tightening its grasp over the machinery of the state; a crucial development for its success regarding TRIPs, for it was the US Trade Representative and not the pharmaceutical industry that had to drive this through.[35] This process, however, shows that the political success of patent reform was dependent upon the political support of all three parties from the outset, when the individual cases were weakest. This is particularly the case given the nature of the argument for patent reform: the linear model. For successfully arguing this case would be significantly impeded were the presumed parties to the process to challenge it.

This, therefore, highlights the crucial political role of the US universities in this process, because the first legislative measure of this process was the Bayh--Dole Act, authorizing, and indeed encouraging, the patenting of publicly funded research results in universities (Slaughter & Rhoades, 2002). Had the universities' interests been such that they themselves opposed this move, the entire process of the political strengthening of big pharma would certainly have been very much more difficult. As such, even if they are utterly indifferent or even against TRIPs, top American university life science departments were extremely important political players in that agreement's implementation. Furthermore, as major players with extensive bioscience patent portfolios, these departments stand to benefit greatly from TRIPs.

This analysis also allows us to explain why this was a particularly American development, because the radicalisation of the assertion of power of global capital will naturally be most prominent and most effective in the national economy at the system's centre.[36] This in turn allows the particular forces at play in that society to be the major beneficiaries of this structural change. In this case, therefore, it was the American social forces of its dominant pharmaceutical corporations and its pre-eminence in molecular biology research (itself a peculiarly American discipline, as Kay (1993) and Kohler (1991) have shown) that were called upon and, using a suitably American metaphor, gladly 'stepped up to the plate'.

How, then, did TRIPs happen? This highly controversial international agreement was enabled by structural changes in the global economy towards a drive for primitive

accumulation of knowledge resources. Capitalizing upon this shift, an American U--I biotech complex, which stood to gain the most from it, was formed by the unification of big pharma, biotech start-ups and life science university departments in a singularly powerful single-issue political coalition in favour of domestic patent reform. Through their initial political successes in the US, regarding domestic patent reform and the legislative encouragement of U--I links, this coalition grew in coherence and power until big pharma, sitting atop this political enablement, could command the international trade machinery of the state at the centre of the global economy to drive through such global reform, fashioned in its own interests: the actual TRIPs agreement, privileging a global pharmaceutical industry and enforcing the patentability of biological materials, not just some generalised global patent reform.

But this analysis does not just illuminate the nature and provenance of the TRIPs agreement. By showing its connection to the ongoing commercialisation of academic research, the latter is also seen to be an indissoluble element of a much bigger transformation to the structure of the global economy, namely the global primitive accumulation of knowledge. As such, this also informs those within the academy who are determined to preserve a public sphere of knowledge production as to the full weight of the social and political forces against which they are faced. This may come as unwelcome news, but is not a counsel of resignation. Rather, successful defence demands such a comprehensive analysis of the strength of the opposition.

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[1] E.g. Maskus (2000).

[2] Sell (2003) provides an excellent summary. See also Drahos & Braithwaite (2002), Dutfield (2003), Matthews (2002), May (2000) and Richards (2004).

[3] Reddy (2000) following Hymer (1975, 1979). The resonance between globalisation and knowledge-intensive activities, including science itself, has been widely observed: e.g. Castells (1993, 1996, 1997, 1998), Drori (2003), Carnoy (1993a, 1993b).

[44] For instance, as early as 1957 Pfizer already had overseas sales exceeding US$ 60 million (Drahos & Braithwaite, 2002: 66).

[5] Though TNCs are now beginning to exploit the possibilities of moving R&D to less developed countries with a relevant knowledge base: Reddy (2000).

[6] It is extremely difficult to be more precise than this because R&D figures are not readily analysable from the filed accounts of the firms (see Angell, 2005: Ch.3). Furthermore, a high-profile estimate of current drug development costs by DiMasi *et al.* (2003, 2005a, 2005b) at $403 million (or $802 million if capitalised) is controversial for reasons of methodology: see Light & Warburton (2003a, 2003b), Angell (2005: 41) and Public Citizen (2001b).

[7] See e.g. Taylor & Silberstom (1973) (quoted in MacDonald (2002: 23); and Cohen et al. (2002), Cohen & Merrill (2003), Levin et al. (1987) and Mansfield (1986).

[8] See e.g. Angell (2005: xxiv), who notes the importance of another form of monopoly rights provided in the US to address this problem, namely the exclusive marketing rights from the Food and Drug Administration (FDA).

[9] Sell (2003) makes a similar point.

[10] See Gallini (2002: 146), Orsenigo (1989: 46) and Kenney (1986: 257).

[11] In fact, such patenting was not completely prohibited, but was allowed only after a laborious administrative process in which special approval was granted to patent (Slaughter & Rhoades 2002: 85).

[12] On fears of Reagan's cuts, see Kenney (1986: 28).

