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ABSTRACT

The model presented in this paper sets forth a view of the relevance of higher education in the 21st century that begins from the changes that are taking place in the production of knowledge. The organization of this model is designed to draw attention to the fact that for the most part universities are organized according to the structures of disciplinary science, and that these structures are being altered by social forces. The major change has been the emergence of a distributed knowledge production system within which knowledge is characterized by new attributes. The main change as far as universities are concerned is that knowledge production and dissemination (research and teaching) are no longer self-contained quasi-monopolistic activities carried out in relative institutional isolation. The real challenge for universities will be the training of knowledge workers. The research practices of universities and those of other knowledge producers are drawing closer. Knowledge is less likely to be produced where it will be needed, and universities must make use of intellectual resources they do not own fully so that they can interact effectively with the distributed knowledge production system. Universities of the 21st century will develop more and different kinds of links with surrounding society. (Contains 1 figure and 13 references.) (SLD)

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Michael Gibbons

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Higher Education Relevance in the 21st Century

by

Michael Gibbons

SECRETARY GENERAL
ASSOCIATION OF COMMONWEALTH UNIVERSITIES

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Higher Education Relevance in the 21st Century

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EXECUTIVE SUMMARY

The model presented in this paper presents a view of the relevance of higher education in the 21st century that begins from the changes that are taking place in the production of knowledge. The aim is to draw attention to the fact that for the most part universities are organised according to the structures of disciplinary science (labelled in the text as Mode 1) and that these structures are changing.

The major change is the emergence of a distributed knowledge production system and within this system knowledge is characterised by a set of attributes that we have labelled Mode 2. The main change, as far as universities are concerned, is that knowledge production and dissemination -- research and teaching -- are no longer self contained activities, carried out in relative institutional isolation. They now involve interaction with a variety of other knowledge producers. In this situation, connections will increasingly involve the use of the potentialities of the new information and communication technologies.

The research practices of universities and industry, as well as other knowledge producers, are drawing closer together. All are now, in effect, actors in the knowledge business. The fact of globalisation means that for each actor, the bulk of the knowledge to which access is required will have been produced elsewhere. Over 90% of the knowledge produced globally is not produced where its use is required. The challenge is how to get knowledge that may have been produced anywhere in the world to the place where it can be used effectively in a particular problem-solving context.

Universities have been far more adept at producing knowledge than at drawing creatively (re-configuring) knowledge that is being produced in the distributed knowledge production system. It remains an open question at this time whether they can make the necessary institutional adjustments to become as competent in the latter as they have been in the former. This requires the creation of a cadre of knowledge workers -- people who are expert at configuring knowledge relevant to a wide range of contexts. This new corps of workers is described in the text as problem identifiers, problem solvers, and problem brokers. The shift from knowledge production to knowledge configuration is a challenge that is particularly acute for the universities of the developing world.

In order to operate efficiently, universities will need to be much reduced in size, and they will have to learn to make use of intellectual resources that they don't fully control. This is the only way that they will be able to interact effectively with the distributed knowledge production system and with the progressive differentiation of supply and demand for specialised knowledge. Universities in the future will comprise a small core of faculty and a much larger periphery of experts of various kinds that are linked to universities in diverse ways. Universities will become a new type of "holding institution" in the field of knowledge production. Perhaps their role will be limited to accrediting teaching done primarily by others while, in research, playing their part by orchestrating problem-solving teams to work on fundamental issues.

A significant adjustment that the universities will have to make in this new context is to develop structures which promote and reward group creativity. So far, the emphasis in universities -- and this is a consequence of the disciplinary structure -- has been on individual performance. Little, if any, attention is given to the challenge of teaching people to be "creative" in a team situation. To avoid wasteful duplication, an ethos based on teamwork and, more importantly, on sharing resources will need to be developed at the centre of an institution's policies.

Universities will play major roles not only in national but also, and increasingly, in regional economic development, in the delivery of life-long learning, and in the development of civic culture. In order to be effective in these spheres, the values of technology transfer will have to be brought from the periphery of universities, where they reside at the moment, to their core. Universities who are serious about playing a role in the complex game of technology interchange will enter into a complex array of partnerships, the dynamics of which will involve a combination of competition and collaboration.

Universities of the future will develop many more and different kinds of links with surrounding society. They will increasingly be ranked in terms of their "connectivity" to the distributed knowledge production system and their relevance as determined by their efficiency in drawing upon the resources of the distributed knowledge production system.

Universities still enjoy a privileged place in the distributed knowledge production system, but existing structures are too inflexible to accommodate emerging modes of knowledge production or the demands that a greater variety of "students" will make. Both students and staff realise that their personal success lies in being able to find a niche in the emerging knowledge society. The problem is that in neither teaching nor research do the universities have this turf to themselves. And here lies a threat to the conventional way of doing things. Or is it, perhaps, an opportunity?

Higher Education Relevance in the 21st Century

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ASSOCIATION OF COMMONWEALTH UNIVERSITIES

It has long been recognised that higher education institutions, particularly universities, are among the most stable and change resistant social institutions to have existed during the past 500 years. Based on the model of the physical campus, residential students, face to face student-teacher interaction, a lecture format, and ready access to written texts, these institutions have effectively developed and transmitted the store of knowledge from one generation to another. They have fulfilled this responsibility in the midst of political and social upheaval, social development, and technological advancement while remaining essentially unchanged in structure and method. Will this proven model retain its resilience and relevance in the 21st century? This paper will seek to answer these questions by speculating on how higher education relevance will be defined in relation to future demands from students and employers, to the institutional forms through which higher education will be delivered, and to the changing requirements of an evolving civilisation.

1. Introduction

During the past twenty years, a new paradigm of the function of higher education in society has gradually emerged. Gone, it seems, is the high-mindedness of a von Humboldt or a Newman, with its pursuit of knowledge for its own sake. In their places has been put a view of higher education in which universities are meant to serve society, primarily by supporting the economy and promoting the quality of life of its citizens. While it is true that universities still retain their role as the "conscience of society," the critical function of universities has been displaced in favour of a more pragmatic role in terms of the provision of qualified manpower and the production of knowledge. These changes are not notional. Rather, they are intended to have direct practical impact on the behaviour and functioning of higher education institutions. The new paradigm is bringing in its train a new culture of accountability as is evidenced by the spread of managerialism and an ethos of value for money throughout higher education systems internationally.

