Higher Education (2005) 50: 275–298
DOI 10.1007/s10734-004-6355-z

Hybrid practices? Contributions to the debate on the mutation of science and university

JUHA TUUNAINEN
Department of Education, Center for Activity Theory and Developmental Work Research, University of Helsinki, P.O. Box 26, Teollisuuskatu 23, 3rd Floor, FIN-00014, Finland (E-mail: Juha.Tuunainen@Helsinki.Fi)

Abstract. This article reflects on current debate over transformations of scientific research and universities. Four well-known mutation theories (Mode-2 knowledge production, triple helix of university–industry–government relations, academic capitalism and enterprise university), and their recent critiques, are reviewed. It is suggested that a better understanding of the changes can be achieved by drawing analytic insight from research that speaks about scientific practices. Advantages that may be so attained are illustrated through a case study of a plant-biotechnology research group that pursued to straddle the fuzzy university-business boundary. On such grounds, three arguments that pertain to the mutation theories are put forward: (1) the need to appreciate the dynamics between theoretical, experimental and applied dimensions of research work; (2) the fact that external research funding intermingles with the complex social ecology of disciplines at the departmental level of universities; (3) the difficulties academics encounter as they try to fuse their university activities with private commercial development.

Keywords: transformation, scientific research, universities, hybrid practices.

Introduction

The title of this article – ''Hybrid practices'' – has a twofold meaning that relates to the sociological studies of scientific practices and to the literature that speaks about the transformation of the university institution. First, ''Hybrid practices'' addresses the kind of research work that the object of this study, a university plant biotechnology[1] group, was involved with: the simultaneous production of agriculturally useful end-products and creation of related scientific knowledge. In previous studies, the term of ''hybrid science'' was used to characterize the combination of scientific work and other social practices, such as agricultural production (Gieryn 1999, p. 251). In this view, science is seen as deeply societal endeavor where practical utility operates as the paramount justification for scientific research. As a growing body of literature shows, this is not

an extraordinary characteristic but, rather, a quite common feature of life sciences, among others (Knorr Cetina 1982; Kimmelman 1992; Miettinen 1998; Kleinman 2003). Second, the slogan refers to a corpus of research according to which the entire university institution was in a state of fundamental transformation. As argued by several authors, economic considerations have penetrated traditional universities with the end-result of that being the emergence of "hybrid organizations" (Slaughter and Leslie 1997, p. 9), "Mode-2 institutions" (Nowotny et al. 2001, p. 79) or "entrepreneurial universities" (Etzkowitz 2003b). From this vantage point, the current paper presents a challenging case: I regard these ideas more as hypotheses to be put to a test through empirical study rather than conceptions that should be taken for granted.

Roughly speaking, two positions can be discerned in the recent debate over the transformation of science and university. First, some authors state that a radical metamorphosis with respect to the knowledge production and the university institution has taken place. In this view, governments have increasingly fostered national prosperity by supporting new lucrative technologies, simultaneously as universities have taken up a role as economic engines of their respective regions. In result, the previously isolated institutional spheres of the university, government and industry have become intertwined giving rise to entirely new types of science and university that bring academic, economic and wider social purposes together in a compatible fashion (Etzkowitz 2003a; Nowotny et al. 2001). Second, there are moderate views on the change. These perspectives known as the academic capitalism (Slaughter and Leslie 1997) and the enterprise university (Marginson and Considine 2000) basically reassert the general transition in the science and technology policy but emphasize its diversified and controversial effects. In this view, universities have become stretched institutions pregnant with conflicts of various kinds.

In the following, I shall summarize four closely interrelated models that represent these two major positions and review criticism directed at them. I shall also briefly revisit my previous empirical research that addressed the work of a plant-biotechnology research group under the auspices of a traditional Finnish university (Tuunainen 2001, 2002, 2005, in press). By elaborating on a broad body of scholarship in science and technology studies (e.g. Clarke and Fujimura 1992; Pickering 1992) I shall, then, suggest that both the radical and the moderate positions would benefit from further empirical research that analyses scientific and administrative work in terms of concrete practical accomplishments.

By so doing, better appreciation of the local and dynamic character of academic life might be preserved.

Theories of transformation

Models claiming radical transformation of science and university

According to Michael Gibbons and co-workers, a radical shift in the way that knowledge is being produced has taken place: ''The Mode-1'' knowledge production has given way to the new mode called ''Mode 2.''[2] Compared with the previous Mode-1 science, which is attributed to reliable academic knowledge produced within autonomous disciplinary contexts, the Mode-2 science takes place in ''the context of application.'' The context of application refers to knowledge, which is being produced within open and shifting organizational boundaries, and is managed for the achievement of particular useful purposes (Gibbons et al. 1994, pp. 3–6). A prime example of the Mode-2 science is biotechnology where researchers no longer try to reveal ''the basic principles of the world'' but seek to produce specific applications in the commercial context and to understand ''concrete systems and processes'' related to such applications (Gibbons et al. 1994, pp. 23–24, 147). Therefore, various sites and practitioners are involved in the Mode-2 knowledge production: these span from researchers that come from different academic disciplines to industrial scientists and other social actors. Due to the more intensive interaction among them, strong social responsibility and accountability permeate the Mode-2 research process. This is to say that a broader set of social interests act as new quality control criteria vis-à-vis the internal scientific peer review of the Mode-1 science (Gibbons et al. 1994, pp. 32, 33).