[13] The percentage of basic research R&D funding going to the life sciences rose in the 1970s from 36 per cent to 44 per cent - in parallel to the increase in the percentage funded by the NIH, from 36.7 per cent in 1971 to 47 per cent in 1981 (Mowery et al., 2004, using National Science Board data) - while that going to physics fell from 18 per cent to 14 per cent: Mirowski & Sent (2002: 24). 'NIH' is the National Institutes of Health, the primary federal funding agency for the life sciences in the US.

[14] See Calvert (2004) on the basic/applied science distinction.

[15] E.g. Mowery et al. (2001), esteemed economists of innovation and no political radicals, argue that these reforms were based on 'a belief by policymakers (based on little or no evidence) that stronger protection for the results of publicly funded R&D would accelerate their commercialization'. See also Eisenberg (1996).

[16] See e.g. Orsenigo (1989: 84), Mazzoleni & Nelson (1998), Nelson (2001), Heller & Eisenberg (1998).

[17] See e.g. Cohen et al. (2002), Klevorick et al. (1995), Levin et al. (1987), Rosenberg & Nelson (1994).

[18] Data from PhRMA (2005).

[19] Compare DiMasi et al. (2003, 2005a, 2005b) with Light & Warburton (2005a, 2005b) and Angell (2005).

[20] Data from Fortune 500, Author's calculation.

[21] For comparison, in 2001, 35 per cent of PhRMA revenues were spent on 'marketing & administration', of which roughly three quarters was marketing (Angell 2005: 120 using PhRMA data), hence 27 per cent. Conversely, R&D represented 16.7 per cent of total revenues that year (PhRMA 2005).

[22] Examples of minor modifications remarketed under new brand names include Clarinex to Claritin, Prozac to Sarafem, Prilosec to Nexium (Angell, 2005: 76 *et seq*).
[23] For 'a damning case, not just against the industry but against our [US] entire system for developing, testing and using prescription drugs' (Angell, 2006) see, for example, Abramson (2004), Avorn (2004), Goozner (2004), Kassirer (2004), Moynihan & Cassels (2005) and Olfman (2006).
[24] Bud (1998: 14) pins down the start of this financial frenzy exactly to June 1979 when Nelson Schneider of investment house E F Hutton heard about Genentech's production of human insulin, became interested and reported biotech to investors as a major technological breakthrough.
[25] For a full discussion of the case and the effect of the judgment, see Krimsky (2003: 62 et seq).
[26] This is not to assert that legislative changes caused such a surge. For arguments against this interpretation see Mowery et al. (2004, 2001) and Kortum & Lerner (1999).
[27] Jaffe (2000: 543) and Author's calculations using USPTO data. Note also that this is just for one class of biotechnology patents.
[28] Rai & Eisenberg (2003: 300) report that in 2000 the top five universities grossed nearly one half of total licensing revenues, while Thursby & Thursby (2003) note that in the same year only 43% of licences earned royalties at all, and only 0.56 per cent earned over $1 million.
[29] See also Mowery et al. (2001: 104) and Owen-Smith and Powell (2003: l697), who note that biotech patents were 49.5 per cent of all university patents.
[30] Federal funding of total US R&D fell below the 50% mark in 1979 and continued to decline to a low of 25% in 2000, while funding from private industry has taken the opposite path: see NSF (2006b).
[31] For instance, Angell (2005: 71) notes that the universities are just as resistant as big pharma to rigorous enforcement of a clause in the Bayh--Dole Act that demands 'reasonable terms' for the contracts resulting from such patents, as this may offend their big pharma sponsors.
[32] At approximately 50 per cent of investment in Europe in 1999 as opposed to 'basic' at 12 per cent, cell factory and plant biotech each 9 per cent and animal biotech 8 per cent: Senker (2000: 57). Dutfield (2003: 146) reports 60 per cent of US and EU biotech firms produce health-related products.
[33] See also Blackburn (2006) and Harvey (1982, 2003).
[34] For discussion of 'historic bloc' and 'primitive accumulation' see e.g. Bieler & Morton (2004), Cox (1987, 1996), Gill (1993), Gramsci (1971), Harvey (2003), Jessop (1997) and Jessop & Sum (2006).
[35] Sell (2003) discusses a similar phenomenon as regards US trade legislation at the time, which during the TRIPs negotiations continually upgraded the privileged position US trade policy provided big pharma. Kenney (1986: 242) also notes the irreducible role of the state in the development of biotech. See also the discussion of Mirowski & Sent (forthcoming) regarding a tripartite analysis of relations between academia, industry and government.
[36] This is not to deny the importance of EU or Japanese pharmaceutical companies regarding the actual TRIPs negotiations, and their own respective domestic political agency. Nevertheless, the TRIPs agreement was overwhelmingly an American initiative (Sell 2003) and I focus on the US aspect for lack of space. For an excellent comparison of the US, UK and Germany regarding biotech and the commercialisation of the university, see Jasanoff (2005).