Some Basic Assumptions

The first assumption of this paper is that the new economically-oriented paradigm is not going to be replaced and that the trend towards increasing accountability will not be reversed. In all countries, developed or developing, the culture of accountability is going to become more and more firmly established. Not only will higher education in the 21st century have to become relevant, but also that relevance will be judged primarily in terms of outputs, the contribution that

higher education makes to national economic performance and, through that, to the enhancement of the quality of life. Though arguments of varying weight and coherence that point out the limitations of this pragmatic approach may be expected to come from all sides, it is further assumed, here, that no other rationale or justification will carry equivalent weight. Relevance is going to become something that will need to be demonstrated, not just once but on an ongoing basis. Economic imperatives will sweep all before it and "if the universities do not adapt, they will be by-passed." (Hague, 1991)

This view of university relevance, judged primarily in relation to their contribution to economic development, constitutes a major shift in perspective and values from the perspective presented to an earlier age by the likes of von Humboldt and Newman. To accommodate the new paradigm, clearly some adaptation -- whether in terms of the university's relations to the surrounding society, its institutional goals, or core values -- is going to be necessary. However, because national economic development is a complex and multifaceted phenomenon, dependent among other things upon history (e.g., previous economic performance) as well as current socio-political factors (e.g., demography, infrastructure, etc.) the range of adaptations may be expected to reflect the local context and, therefore, to vary widely across countries and over time. The response to the imperative of a more pragmatic notion of relevance is a source of the expansion of diversity across higher education systems.

In a dynamic environment, of course, change is not a once for all event. Rather, it is a series of more or less continuous adaptations to changes in the environment. Though these adaptations may be local and vary considerably in magnitude, change will be continuous and each innovation will be judged in terms of its "contribution" to overall economic performance. Over time, then, it is to be expected that "relevance" in general will be translated into a nest of performance objectives related to teaching quality and research performance, among others. Each will make its contribution to, and be shaped by, the "culture of accountability" that is already evident internationally across so much of the institutional scene.

In this paper, we will consider the implications for change in higher education systems that derive from shifts in certain demand and supply factors. To set the stage for considering these changes, the paper begins by discussing the attributes of a new mode of knowledge production. This will provide a framework for examining, first, the history of the massification of higher education and, second, the nature of competitiveness in a globalising economy. The key empirical changes to examine, here, are diversification of higher education institutions in terms of mission statements, operating procedures, and clients (a broader category than students); and the centrality of knowledge and intellectual capital in the innovation process brought about by globalising processes. In particular, we point to the fact that international competition is creating demand for knowledge workers of all kinds, a change that cannot but influence universities who not only produce knowledge (research) but also, and perhaps more importantly, train the future cadres of knowledge producers in most societies. This is the substance of the second section.

In the third section, we turn to the types of institutional responses implied by this new mode of knowledge production and in particular to demands for knowledge and skills relevant to a knowledge-based economy. These changes call for a high degree of institutional flexibility as higher education systems become increasingly integrated into larger innovation, competitive, and economic development processes.

Finally, we ask who benefits from a more relevant higher education system? This is a question about the social return to a "relevant" higher education system, in terms of the ability of higher education to respond to the imperatives of the emerging culture of accountability. In the closing paragraphs, we briefly explore the question of whether in adopting the new economic paradigms universities can still maintain a role as stabilising elements in a world dominated by the fragmenting and dissolving effects of globalising economic activity.

ANALYTICAL FRAMEWORK

To have some coherence, the discussion of the range of responses required by higher education institutions needs the guidance of an analytical framework. Without it, the trends identified or the changes required may appear as totally unconnected events. In this paper, the point of departure is knowledge production. We will argue that the consequences of the massification of higher education and the pressures of international competition have together contributed to change the basis upon which research is carried out. It is true that the massification of higher education has meant that more and more young people are attending university. And, it is perhaps not surprising to find that these are exerting considerable pressure on curriculum development throughout higher education. In line with the new paradigm of higher education, relevance for most students is a multifaceted notion. Nonetheless, it contains a considerable element of self interest. Students everywhere want to get good, satisfying jobs. However, from the point of view of the framework we will present, the expansion of higher education has meant the training of many more individuals in the ethos of research and has given many of them specialised knowledge and skills. The majority of these are no longer employed in academic life, but work in organisations widely distributed throughout society. It is hardly surprising to find that these graduates bring both the ethos and their specialist skills to bear upon the problems they encounter in their jobs. Most graduates from higher education are familiar with making use of knowledge and information when faced with a problem. It is natural that they use the skills they have learned in university for problem-solving. When they reach an impasse, they return to their universities and their libraries to seek the information that they need to move ahead.

At the same time, the imperatives of international competition have increased the importance of knowledge and information in the innovation process. Firms have always differed in their ability to exploit knowledge; the most successful being those that are consistently better at doing this than their competitors. The point is that successful exploitation now requires that firms become active participants in the production of knowledge itself. This development has not only modified the way firms organise themselves to compete, but has also begun to alter their relationships to universities, particularly in relation to the range of intellectual problems which university scientists find challenging. This is changing the way both universities and firms are organising themselves to carry out research.

THE EMERGENCE OF A NEW MODE OF KNOWLEDGE PRODUCTION

It is worth recalling at the outset that it is only recently that universities have organised themselves to conduct research. Although individual research activities can be found in universities going back to the 19th Century and even earlier, it is really only since the end of World War II that research -- particularly basic research -- was taken up by universities and became one of their core

values. Throughout the 20th Century, universities have systematically developed structures that allowed them to add the function of generating new knowledge to their previous ones of preserving knowledge and transmitting it.

DISCIPLINARY STRUCTURE: MODE 1

The research structures that have gradually been put in place in universities are supported by a set of research practices which ensures that results are scientifically sound. These research practices set the terms of what shall count as a contribution to knowledge, who shall be allowed to participate in its production, and how accreditation shall be organised. Together, these practices have generated what we know as the disciplinary structure of knowledge. This structure, in turn, has come to play a central role in the management and organisation of universities today. Of particular importance for the argument presented in this paper is the fact that the disciplinary structure is specialist. Whether in sciences, the social sciences, or the humanities, specialism has been seen as a secure way to the advance knowledge and its organisational imperatives have everywhere accompanied its implementation.