The emergence of the Mode-2 science also parallels wider transformations in society (Nowotny et al. 2001). As claimed by Gibbons , the more open system of knowledge production is not ''an autonomous development affecting science only; rather it reflects, and is reflected in, the emergence of a more open type of society.'' Science, in this perspective, has no intrinsic character but becomes intermingled with the rest of the society where boundaries between major social institutions (e.g. the state, the market, culture and science) have become increasingly transgressive and fuzzy. This is largely due to the intensification of international rivalry in the global business and industry. In this connection, also the institutional structure of the university has grown to be

more open, or ''context-sensitive,'' than it used to be. The demarcation between universities and other kinds of organizations, such as industrial enterprises, has eroded as scientists have become responsive to the needs of industry. Universities have, thus, become ''stretched'' institutions that encounter competitive and even contradictory pressures, such as creating effectively scientific knowledge and satisfying mass education demands (Gibbons et al. 1994, pp. 70–89; Nowotny et al. 2001, pp. 79–94).

A closely related idea with the Mode-2 knowledge production is ''the triple helix of university–industry–government relations'' introduced by Henry Etzkowitz. In Etzkowitz's terminology, the triple helix is a metaphor representing the close interaction and, indeed, increasing overlap between previously separate institutional spheres of the university, industry and government (see Figure 1). In result, boundaries between these institutions have become blurred. With respect to universities, this involves incorporation of the traditional academic mission – ''the extension of knowledge'' – into a compatible relationship with the ''capitalization of knowledge:'' Scientists in many fields start to look at their work from the viewpoint of commercial potential while simultaneously pursuing theoretical and methodological advancement (Etzkowitz 1998, pp. 824–829). It also implies becoming of ''an entrepreneurial university.'' As elaborated by Etzkowitz, the entrepreneurial university is a hybrid organization, which incorporates ''the third

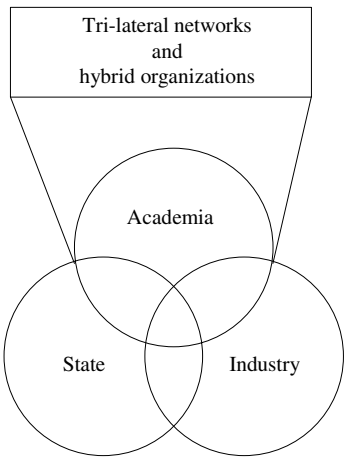

Figure 1. The triple-helix model (reprinted by permission of Sage Publications Ltd from Etzkowitz 2003a, p. 302). ©Sage Publications, 2003.

mission'' of economic development alongside scientific research and higher education. This is done, for instance, through university patenting and licensing offices, spin-off firms, business incubators and science parks (Etzkowitz 2003b).

In Etzkowitz's perspective, the emergence of the entrepreneurial university is presented as irresistible, unavoidable development, ''an internal dynamic working itself out'' (Etzkowitz 2002, p. 121). It is also observable all over the world, in North America as well as in Asia, Europe and Latin America (Etzkowitz et al. 2000a, 2000b). Moreover, he states the trend is going from strength to strength. ''The University of the Future'' will be a business incubator entirely, meaning that technology transfer and incubation of new firms will convert from happenstance into a permanent organizational activity that takes place in each and every department. Not even tensions between academic research, higher education and societal service hinder this development, as the contradictory objectives become reconciled through clear guidelines and elaborate organizational practices (Etzkowitz 2002, 2003a).

Models claiming for moderate transformation of universities

The thesis according to which university faculty is increasingly engaged with technology transfer and industrial collaboration is further examined by Slaughter and Leslie. In their study of public research universities operating in Australia, UK, Canada and the United States, Slaughter and Leslie found that during the past 20 years universities have become increasingly involved with ''the profit motive'' and ''market-like'' behavior. The background to this development can be found in the globalization of the economy, the emergence of policies aimed at securing nations' industrial competitiveness and the change in the financing of universities from block-grant funding to targeted, competitive funds (Slaughter and Leslie 1997, Ch. 2). In consequence, ''the academic capitalism'' has evolved within universities.

Academic capitalism refers to ''market and market-like'' efforts by using which institutions and professors try to secure their external grants (Slaughter and Leslie 1997, pp. 8, 9). Examples of such activities include competitive research funds, consulting, technology transfer, patenting and licensing, as well as arm's length corporations, spin-off firms and research parks (Slaughter and Leslie 1997, p. 65). In addition, new kinds of hybrid entities spanning the customary public–private boundaries have been formed, for example, cooperative research centers

that bring together universities, industries and government agencies in the context of strictly commercial research. Such centers provide long-term funds for large projects, cover patenting and licensing costs and finance the process of bringing research results to the market (Slaughter and Leslie 1997, pp. 149–151). Given these trends, it is no wonder that different disciplines are in varying positions as regards their ability to take advantage of the academic capitalism. Clearly, those fields that are closest to the market, such as biotechnology, are better off in this respect than some others, say, humanities (Slaughter and Leslie 1997, p. 7).