The disciplinary structure also organises teaching in universities by providing a framework for the undergraduate curriculum. The disciplinary structure is the essential link which connects teaching and research and which underpins the argument that in universities they properly belong together. Of course, research not only adds to the stock of specialist knowledge but transforms it as well. The research enterprise is a dynamic one. Its research practices articulate the disciplinary structure and, overtime, modify what are regarded as the essential ideas, techniques, and methods that students need to be taught.

CHANGING RESEARCH PRACTICES: MODE 1 AND MODE 2

Most universities have imported a model of knowledge production that has a disciplinary basis. This structure provides the guidelines for researchers about what the important problems are, how they should be tackled, who should tackle them, and what should be regarded as a contribution to the field. In its social dimensions, it also prescribes the rules for accrediting new researchers, procedures for selecting new university faculty, and criteria for their advancement within academic life. *In brief, the disciplinary structure defines both what shall count as "good science" and prescribes, as well, what students need to know if they intend to become scientists.* Let us label this mode of knowledge production as Mode 1.

Because the disciplinary structure has been institutionalised in them, universities have tended to become the primary legitimators of this form of knowledge production. But a growing amount of evidence indicates that a new mode of knowledge production may be emerging. In keeping with academic tradition, and for the purposes of this paper, let us distinguish it from Mode 1 by creatively labelling it as Mode 2. It is part of the burden of the argument presented here to show how the imperatives of Mode 2 are going to change the way that universities carry out teaching and research in the future. In addition, Mode 2 will provide some of the criteria against which their future relevance will be defined (Gibbons, et al, 1994).

Most of those who have been through a higher education system today will be familiar with the characteristics of Mode 1, since it is the process by which they were themselves formed. However, the same will probably not be true when it comes to Mode 2. Accordingly, this part of the argument begins by identifying the principal differences between Mode 1 and Mode 2.

The term Mode 1 refers to a form of knowledge production -- a complex of ideas, methods, values, norms -- that has grown up to control the diffusion of the structure of specialisation to more and more fields of enquiry and ensure their compliance with what is considered sound scientific practice. Mode 1 is meant to summarise in a single phrase the cognitive and social norms which must be followed in the production, legitimisation, and diffusion of knowledge of this kind. For many, research which adheres to these rules is by definition "scientific" while that which violates them is not. It is partly for these reasons that whereas in Mode 1 it is conventional to speak of science and scientists, it will be necessary in this paper to use the more general terms knowledge and practitioners (or researchers) when describing Mode 2. This is intended merely to highlight differences. It is not to suggest that practitioners of Mode 2 are not behaving according to the norms of scientific method.

It is my contention that there is now sufficient evidence to indicate that a new, distinct set of cognitive and social practices is beginning to emerge, and that they are different from those that govern Mode 1. These changes appear across the research spectrum and can be described in terms of a number of attributes which, when taken together, have sufficient coherence to suggest the emergence of a new mode of knowledge production. Analytically, these attributes can be used to allow the differences between Mode 1 and Mode 2 to be specified. Thus,

- in Mode 1 problems are set and solved in a context governed by the (largely academic) interests of a specific community. By contrast, in Mode 2 knowledge is produced in a context of application;
- Mode 1 is disciplinary while Mode 2 is transdisciplinary;
- Mode 1 is characterised by relative homogeneity of skills, Mode 2 by their heterogeneity;
- in organisational terms, Mode 1 is hierarchical and, in academic life at least, has tended to preserve its form, while in Mode 2 the preference is for flatter hierarchies using organisational structures which are transient;
- in comparison with Mode 1, Mode 2 is more socially accountable and reflexive.
- in comparison with Mode 1, Mode 2 involves a much expanded system of quality control. Peer review still exists to be sure, but in Mode 2 it includes a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localised context.

Some Attributes of Knowledge Production in Mode 2

In the previous paragraphs, the characteristics of Mode 2 were presented in outline form. Five attributes were identified:

1. Knowledge produced in the context of application
2. Transdisciplinarity
3. Heterogeneity and organisational diversity
4. Enhanced social accountability
5. More broadly based system of quality control

It will be helpful for what follows later to describe briefly what it meant by each of these attributes.

KNOWLEDGE PRODUCED IN THE CONTEXT OF APPLICATION

The relevant contrast here is between problem-solving which is carried out following the codes of practice relevant to a particular discipline and problem-solving which is organised around a particular application. In the former, the context is defined in relation to the cognitive and social norms that govern basic research or academic science. Latterly, this has tended to imply knowledge production carried out in the absence of some practical goal. In Mode 2, by contrast, knowledge results from a broader range of considerations. Such knowledge is intended to be useful to someone whether in industry or government, or society more generally. This imperative is present from the beginning. Knowledge thus produced is always produced under an aspect of continuous negotiation, i.e., it will not be produced unless and until the interests of the various actors are included. Such is the context of application. In this sense, application is not product development carried out for industry, and the processes or markets that operate to determine what knowledge is produced are much broader than what is normally implied when one speaks about taking ideas to the market place. Nonetheless, knowledge production in Mode 2 is the outcome of a process in which supply and demand factors can be said to operate. But the sources of supply are increasingly diverse, as are the demands for differentiated forms of specialist knowledge. Such processes or markets specify what we mean by the context of application. Because they include much more than commercial considerations, it might be said that in Mode 2 science is both in the market but also has gone beyond it! In the process, knowledge production becomes diffused throughout society. That is why we also speak of socially distributed knowledge.

Research carried out in the context of application might be said to characterise a number of disciplines in the applied sciences and engineering (e.g., chemical engineering, aeronautical engineering or, more recently, computer science). Historically these sciences became established in universities but, strictly speaking, they cannot be called applied sciences, because it was precisely the lack of the relevant science that called them into being. They were genuinely new forms of knowledge though not necessarily of knowledge production because they too soon became the sites of disciplinary-based knowledge production in the style of Mode 1. These applied disciplines share with Mode 2 some aspects of the attribute of

knowledge produced in the context of application. But in Mode 2 the context is more complex. It is shaped by a more diverse set of intellectual and social demands than was the case in many applied sciences while it may also give rise to genuine basic research.

TRANSDISCIPLINARITY

Mode 2 does more than assemble a diverse range of specialists to work in teams on problems in a complex applications oriented environment. To qualify as a specific form of knowledge production it is essential that inquiry be guided by discernible consensus as to appropriate cognitive and social practice. In Mode 2, the consensus is conditioned by the context of application and evolves with it. The determinants of a potential solution involve the integration of different skills in a framework of action, but the consensus may be only temporary depending on how well it conforms to the requirements set by the specific context of application. In Mode 2 the shape of the final solution will normally be beyond that of any single contributing discipline. It will be transdisciplinary.

Transdisciplinarity has four distinct features. Firstly, it develops a distinct, but evolving framework to guide problem-solving efforts. This is generated and sustained in the context of application and not developed first and then applied to that context later by a different group of practitioners. The solution does not arise solely, or even mainly, from the application of knowledge that already exists. Although elements of existing knowledge must have entered into it, genuine creativity is involved and the theoretical consensus, once attained, cannot easily be reduced to disciplinary parts.

Second, because the solution comprises both empirical and theoretical components it is undeniably a contribution to knowledge, but not necessarily disciplinary knowledge. Though it has emerged from a particular context of application, transdisciplinary knowledge develops its own distinct theoretical structures, research methods, and modes of practice, although they may not be located on the prevalent disciplinary map. The effort is cumulative, even if the direction of accumulation may travel in a number of different directions after a major problem has been solved.

Third, unlike Mode 1 where results are communicated through institutional channels, Mode 2 results are communicated to those who have participated as they participate. In this sense, the diffusion of the results is initially accomplished in the process of their production. Subsequent diffusion occurs primarily as the original practitioners move to new problem contexts rather than through reporting results in scientific journals or at professional conferences. Communication links are maintained partly through formal and partly through informal channels.

Fourth, transdisciplinarity is dynamic. It is problem-solving capability on the move. A particular solution can become the cognitive site from which further advances can be made. But where this knowledge will be used next and how it will develop are as difficult to predict as are the possible applications that might arise from discipline-based research. Mode 2 is marked especially but not exclusively by the ever closer interaction of knowledge production with a succession of problem contexts. Even though problem contexts are transient, and problem solvers highly mobile, communication networks tend to persist and the knowledge contained in them is available to enter into additional configurations.

HETEROGENEITY AND ORGANISATIONAL DIVERSITY

Mode 2 knowledge production is heterogeneous in terms of the skills and experience people bring to it. The composition of a problem-solving team changes over time as requirements evolve. This is not planned or co-ordinated by any central body. As with Mode 1, challenging problems emerge, if not randomly, then in a way which makes their anticipation very difficult. Accordingly, Mode 2 is marked by:

- (a) an increase in the number of potential sites where knowledge can be created; no longer only universities and colleges, but non-university institutes, research centres, government agencies, industrial laboratories, think tanks, consultancies, through their interaction.
- (b) the linking of sites together in a variety of ways -- electronically, organisationally, socially, informally -- through functioning networks of communication.
- (c) the simultaneous differentiation, at these sites, of fields and areas of study into finer and finer specialities. The re-combination and reconfiguration of these sub-fields generate the bases for new forms of useful knowledge. Over time, knowledge production moves increasingly away from traditional disciplinary activity into new societal contexts.

In Mode 2, flexibility and response time are the crucial factors. Because of this, the types of organisation used to tackle these problems may vary greatly. New forms of organisation have emerged to accommodate the changing and transitory nature of the problems Mode 2 addresses. Characteristically, in Mode 2 research groups are less firmly institutionalised: people come together in temporary work teams or networks which dissolve when a problem is solved or re-defined. Members may then re-assemble in different groups involving different people, often in different loci, around different problems. The experience gathered in this process creates a competence which becomes highly valued and which is transferred to new contexts. Though problems may be transient and groups short-lived, the organisation and communication pattern persists as a matrix from which further groups and networks, dedicated to different problems, will be formed. Mode 2 knowledge is thus created in a great variety of organisations and institutions, including multi-national corporations, network firms, small hi-tech businesses based on a particular technology, government institutions, research universities, laboratories, and scientific institutes as well as national and international research programmes. In such environments the patterns of research funding exhibit a similar diversity, being assembled from a variety of organisations with a diverse range of requirements and expectations which, in turn, enter into the context of application.

SOCIAL ACCOUNTABILITY AND REFLEXIVITY

In recent years, growing public concern about issues to do with the environment, health, communications, privacy, procreation, and so forth, have had the effect of stimulating the expansion of knowledge production in Mode 2. Growing awareness about the variety of ways in which advances in science and technology can affect the public interest has increased the numbers of groups who wish to influence the outcome of the research process. This is

reflected in the varied composition of the research teams. Social scientists work alongside natural scientists, engineers, lawyers and businessmen because the nature of the problems requires it. Social accountability permeates the whole knowledge production process. It is reflected not only in the interpretation and diffusion of results, but also in the definition of the problem and the setting of research priorities. An expanding number of interest, and so called concerned groups are demanding representation in the setting of the policy agenda as well as in the subsequent decision making process. In Mode 2 sensitivity to the impact of the research is built in from the outset. It forms part of the context of application.

Contrary to what one might expect, working in the context of application increases the sensitivity of scientists and technologists to the broader implications of what they are doing. Operating in Mode 2 makes all participants more reflexive. This is because the issues which forward the development of Mode 2 research cannot be specified in scientific and technical terms alone. The research intended to resolve these types of problems has to incorporate options for the implementation of the solutions, and these are bound to touch the values and preferences of different individuals and groups which have been traditionally seen as located outside of the scientific and technological system. They can now become active agents in the definition and solution of problems as well as in the evaluation of performance. This is expressed partly in terms of the need for greater social accountability. But it also means that the individuals themselves cannot function effectively without reflecting -- trying to operate from the standpoint of all the actors involved. The deepening of understanding that this brings, in turn, has an effect on what is considered worthwhile doing and, hence, on the structure of the research enterprise itself. Reflection of the values implied in human aspirations and projects has been a traditional concern of the humanities. As reflexivity within the research process spreads, the humanities too are experiencing an increase in demand for the sorts of knowledge they have to offer (Cambrosio, et al)

QUALITY CONTROL

Criteria to assess the quality of the work and of the teams which carry out research in Mode 2 differ from those of more traditional, disciplinary science. Quality in Mode 1 is determined essentially through the peer review judgements about the contributions made by individuals. Control is maintained by careful selection of those judged competent to act as peers, which is in part determined by their previous contributions to their discipline. In this way, the peer review process is one in which quality and control mutually re-enforce one another. It has both cognitive and social dimensions, in that there is professional control over what problems and techniques are deemed important to work on as well as who is qualified to pursue their solution. In disciplinary science, peer review operates to channel individuals towards work on problems judged to be central to the advance of the discipline. These problems are defined largely in terms of criteria which reflect the intellectual interests and pre-occupations of the discipline and its gatekeepers.