The encroachment of the market and market-like mechanisms into the academe has not taken place without controversies. Instead, and contrary to the enthusiasm by Etzkowitz et al. (1997, p. 9), Slaughter and Leslie (1997) consider that research universities are pregnant with contradictions as the faculty is employed by the public sector while being increasingly autonomous from it. For instance, academics are encouraged to become more active in terms of commercially exploiting their knowledge and expertise while the number of students has increased and instructive responsibilities proliferated (Slaughter and Leslie 1997, p. 61). Other sources of conflicts within universities include attempts by central administration to control and monitor entrepreneurial activities of researchers as well as unstable norms regulating the ownership of intellectual property rights (Slaughter and Leslie 1997, pp. 146–149, 190–192). Despite all these difficulties, Slaughter and Leslie state that the academic, commercial and bureaucratic cultures are integrating and the distance between universities, industries and governments is decreasing. Universities as special institutions enjoying a measure of autonomy are in wane: They are becoming similar to other large, entrepreneurial organizations (Slaughter and Leslie 1997, p. 222).

If Slaughter and Leslie's study was mostly concerned with the dependence of universities on external funding, a study by Marginson and Considine focused on the changes that have taken place with respect to university governance and management. Examining 17 Australian universities the writers conclude that there is a general pattern – indeed, a widespread ''revolution'' – of making the university more like an enterprise. The top–down management models and strong executive control of the university are strictly aligned with changes in the global economy and national higher education policy (Marginson and Considine 2000, pp. 3 and 4). The authors identify several trends characterizing the transformation. These include the replacement of collegial decision-making bodies with new managerial structures that make use of incentives, targets and plans of different kinds and emphasize the authority of individual

academic leaders, such as deans of faculties and heads of departments. A related change is the transfer of decision-making power and budgetary autonomy from the university's central administration to the faculties and departments. Marginson and Considine (2000, pp. 9–11) also see the role of academic disciplines to be in the decline owing to the establishment of interdisciplinary schools and research centers within universities. As a result, the authors maintain, the university is lurching into the economic world at the same time as its internal intellectual coherence is falling into decline.

Compared with models like the Mode-2 knowledge production or the triple helix Marginson and Considine do not, however, proclaim this trend a universal and uniform development. Instead, they claim it plays out variously in different kinds of universities. Old, established universities that embodied robust "academic cultures" were capable of reproducing themselves despite cutbacks in government funding and the emergence of new managerial models. In such institutions, scholarly cultures were self-sustaining and the disciplinary identity of academics retained salience. In spite of the fact that faculties were reformed, performance drivers installed and private funding created, the collegial loyalties among academics remained strong and managerialism was resisted (Marginson and Considine 2000, pp. 193–196, 221–222). Several other types of universities – those established after World War II and the technical institutes – were less traditionally academic and more open to corporatist tendencies. They focused on industrial relations, were often strong in applied sciences, emphasized professional education (such as law and medicine) and had weaker disciplinary cultures. Some of the newest universities even sought to remake themselves along the lines of entrepreneurialism at the price of short-termism, academic vigor and heightened dependence on external marketing (Clark 1998, Marginson and Considine 2000, pp. 196–202).

Reflections on the four models

Evidently, the previous models capture some relevant trends with respect to the dynamics in the current academe. For instance, the university–industry collaboration relations that proliferate in some high-technology fields, such as biotechnology, have been demonstrated through an extensive set of studies (Blumenthal et al. 1986a, 1986b; Kenney 1986; Curry and Kenney 1990; Krimsky et al. 1991; Webster 1994). Moreover, it has been claimed, the significance of these relations has increased over

time: the excitement about industrial involvement with university research should not be received with a *déjà-vu* attitude but the distinctive nature of the current situation should be appreciated (Geiger 1988).[3] Nonetheless, some of the models – most remarkably the radical ones – have been regarded as fairly problematical. Let us begin with the Mode 2.

Of the above conceptualizations, the Mode-2 knowledge production has been subject to the hardest criticism. In addition to the fact that the thesis underestimates the relevance of path-dependent trajectories and boundaries of established scientific institutions, such as universities and disciplines (Shinn 1999; Jansen 2002; Krücken 2003), its assertion that the nature of scientific research has altered has been called into question. For instance, Etzkowitz and Leydesdorff (2000, pp. 115–116) state that the Mode-2 science is not a new phenomenon at all. Referring to a dissertation by Robert K. Merton, the authors argue that about half of the discoveries in the 17th century had their origins in attempts to solve the problems of navigation, mining and so forth. Therefore, rather than being a novel phenomenon, the Mode-2 type of research is the original form of science prior to its institutionalization into the university in the 19th century. In the same way, Godin (1998, pp. 470–474) referred to a number of historical studies and claimed that research has always shifted between fundamental and applied spheres. Rip (2000, pp. 35–36), on the other hand, described the European Renaissance during the fourteenth to the sixteenth centuries and stated that the ambivalent position of the so-called professors of secrets, who collected recipes from different crafts and sold them to sponsors, closely resemble the present-day biotechnologists and other scientists working in commercially important areas.