In Mode 2 additional criteria are added through the context of application which now incorporates a diverse range of intellectual interests as well as other social, economic or political ones. To the criterion of intellectual interest and its interaction, further questions are posed, " Will the solution, if found, be competitive in the market? Will it be cost effective? Will it be socially acceptable?" Mode 2 quality is determined by a wider set of criteria that reflects the broadening social composition of the review system. This implies that "good

science" becomes more difficult to determine. Since it is no longer limited strictly to the judgements of disciplinary peers, the fear is that control will be weaker and result in lower quality work. Although the quality control process in Mode 2 is more broadly based, it does not follow that because a wider range of expertise is brought to bear on a problem that it will necessarily be of lower quality. It is of a more composite, multi-dimensional kind.

Mode 2 lies at the centre of the framework of this paper. This rather lengthy, technical excursus identifying the characteristics of a new mode of knowledge production has been essential, for a number of reasons. First, and perhaps most importantly, it presents the contours of the intellectual landscape -- the research environment -- in which universities, in the future, are going to have to participate. Second, this is also the environment in which many other types of institutions, including but not solely business corporations, will also have to operate. Third, if universities intend to practice research at the scientific forefront of many areas, they are going to have to organise themselves so that they can operate in Mode 2. One consequence of this is that they will have to become more open, porous institutions, more aggressive in seeking partnerships and alliances, than they are currently. Fourth, these changes are far reaching and profound and are themselves helping to establish the context within which relevance will come to be interpreted.

In the next section, we identify first some of the trends set in motion by the massification of higher education; and second, the impact of globalisation and international competitiveness on shaping the cognitive landscape on which all knowledge producing institutions are going to have to play. It will be clear from these presentations that the shift to Mode 2 is already well underway. Furthermore, these expositions will help to characterise the "dynamics of relevance" from which it will be possible to critically examine, in the subsequent sections, some of the responses that universities will need to make in order to adapt to the new knowledge environment. It is my contention that only with a firm grasp of the attributes of Mode 2 knowledge production and the transformations that it is inducing will universities be able to see the kinds of institutional adjustments which they need to make if they are to perform well, and remain relevant, in the future.

2. *The Changing "Dynamics of Relevance" for Higher Education*

Who will be the students in the 21st century? Who will be the main "consumers" of higher education, and what are they likely to demand? How will labour markets and employment relations be organised (e.g., the growth of independent contractors), and how will these trends affect individual decisions as to what to study and for how long? What are likely to be the most significant trends in the global economy? How are these likely to affect supply and demand for university graduates (and post-graduate degree holders), and what shape is this demand likely to take? Also, what will be the relationship between the tertiary sector and the private sector? Are tertiary institutions likely to become more frequent corporate partners in training and research, or will their institutional independence remain largely uncompromised? To what extent will learning be incorporated into the workplace as an accepted part of one's job responsibility, i.e. the growing integration of work and learning?

The notion of a "dynamics of relevance" in the title of this section is intended to draw attention to the fact that relevance is not a static concept but rather a functional one; one that is intended to be adapted to a particular, but evolving, techno-economic environment. The "dynamics of relevance"

must be related to the processes of higher education massification on the one hand and to globalisation and the strengthening of international competitiveness, on the other hand. As we have indicated, the former affects both the kinds of students and the institutional situations in which they will seek instruction and in which staff have to work and carry out research, while the latter touches the innovation process on which competitiveness depends. Globalisation, now so evident in financial markets, is increasingly characteristic of the realm of knowledge production. In so far as this process is altering the nature of research, it touches the heartland of the university, its modes of organisation, and its core values.

Since the end of World War II, universities have sought to establish themselves as the prime institutions for carrying out basic research, while applied research was left to government or industrial laboratories. Now, the global nature of knowledge production is rendering this institutional division of labour less and less relevant. Before turning to this phenomenon, let us first examine the consequences of nearly half a century of massification in the higher education systems of the world.

Massification of Education and Research: Customers for Higher Education

The development of mass higher education in modern industrial societies after World War II exhibited a rapid growth of enrolments, both in absolute numbers and in the proportion of the traditional age cohort. This was preceded or accompanied by a very large increase in the numbers of young people, first from middle and then from lower middle and working class origins, who were enabled or encouraged to stay on in secondary school beyond school leaving age to the age of transfer. Almost everywhere this required a reform of secondary education, and the creation of a comprehensive secondary school in place of or alongside the traditional elite secondary schools. A growing fraction of this new population was then enabled or motivated to qualify for entry to some form of higher education, either through passing the entry examinations (e.g., "A" level exams in the United Kingdom), or gaining the requisite school leaving certificate (e.g., the baccalaureate in France).

Behind this great increase in participation in formal secondary and higher education were a number of more or less independent forces: the democratisation of politics and society that followed World War II; the growth of the public sector that required more white collar workers (and university graduates); an expanding industrial economy that required more highly skilled and educated workers; the widespread belief that further economic development depended on a supply of educated manpower, especially scientists and engineers; and finally the attractiveness of education itself as a major element of the new welfare states, sustaining and legitimating democratic societies.

Growth in the numbers of students seeking a university-type education had a number of consequences for the systems of higher education. First came growth in the old, elite universities. This was followed by the creation of new universities, then the expansion of non-university forms of post-secondary education offering different or no degrees, and finally, the assimilation of the new sectors into the degree granting system. As the system became more diversified, the universities themselves became more differentiated, with the inclusion in both old and new universities of new faculties and departments representing subjects formerly excluded from them, preparing students for new or semi-professions.

All this involved changes in the character and aspirations of the student body, in the curriculum, in modes of governance, in relations between students and teachers, in forms of finance, and in the relations of the universities with other institutions in society. During this period, all forms of higher education admitted more first generation students from lower social strata, many of them mature students, staying on longer, preparing for other than the civil service or the old professions, often married and with outside jobs, and with fewer expectations that a degree gave them the right to secure careers. After some resistance, the curriculum began to reflect this changed nature of the student body, including their cultural and occupational interests. Meanwhile, older elite forms of higher education survived alongside the newer mass forms, particularly in elite subjects such as medicine, law, and classical languages, as well as in advanced seminars and in post-graduate studies generally.

The new institutions of mass higher education have begun to affect all the other institutions of society, both by creating large populations of scientists and engineers who spread out through the economy and captured jobs formerly held by technicians, and by producing even larger numbers of non-technical graduates who transformed jobs formerly held by non-graduates. Mass higher education created a growing market for new cultural products of all kinds, and a voting population prepared to support the further expansion of higher education and those aspects of the welfare state employing its graduates and serving their interests. The higher education system also underpinned the widespread distribution of initiative and innovation in the economy, and in several countries, but particularly in the United States, it made possible the explosive growth of small service and high technology industries.

Among the most significant effects of mass higher education, of special significance for the production and distribution of knowledge, is the great increase in the market for continuing education. With the emergence of a learning society, life-long study, as well as training and re-training, become possible and are taken for granted by large fractions of the population. This readiness to learn greatly increases the capacity of a labour force to respond to rapid technological change. It is at least as important as the innovations that support it, or the competitive markets that drive it. In this respect at least, the lesson of history has been grasped; a labour force of craftsmen organised around traditional habits and skills is the enemy of technological change, as continuing education is its friend.

Education and training in advanced industrial societies have the paradoxical task of preparing people to perform difficult jobs competently, while bringing them to accept that they will have to change their jobs and skills quickly and often. This requires not only training in the skills and habits themselves, but also the inculcation of positive social attitudes towards change. We can see both clearly in sections of the population which do not possess them, e.g., workers in traditional heavy industries, or miners, who have prided themselves on skills in a valued, life-long working class occupation. Those workers, many of them now among the long term unemployed, have been the real victims of rapid social change, as have been their occupational communities. Modern mass higher education teaches people not to become too closely devoted to one occupation or a single set of skills. It prepares them for the likelihood that both will change often and that they must travel fast. To travel fast one must travel light, in skills as well as attitudes. The only skill that does not become obsolete is the skill of learning new skills. This dynamic of higher education weakens many social ties and institutional links, which if left untouched would

hinder social, occupational, and geographical mobility. But these changes have also weakened family ties with as yet undisclosed consequences for the character structure of the second generation of post-industrial men and women.

The growth of mass patterns in research both resembles and differs from those in education. For one thing, research is inherently an elite activity, even when carried on by large numbers of people. It is done for the most part by people who themselves have had an elite higher education, at least in their post-graduate studies. In the past, recognition of competence to carry out research arose out of an intense socialisation to an academic discipline. The greater part of research still retains this character. But new patterns of research in Mode 2, emerging in and alongside universities, are related to the massification of higher education and are an outgrowth of it. These new forms of research involve close working relationships between people located in different institutions, not all of whom need be researchers. There are, thus, frequent interactions of university based research scientists with business people, venture capitalists, patent lawyers, production engineers, as well as research engineers and scientists located outside the university. The research itself is more likely to be part of a national programme directed to some socio-technical goal that may have originally arisen out of a line of academic research. Accordingly, it is likely to be sensitive to its commercial possibilities, and may be initiated or carried forward out of a sense of these possibilities. It may not be reported in the traditional way through scientific conferences and journals, but be confined to reports closely held by commercial sponsors. It may involve shared use of academic and industrial facilities and technology; is more likely to be transdisciplinary, and to be carried out by people whose disciplinary and institutional loyalties are ambivalent.

This style of research has visible consequences for the larger society. It raises ethical and political problems which in turn call for people with special training or sensitivity to those issues both in the generation of research programmes and in their evaluation. As a consequence, social scientists are increasingly being brought directly into research teams. Research in Mode 2 requires different patterns of funding than traditional discipline-based research. It depends less on funding from central government or non-profit foundations, and more on the firms, industries and social lobbies directly involved, though central government may add its money to that of the universities and private industry if it wishes to further research in specified areas.

The conduct of research in the context of application as well as its distributed nature mean that contemporary science cannot remain easily within the confines of university departments or academic centres. This is prompting the emergence of a host of new institutional arrangements, linking government, industry, universities and private consultancy groups in different ways. The tradition of university-based research is threatened by the encroachment of industry and the mentality and values of profit-making. On the other hand researchers in countries with traditions of non-university research feel the need to link their research institutions more closely with universities so as to be more open to innovation and intellectual competition. The movement of research from the university into other forms of organisation in which the university is only one participant has a parallel in training. A multi-billion dollar knowledge industry has developed outside established educational institutions, responding in more direct, and usually more effective ways to the needs of industry and the labour market. This is eroding of the traditional monopoly that universities have enjoyed in providing training and granting educational credentials with good currency in the private sector.

Patterns of Massification in Higher Education

A profound transformation of knowledge production inside and outside of universities is currently underway, one which both depends on and contributes to the progressive massification of higher education. In this section we will identify major elements of that transformation with a view to highlighting how they are likely to affect knowledge production not only in the sciences and technology, but also in the social sciences and the humanities. Ten shifts have accompanied the massification of higher education as it has taken place in most industrialised countries.

DIVERSIFICATION OF FUNCTIONS

Across most higher education systems mainstream undergraduate education and post-graduate training have become comparatively less important, as other activities such as part-time study and the continuing education of mature professionals become more important. Universities increasingly serve a growing variety of functions from the most abstract research to the most utilitarian training force. As a result the distinction between an institution's core and its periphery has become less clear. Some traditional functions and activities, like student associations and their cultural activities, are now more periphery than core. The total mission of higher education has become fuzzier and more diverse, more difficult to define and defend.

SOCIAL PROFILE OF STUDENT POPULATIONS

Students are no longer predominantly male and drawn from the upper middle and professional classes; nor are they destined to fill élite positions in society and the economy. Instead they are drawn from a much broader social base; the balance between the sexes is more equal; and most graduates now go, not to positions of leadership, but to join the vast middle-range salaried strata of the public services and private corporations. As higher education becomes a more common experience, prospective students are less often drawn away from their families and homes. Instead they frequently stay in place, enriching the lives of their own communities rather than refreshing metropolitan élites. The more equal balance between women and men, combined with the growth of feminism, has been a powerful influence re-shaping the intellectual contours of many subjects, especially in the human and social sciences. This is a good example of how higher education's changing social profile has radical effects on what its members think it worthwhile to study and teach. Also the democratisation of graduate origins and destinations means that the core skills and liberal values of higher education are being reinterpreted in different ways by groups which bring into the university the cultural and political currents and conflicts of the larger society. As knowledge production moves out of the university into the larger society, so the society's diverse values move in. The boundaries of the university are increasingly blurred by both tendencies.