This sort of counter-evidence lends support to the judgment that the Mode-2 thesis overstates the change science has undergone while simultaneously dismissing relevant earlier literature and empirical evidence. In Elzinga's (2002, p. 3) viewpoint, the model is ''one-eyed and reductionist'' since it focuses mainly on ''a relatively small – albeit significant and dramatically changing – domain of the vast diverse landscape of science in society.'' Muller (2000), on the other hand, claims that it over-dichotomizes the evolution of science ''presenting it as two discrete ideal types that probably never exist in their pure form in the real world.'' The Mode 2 thesis also has a close affinity to the language of science and technology policy and the political neo-liberalism (Weingart 1997; Häyrinen-Alestalo 1999; Krücken 2002; Shinn 2002). Shinn (1999, p. 172), for instance, maintains that the Mode-2 argument easily links to ''a partisan political agenda and ideology''

rather than ''a serious-minded history and sociology.'' Hence, it seems that the New Production of Knowledge is neither an empirical study nor a sociological theory but, rather, ''diagnosis-of-the-era'' type of theorizing (Miettinen 2002; Tuunainen 2002).[4]

According to Noro (2000), diagnoses of the era represent ''the third type of sociological theory.'' Referring to a German historian of ideas Walter Reese–Schäfer Noro conceives of diagnoses of the era (in German: Zeitdiagnose) as theories that seek to answer such existential questions, like who we are and what is the nature of our epoch. Such descriptions of the spirit of the ages usually combine familiar materials in a novel way, are normative in nature and pursue to yield new topical insight. Therefore, they may be effectively used as conceptual devices for policy making, as recently illustrated by the Mode 2 in the context of South African higher education policy (Kraak 2000a). In academic writing, examples of such theorizing involve books like ''The Coming of Post-Industrial Society'' by Bell (1973), ''The Consequences of Modernity'' by Giddens (1990), or ''Risk Society'' by Beck (1992). In a similar vein, the protagonists of the Mode-2 thesis claim that not only have science and university changed but the entire society as well: it has become transgressive, meaning that such modern categories as science, politics, culture and the market have become subject to the same co-evolutionary trends and, thus, invaded each other's domain (Nowotny et al. 2001, p. 4). The problem with such a perspective is that it does not leave any room for science as a distinct social and cultural sphere: the demarcation of science from non-science seems to vanish altogether, a position recently challenged both empirically and theoretically (Krohn and van den Daele 1998; Gieryn 1999).

Whereas the Mode-2 thesis has over the years been expanded into ever more abstract and encompassing theory concerning the place of knowledge production in the post-modern age (Nowotny et al. 2001), the other models represent stronger empirical footing. For instance, the triple helix of university–industry–government relations is clearly on its way from the complex systems-theoretical model, which informed the theory in its early stages (Leydesdorff 1996, 2000), toward more empirical foundation. In Etzkowitz's writings, at least, ever more attention is given to case studies of different US research universities, such as Stanford and MIT. In the worldwide triple-helix conferences, on the other hand, scholars from different countries seek to understand their particular cases by way of using the generic idea of the triple helix. This growing body of empirical research seems to counterbalance and neutralize some of the normative tendency and

over-theorization built into the triple-helix model (Elzinga 2002, pp. 15, 25). As Shinn (2002, p. 605) recently noted, it remains yet to be seen how the evolving triple-helix model succeeds in maintaining equilibrium between the increasing empirical evidence and the complex systems-theoretical underpinning.

With respect to the proposed institutional change of the university, the different models stand in contrast to one another. This is evident as regards the generality of the claims being made and the empirical data applied. Two positions stand out most clearly. First, there is a strong thesis suggesting that coming of entrepreneurial universities is an inevitable phenomenon taking place all over the globe. Most clearly, Etzkowitz represents this stance. He substantiates his claim by chronicling the histories of the prestigious private US universities, such as Stanford, and considers that the other institutes are emulating these models worldwide (Etzkowitz 2003b). On the other hand, there are more cautious claims put forth by Slaughter and Leslie as well as Marginson and Considine. They make it quite clear that the validity of their arguments is restricted in various ways. In this perspective, different kinds of universities in different countries seem to adopt dissimilar developmental pathways towards entrepreneurialism in so far as such mutations are sought for. For instance, Marginson and Considine demonstrated that old established universities with a comprehensive coverage of scientific disciplines and units possess the strongest willingness to resist managerial and corporate leanings. The data from the UK by Deem and Johnson (2003) backed up this conclusion: only a minority of academics was highly-oriented towards financial activities, such as consultancy or spin-off companies. When assessed from such perspectives, the stance taken by Etzkowitz seems less justified; he even admits himself that his argument is based on a convenience sample only, rather than any representative collection of universities (Etzkowitz 2002, pp. 117–118).