EDUCATION FOR THE PROFESSIONS

Modern higher education systems are no longer dominated by the arts and the sciences. These core subjects have been covered over by layers of professional education: first, by the liberal professions; then by technical professions, principally the many branches of engineering and the technical sciences that accompanied the successive waves of industrialisation including the latest wave of the information sciences; by the caring professions which were stimulated by the growth of the welfare state; and most recently by the new upsurge by the enterprise professions, centred

upon business, management, and accountancy. The next wave may well have the environmental sciences at its core. The intellectual effects of the shift from liberal education to professional training have been often observed, but their cumulative effect may only become decisive now in re-shaping higher education.

TENSIONS BETWEEN TEACHING AND RESEARCH

Paradoxically, although higher education has moved towards a mass system of teaching large numbers of students, its fundamental orientation has tilted towards research. The product of élite institutions is seen to be knowledge in the form of scientific publications and technological devices rather than in the form of trained young minds. Most teachers, even in non-élite institutions, have reshaped their professional ambitions accordingly. The acceleration of knowledge production in the research enterprise serves to highlight the provisional character of all knowledge. It becomes increasingly difficult to sustain a coherent undergraduate curriculum, weakening even further the traditional concern of the universities to provide trained minds.

GROWTH OF PROBLEM-ORIENTED RESEARCH

Alongside the growing prominence of research an equally important shift has taken place in its character. Less and less it is curiosity-driven and funded out of general budgets which higher education is free to spend as it likes. More and more it takes the form of specific programmes funded by external agencies for defined purposes. This shift is also reflected in a changing view of university research. The emphasis has moved away from free enquiry to problem-solving -- perhaps with too little regard being paid to problem definition and articulation. It also is reflected in a changing economy of research. Projects are constrained by specifications of increasingly expensive equipment and by specialised skills of researchers. It is hard to obtain support for research which is not cost-conscious, leading to a rationing of equipment and personnel. The result is a squeeze of both actual and intellectual research possibilities entailing their concentration in certain locations only.

DECLINE OF PRIMARY KNOWLEDGE PRODUCTION

The emphasis in many research fields has switched from primary production of data and ideas to their configuration in novel patterns and dissemination to different contexts. One reason is that primary research has become very expensive because it requires access to sophisticated equipment and highly expert staff. In the social sciences and humanities there has been a drift away from monographs, which are more costly, to works of synthesis, which are cheaper to produce. Another reason is that advanced information technologies have made research results quickly accessible and ubiquitous. Active researchers no longer need to cluster, physically, around sites of primary knowledge production. Finally, the reconfiguration of new knowledge can be as exciting a process intellectually as is primary production.

BROADENING OF ACCOUNTABILITY

Another shift in higher education is from being inner-directed to becoming outer-directed, not in the sense of David Riesman's celebrated characterisation of post-war America but in reference to the self-image of universities as autonomous bodies. They perceive themselves largely as self-contained and self-referential institutions. Practices such as peer review and academic tenure

still reflect this view. University teachers once enjoyed high social status. Today, higher education appears in a different light. Universities form part of a larger and denser network of knowledge institutions that extends into industry, government, and the media. Both their autonomy and their monopoly position are reduced. This is reflected in a diminished social status of higher education teachers and in their relationships with other professional groups and the market. Knowledge is generated across rather than in self sufficient institutions.

TECHNOLOGY FOR TEACHING

Formerly students were taught in classrooms and laboratories, face-to-face and, ideally, in small groups. In the future it is likely that they will be also taught through computers, videos, television, and at a distance. One result might be that undergraduate education will be transformed -- for the better, if new technology encourages independent learning; for the worse, if it creates an alienating anti-humane environment or leads to mechanistic forms of learning. Another result might be to further weaken the already weak links between teaching and research. Teaching and research may occur in different places and might be funded from separate sources. Intellectually they may grow apart because technology-assisted teaching needs to be highly structured while research will deal increasingly with indeterminate knowledge.

MULTIPLE SOURCES OF FUNDING FOR HIGHER EDUCATION

Although in most highly industrialised countries the state will remain the predominant source of funding for higher education, block-grant funding is likely to be replaced by a more targeted approach, especially in research, and in undergraduate education by allocation mechanisms mimicking the market. At the same time non-state income is likely to become more significant with the state itself encouraging this shift. These changes in funding patterns will result in important intellectual consequences reinforcing the separation between research and training. The targeting of research funds is likely to lead to more mission-oriented research. But greater pluralism of research funds will also contribute to intellectual diversity, counter-acting perhaps other prevailing trends.

EFFICIENCY AND THE BUREAUCRATIC ETHOS

The last of the ten shifts in higher education is the least tangible but perhaps the most important one. It has two aspects. The first is the easily understood process of specialisation and fragmentation that have accompanied the division and sub-division of knowledge up to now. This cognitive phenomenon has marked the organisational development of the modern university. Faculties have become organisational rather than intellectual categories. Even departments are seen as largely administrative units rather than as intellectual centres. The real academic unit has become the course or research team. The second aspect relates to the pressure of remorseless specialisation that has led universities to abandon most moral and cultural claims transcending the accumulation of intellectual and professional expertise

CONSEQUENCES FOR MASS ACCESS

Taken together these ten shifts are likely to stimulate further the demand for access to higher education. They underlie trends routinely experienced by students, university teachers, administrators and researchers alike. The shift away from a standardised population of

undergraduates is not new. Going on to higher education is rapidly becoming as automatic as staying on at school after the minimum leaving age. The change in student profile away from middle-class males to a more balanced student population in terms of gender and class is irreversible.

Nor will the shift from the traditional arts and sciences to vocational courses be reversed even if tomorrow's students have more diffuse ambitions. Vocational courses may take on some of the general functions previously performed by academic courses. Once students were socialised into the prevailing intellectual culture through the classics, more recently through history or economics. In the future, business studies, perhaps with a green tinge, combining today's twin enthusiasms for enterprise and the environment, may fulfil a similar role.