Despite the estimations that a minority of academics, sciences and universities have become active entrepreneurs (e.g. Weingart 1997; Elzinga 2002; Deem and Johnson 2003; Krücken 2003), there is a tendency in each of the four theories to represent their data in such terms. All of them work towards the claim that a new kind of science and university is in the process of coming. The ''new'' universities, or modes of science, are always kinds of generic abstractions constituted by more or less convincing empirical material. As such, they all too easily obscure the intrinsic dynamic, internal variance and contradictory tendencies present in scientific practices and universities. Therefore, in my view, the

general claims should be broken down into a set of more specific research questions, such as: How to conceptualize development of a local research program? Or, is the fusion of university activities and commercial development really possible in the confines of an ordinary department?

From the generalized accounts of science and university to the analysis of local practices

My argument in this paper is that questions like these can be fruitfully addressed by drawing analytic ideas from research in science and technology studies that analyze scientific practices. As seen from such a perspective, science is a disunified endeavor and should, thus, be investigated in terms of actual work activities pursued by working scientists in diverse concrete locations. That is, instead of representing science as a unitary social institution characterized either in terms of the Mode-2 knowledge production or the entrepreneurial science, it should be conceptualized in terms of historically-evolving local activities where researchers make use of heterogeneous sets of cultural resources (e.g. research materials, instruments, methods, hypotheses and theories) to achieve their particular objectives (Clarke and Fujimura 1992; Pickering 1992; Miettinen 1998; Knorr Cetina 1999). This perspective that highlights the productive, dynamic and contingent nature of scientific action can also be applied to the study of university institution, thereby shifting the analytic focus away from the formal organization to more specified occasions to see how local research groups are connected with their specific organizational contexts whether individual departments or entire universities (Fujimura 1996; Lenoir 1997).

In this Section, such an approach is used to illustrate three particular issues that bear relevance to both radical and moderate theses of transformation. These include: (1) the need to appreciate the dynamics between theoretical, experimental and applied concerns of research work; (2) the fact that effects of external, competitive research funding intermingle with complex social ecologies of disciplines at university departments; (3) the difficulties academics encounter as they try to fuse their research and teaching activities with private commercial development within university organization.

Scientific practice: Intertwining of theoretical, experimental and applied concerns in research work

The plant-biotechnology research group I have investigated studied virus resistance in the potato by making use of two specific experimental approaches. First, it examined the natural virus resistance trait in a wild potato species combined with several attempts of transferring that trait to the cultivated potato gene pool. Second, a novel genetic-engineering approach was developed by the virtue of which the potato-virus genome was used as a source of virus resistance. I conceptualized these two research approaches as distinctive but closely interconnected experimental systems[5] (Rheinberger 1997), those of the wild potato and the viral gene system. These systems comprised three entwined concerns: (1) the pursuit of theoretically understanding the virus-resistance mechanism in the potato; (2) the creation of the cultivated virus-resistant potato; (3) the development of appropriate cell and molecular-biological research materials, tools and methods. In practice, these concerns were part and parcel of the one and the same dynamic research activity and were interconnected in various ways along the sequential progression of the group's research program (Tuunainen 2001). This can be illustrated by looking at an early phase of the group's experimentation.

When the researchers started their work, in 1990, they did not know which genes in the genome of the wild potato caused the resistance effect; these had to be localized first. Therefore, the initial stages of the research program involved producing new knowledge. This was accomplished by, first, creating suitable plant material by hybridizing the virus-resistant wild potato and the virus-susceptible cultivated potato, and second, by using these potato hybrids as tools for localizing DNA fragments that contained the resistance genes. In this research, elaborate cell and molecular biological techniques were developed and utilized. The application object was addressed, finally, in the third phase of the experimentation. It consisted of the attempt to realize the virus-resistant potato by transferring the localized and isolated DNA fragments to the cultivated potato gene pool (Tuunainen 2001).

Although multiple attempts were made to materialize the virus-resistant potato by means of using the wild potato system, the experiments ultimately failed. Nonetheless, the research proved advantageous in terms of creating new knowledge: the virus-resistance mechanism of the wild potato was better understood, thus, becoming a suitable model plant for further studies on the virus movement in plants. In addition, during the course of experiments useful research tools, techniques and

methods were developed. Later, these proved crucial for the group as it sought to create the virus-resistant potato by using the second experimental system, the viral gene system (Tuunainen 2001).

With respect to the viral gene system, the research turned out to be successful: the group succeeded in creating the virus-resistant potato by introducing the viral gene into the genome of a Finnish potato cultivar. As such, the genetic-engineering method was novel. It was materialized as a result of two early developments, the first being the gradual accumulation of a variety of molecular-biological tools and methods in the group. The second was hearing about a new, unpublished research result from Cornell University via informal communication channels. On these bases, the group decided, impulsively, to set up an experiment to transfer the viral gene into the cultivated potato. In the transgenic potatoes so created, an unusual virus-resistance effect emerged (Tuunainen 2001).

Subsequently, the research continued in both scientific and commercial contexts. First, the genetically engineered virus resistance was theoretically interesting and, thus, its mechanism became the topic for further investigation. Second, the virus resistance effect was potentially useful in agricultural–industrial production, so, it was patented. Along with the methods of its creation, it was also subjected to further development with an industrial partner. In a joint research with a Danish plant-breeding company, the interconnection between the theoretical, experimental and applied attachments of research continued to exist: the applied work contributed to the fundamental understanding of the virus-resistance mechanism while simultaneously being useful from the perspective of breeding work (Tuunainen 2002).

In summary, the theoretical, experimental and applied concerns ran through the examined group's research program permanently. Although this sort of hybrid science is part and parcel of the scientific endeavor, the fact that local research agendas address simultaneously theoretical problems, produce instrumentalities and strive for useful applications should not be obscured by way of adopting indistinct analytic language. This is what may happen if one starts speaking about "contextualized knowledge" (Nowotny et al. 2001) or "Mode-2 science" (Gibbons et al. 1994). Such a vocabulary all too easily glosses over the triple orientation of the research program better appreciated by "the entrepreneurial science" (Etzkowitz 1998). Nonetheless, even Etzkowitz's conception is too off-hand: He just passingly mentions the existence of the three dimensions without really analyzing them. In my perspective, their intertwinement should be more clearly acknowledged; understanding

their dynamics might give us better starting points to discuss how academic research is connected to social utility and how it may, eventually, turn into commercial development.

External research funding and segmentation of university department into competitive research approaches

Like cancer research (Fujimura 1996), agricultural science has undergone significant transformation during the past few decades. The established mode of research – agronomical study of cultivation methods – has been supplemented by two new approaches, biotechnology and genetics (Busch et al. 1991). At the same time, an equally powerful critical perspective, that of agroecology, has evolved (Rosset and Altieri 1997; Lacey 2000). In result, the modern agricultural scientific enterprise has become increasingly fragmented and even contradictory. This was evident as regards the university department wherein the biotechnology group operated: The Department of Agronomy, as I chose to call it, was a heterogeneous organizational unit in terms of research approaches applied. Basically, there were six major agricultural scientific subdisciplines present in the department, genetic engineering, plant physiology, agronomy, horticulture, farming-systems research and agroecology. Although these shared the common objective of fostering agricultural production in Finland, they also varied considerably in their background and orientation: the units of analysis, for instance, ranged from the minor parts of individual plants to plant populations, finally, ending with studies that addressed the population dynamics of complex field ecosystems. In a similar vein, they made use of dissimilar research technologies reaching molecular biology and genetic engineering on one side and quantitative investigation of the field ecology on the other.

The emergence of plant genetic engineering in this context was a result of three coalescing developments: (1) the promotion of biotechnology by the Finnish government; (2) the transfer of the plant biotechnology group's research agenda to Finland from abroad; (3) the effort to modernize the department's activities by the faculty leaders. In parallel to the developments in several other European countries, such as Germany, France and UK (Gottweis 1998), also the Finnish government began to place special attention to the advancement of biotechnology and molecular biology in the mid-1980s. By doing so, the government wanted to upgrade the level of biotechnological research in

the country as well as to promote creation of economically valuable innovations. Simultaneously as these initiatives led to a substantial biotechnology-funding program (Laiho et al. 1996), the forthcoming leader of the investigated research group was working at the Rothamsted Experimental Station, UK. While working therein, the group leader was inspired to transfer to Finland and to establish a group of her own at the University of Helsinki. In order to do that, she applied for funding from a major Finnish science-funding agency and, due to the increased allowances directed at biotechnology, received a positive response. Interestingly enough, these developments matched with the concurrent attempts within the university to modernize its agricultural scientific research and teaching tradition by way of introducing genetic engineering into the Department of Agronomy. In consequence, an organizational niche for the embryonic biotechnology group was created at the department and the research group leader was appointed to the position of full professor (Tuunainen 2005).

Despite the favorable policy context, genetic engineering did not easily fit together with the other research approaches but the department was soon subjected to centrifugal forces leading to segmentation. Nearly all of the scientists I discussed with reported about such tensions and aligned them with several other issues, such as the decline in the funding level of the agricultural sciences and the simultaneous upward turn in the biotechnology funding and competitive grants. A closely related issue with the allocation of resources was the strengthening of individual leadership in the Finnish universities during the 1990s. As indicated by other studies (Kekäle 1997; Ylijoki 2003), academic capitalism and managerial governance were, indeed, on the increase in Finland. Nonetheless, focusing solely on such political and administrative matters is insufficient from the perspective of the studied case example; one needs also to pay attention to the substantial differences in the scientific research approaches present in the studied department. There were three sources of conflicts between them: (1) the dissimilar topics and methodologies of the established agronomy and the new research approaches (e.g. genetic engineering); (2) the entrenchment of disciplines within formal organizational units, such as the departmental subdivisions; (3) the larger ethical–ideological controversy between genetic engineering and agroecology (Tuunainen 2005).

These sources of conflicts not only established boundaries between different research approaches but were interrelated with one another as well. For instance, already in the early stages of the group's research, a question was raised as to whether genetic engineering that involved

plant breeding was situated in the correct department. Some faculty members considered that instead of the Department of Agronomy, where cultivation methods were being studied, the group should have been placed at the Department of Plant Breeding. This had not occurred, however, due to the fact that no open vacancies were available in that department at the time when the group was established. Later on, as the research group expanded in the agronomy department owing to the large sums of external funding it was able to attract, concerns on the focus of the departmental research activity strengthened. These tensions were, then, intertwined and further escalated by the concurrent ethical–ideological disputes concerning the agricultural application of genetic engineering that came up in Finland and elsewhere in Europe around 1998–99. In this regard, effects brought about by growing external funding constitute just one ingredient in the complex social ecology of disciplines at university departments.

Research group-firm hybrid entity: Difficulties of fusing university activities with commercial development

As acknowledged by the Mode-2 and the triple-helix models, academic researchers may seek to maintain their university positions simultaneously as they want to become engaged in the operation of a private company. Such was the matter in the studied case example. Instead of contenting themselves with industrial collaboration or consulting, the research group members sought to create what Etzkowitz et al. (2000b, p. 320) called ''a hybrid firm.'' The hybrid firm is a company that straddles the public and private spheres of activity: it is a commercial enterprise, which is still located ''within the university and department on the university for a degree of administrative and financial support.'' In such a firm, the staff occupies both academic and company positions concurrently, therefore the dividing line between the university and industry seems to vanish altogether.

To understand how university administration responded to such a development, I used the concept of boundary work (Gieryn 1999). Boundary work in this case was not a matter of separating science from non-science but, instead, a set of local bureaucratic procedures through which the demarcation of private business from public university activities was pursued by administrators. Because no clear-cut rules and regulations existed in relation to managing start-up companies in departments, determining the conditions for the business activity

became an issue of a heated battle between the research group leader and those in administrative positions. When thematized from the point of view of boundary work, the following issues came up as controversial: (1) The bureaucratic accountability of and teaching performance by the group leader; (2) the loan of the university's research materials and instruments to the group's firm; (3) the ownership of intellectual property rights. Eventually, these dilemmas were worked out through the establishment of two boundaries, social and spatial, by means of which the group's business activity was separated from its public-sector research (Tuunainen in press).

The group's combining its academic work with the business activity provides an apt example to raise a general question about the limits of commercialization and entrepreneurship within universities. As the case example clearly illustrated, hybridization of the academic research with the private enterprise was not possible. On the contrary, the hybrid entity was abandoned and the firm was sealed away from the university's core academic units to more peripheral organizational position, the business incubator operating in a science park. Thus, the case example did not lend support to the generalized thesis stating that universities are globally becoming entrepreneurial organizations that pursue knowledge production and commercial development in a compatible fashion (Etzkowitz 2002). Instead, it revealed some of the basic issues all similar endeavors are likely to encounter: the problems of combining many divergent and, perhaps, contradictory functions of the university. Supported by earlier observations (Packer and Webster 1996; Rappert and Webster 1997; Krücken 2003) I would, thus, suggest that the new commercial rhetoric, which is often closely linked with the current policy concerns, is not necessarily met by equally dramatic changes at the level of local departmental practices. While universities certainly adapt to the changing political conditions they, simultaneously, want to maintain their public character and protect their core units from direct commercial influence. In this respect, institutional structures and practices of universities seem to be more stable than the bulk of the discourse going along with the entrepreneurial university might make us believe.

Conclusion

I began this article by reviewing the recent literature according to which science and the university have dramatically changed in their character.

Of the many alternatives that have tried to capture the typical features of the current situation, I chose to focus on four prominent conceptualizations, namely, the Mode-2 knowledge production, the triple helix of university–industry–government relations, the academic capitalism and the enterprise university. I summarized the main points of these models and considered criticisms directed at them. In addition, I revisited my empirical research results relating to the work of the university plant-biotechnology research group and connected these with several positions taken by the proponents of the four models. What might be concluded on the grounds of such an endeavor?

On the grounds of the review, there can be little doubt that universities have changed in many respects during the recent years. Analysts have attributed these alterations to ensue from the emergence of the global economy, the new public policy priorities and the sharpened economic competition among nation states. As noted by Kleinman and Vallas (2001, p. 455), for instance, ''universities are increasingly viewed as mechanisms for enhancing national competitiveness.'' While not wanting to question such general statements, I want to assert their multifaceted character: the changes universities are living through are not uniform nor are they pervasive. Instead of being isomorphic with one another, there are, actually, different kinds of universities in the world just as there are different kinds of activities within each university. Further, as these functions are not always in harmony with one another, it is questionable whether any of the all-embracing conceptualizations is defensible as such. In my view, this was nicely exemplified by the analysis of the research group-firm hybrid entity. As illustrated, commercialization of the academic research through the spin-off company turned out to be in conflict with the other university activities, most apparently, with publicly-funded research and undergraduate teaching. The attempt to hybridize the public and private activities was, thus, willingly resisted by administrators, thereby providing a challenging case for Etzkowitz's totalizing entrepreneurial university model.

On these grounds, the moderate stances taken by Slaughter and Leslie as well as Marginson and Considine proved more reasonable. Although also these authors worked towards generic arguments, they, nonetheless, clearly indicated that there is considerable internal variance as regards different kinds of universities and disciplines. Further, these models concentrated on just a few features of the contemporary university activities: the growing dependence of academics on external, competitive funds (the academic capitalism) and the introduction of new

managerial instruments and executive power into universities (the enterprise university). While these tendencies are topical in Finland, it is equally plausible that they become complexly intermingled with many other issues at the grassroots of universities and their departments. Academic capitalism is a case in point. As described, the increase in external, competitive funding has a direct influence on the lives of researchers and research groups at academic settings. The investigated research group, for instance, was established on the basis of such grants. Nonetheless, the analysis also demonstrated the limits of the academic capitalism through the segmentation of the departmental work community. It appeared, in this instance, that many other issues additional to research funding also had a role to play, that is, competitive external grants constituted just one ingredient in the complex ecology of the disciplines in the department.

This reflects the fact that academic capitalism – alongside with the enterprise university – does not speak about scientific practice *per se* but more about the administrative and political issues of the academe. Of the four models, scientific research was particularly addressed by the Mode-2 knowledge production thesis as well as Etzkowitz's triple-helix model. While Gibbons and the other proponents of the Mode-2 spoke about the emergence of an entirely new kind of research, which is transdisciplinary and application-oriented in nature, Etzkowitz and Leydesdorff, among others, claimed that this is nothing new but, actually, the original form of research before its institutionalization into universities. Not being able to examine this issue empirically, my particular study gave rise to another point of concern with respect to the Mode-2, that is, its tendency to describe knowledge production through indistinct and totalizing language, which does not adequately differentiate between the theoretical, experimental and applied agendas of local research programs. Analyzing dynamics between these is vital, in my view, if we are to understand how patentable innovations and industrial collaboration sprout from the university research, an issue generally left unstudied by all of the four models.

All in all, I believe this article has demonstrated the need for seeing scientific work and universities as complex and, occasionally, contradictory entities whose developmental trajectories are shaped by multiple historical, political and cultural characteristics. It has also further substantiated the advantages that may be achieved when such developments are addressed empirically and in terms of local practical actions taken by working scientists, policy-makers and administrators. Therefore, the practice-oriented sociology of science has much to offer

for scholars working in the neighboring fields of investigation, such as that of higher education research.

Acknowledgements

My thanks are due to the members of our research group at the University of Helsinki, Finland, and the three anonymous reviewers from this journal for their criticism and suggestions concerning the earlier version of this article. I am also grateful to the Academy of Finland for funding the projects Technical Innovations and Organization of Research Work (No. 37370) and Changing University Research and Creative Research Environments (No. 49789) (Finnish Center of Excellence Program 2000–2005).

Notes

1. As a general term, biotechnology refers to "any technique that uses living organisms or parts of organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses" (Busch et al. 1991, p. 1). In this paper, I am speaking about biotechnology in a more limited sense, however: I am focusing on plant genetic engineering where novel cell and molecular biological research methods, such as recombinant DNA techniques, are used to improve crop plants.
2. The central viewpoint that Gibbons and others took up have also been restated by Ziman (2000). In his view, due to the financial ceilings placed on the funding of universities, scientists have become more responsive to societal needs for their research and more concerned about its quality and impact. As a result, he argues, science is being transformed as a cultural form into what he calls "postacademic science." Postacademic science is oriented towards producing proprietary knowledge, it strives for local, transepistemic understanding about practical matters and incorporates interests of various kinds. Surprising as it may sound, postacademic science is a single culture. In that culture, heterogeneous networks constituted by academics and industrialists create knowledge, transcend traditional boundaries demarcating basic and applied research and form hybrid teams that override old institutional loyalties.
3. Geiger (1988, pp. 341–342) lists four reasons for this: (1) industry is nowadays willing to make huge, long-term contractual commitments supporting university research; (2) universities are eager to seek out these contracts; (3) there is a whole diversity of new arrangements that have been worked out by universities to facilitate technology transfer; (4) some of these have been facilitated by governmental bodies.
4. For an attempt to transform the abstract formulations of Mode 2 into empirical research (see Subotzky 1999; Kraak 2000b).
5. In science and technology studies, the concept of the experimental system has been an important analytical tool widely used and discussed. Most systematically, it has

been elaborated by Rheinberger (1997). He regards experimental systems as ''the smallest integral working units of research'' that are designed to create new phenomena and knowledge (Rheinberger 1997, p. 28). Theoretically, he discerns two types of elements in them. He calls the first a scientific object, or an ''epistemic thing.'' An epistemic thing is ''that material entity which is the object of manipulation'' (Rheinberger 1997, p. 110). During the research process scientific objects continually make their appearance and become successively redefined in changing experimental contexts. These contexts form the second element of the experimental systems, and Rheinberger calls them technical conditions, or ''technical things'' (Rheinberger 1997, pp. 28–31). They are materials and methods of experiments that ''determine the space and realm of representation of an epistemic thing'' (Rheinberger 1997, p. 111).

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