The shift from teaching to research is likely to be complicated by the move towards greater mass access. The scientification of new subjects, by providing them with respectable research bases, will continue to boost research. The incorporation of new institutions into the extended university may stimulate their research ambitions, in the form of action research linked to teaching and professional practice. The need to concentrate research funds, especially at the high-cost cutting edge, will however encourage the emergence of mainly teaching institutions.

Both the shift from curiosity-driven to problem-solving priorities in research and the decline of primary knowledge production will be further stimulated by the growth of a mass education system. So will the shift from a self-referential autonomy of universities to a greater emphasis on accountability within a denser network of other knowledge institutions. The special privileges higher education could claim when it was still dominated by traditional universities will be more difficult to sustain when the educational system includes other private and public institutions and agencies with more mundane functions.

The changes in the now predominant pattern of undergraduate education, the spread of new teaching technologies especially in the United States, and the relative decline of small-group face-to-face teaching, are also likely to be encouraged by mass access, mainly on grounds of cost. The extent to which the new technologies will enter higher education and how they will blend with more traditional forms of teaching is still an open question.

The move towards plural funding will also translate into a wider-access system. Most governments encourage educational institutions to raise additional private income and governments everywhere had to reinterpret their responsibilities for higher education. These are no longer seen largely in fiduciary terms, as a public-interest obligation to maintain a healthy higher education system for scientific, cultural, and civic reasons. Instead governments increasingly regard themselves as the biggest and most powerful customer, buying student places and commissioning useful research. At first sight it looks as though this trend will continue as the system moves towards mass access. But it can also be argued that, as higher education takes on some of the universal characteristics possessed by compulsory school and near-compulsory further education and training, to define it in customer-contractor terms will become more difficult. The pressure then will mount again to satisfy less utilitarian expectations and to regain some of its lost civic quality.

The transition will be a highly complex process. Instead of a single strong flow there will be cross-currents, eddies, and even undertows. Massification is not leading straight to a Brave New or Big Bad World; its consequences are ambiguous. To explain these trends solely in socio-economic, political, and organisational terms, as is generally the case, leads to a failure to recognise their complexity and inherent ambiguity. Rarely are they examined in relation to shifting intellectual values and altered constructions of knowledge. Any analysis of higher education institutions must rest both on a perspective from the inside, meaning the scientific nature of knowledge, and on a perspective from the outside, the pressures exerted and expectations harboured by society.

Collegiality, Managerialism and the Fragmentation of Knowledge

Knowledge can no longer be regarded as discrete and coherent, its production defined by clear rules and governed by settled routines. Instead, it has become a mixture of theory and practice, abstraction and aggregation, ideas and data. The boundaries between the intellectual world and its environment have become blurred as hybrid science combines cognitive and non-cognitive elements in novel and creative ways. Similar changes have taken place in the socio-economic order, partly as a result of the impact of technology. Large and rigid organisations have been overlaid by new means of communication and production that are both more fragile and less formal. The impact of this post-industrialism has mirrored and reinforced the drift towards confusion in the intellectual world.

In this, the massification of higher education is a key phenomenon. To understand knowledge it is necessary to understand the institutions in which it is produced. The most important of these institutions remains the university or more accurately, the extended university. But the traditional university engaged primarily in the formation of academic and professional élites and in pure research is now only a small part of the spreading higher education and research systems possessed by most advanced countries.

Nor is it always the most important part. Alternative institutions like the polytechnics in England, once firmly regarded as second-tier, have grown to rival the universities. The so-called corporate classroom has assumed greater importance as the advanced training needs of knowledge-oriented companies have increased. R&D has flourished in an industrial environment. All, or most of, these arenas of intellectual activity can reasonably be embraced within the extended university. The advantages that these new locations of knowledge production have over traditional universities are two-fold. First, they offer more effective managerial models. In them, unlike the old universities, strategic planning is not inhibited by collegial government, nor tough choices obfuscated by the need to secure consensus. Second, they promise greater flexibility of response to fast-changing intellectual and professional needs. They seem to belong to a forward-looking enterprise culture sceptical of the traditional demarcations, taxonomies, and hierarchies that clutter the old academic culture.

Tighter management and greater flexibility highlight two important trends. The first is the effect of the managerial revolution that is taking place throughout higher education. This partial repudiation of collegiality has been most marked in new knowledge institutions on the periphery, but spread rapidly to the core of old institutions during the 1980s. As a result the university has moved much closer to an industrial pattern of organisation with senior management teams and

strategic plans, line managers, and cost centres. Just as universities have moved closer to a corporate model of management, so private corporations have become more collegial. Large rigid hierarchies of line managers have tended to be replaced by more loosely coupled networks of team managers, at any rate in more forward-looking industries, particularly those prominent in the creation of an information or knowledge society.

Despite this convergence, the effect on the university has been profound. This managerial revolution has not only produced a much tighter organisational framework but created at the centre of the university, in its administration, a managerial energy that competes with as well as complements the academic energy of its constituent departments and research teams. This new energy has combined with the older, slower bureaucratisation of higher education to produce institutions that reflect the growing complexity of the modern university and its importance both in knowledge production and in nation maintenance. Together they have re-defined the university in organisational rather than normative terms.

There seems to be a paradox here. Just when the university has become a more powerful centripetal institution, the knowledge which is its chief commodity has become diffuse, opaque, incoherent, centrifugal. This has taken three forms. The first is the ceaseless subdivision of knowledge of greater scientific sophistication. Many of today's most creative sub-disciplines have been formed by associating previously unconnected fragments of other disciplines. These new fields of inquiry tend to be volatile and parochial, both qualities which undermine the idea of a broader and coherent intellectual culture. The second is that wider definitions of knowledge have come to be accepted, partly because of the erosion of older ideas of academic respectability and partly because of the impact of new technologies. New disciplines have entered the curriculum of the extended university as taboos have tumbled, while technology has not only created new professions which demand new skills but radically affected what is possible in established disciplines. An over-arching discipline like information technology stretches all the way from the most abstract concepts of artificial intelligence, which address fundamental ideas of mind and logic, to routine skills training in the day-to-day use of computers. It has opened the way to a quantification revolution not only in the natural and applied sciences but in the human and social sciences as well. The third form of disintegration is the deliberately de-centred diversity and incoherence associated with post-modernism. Post-modernism has become a kind of sub-intellectual *patois*. Certainly it has become a formidable publishing industry in its own right.

These three forms are contradictory in their details. For example, the subdivision of science into expert fragments can be taken to represent the triumph of positivism; post-modernism can be taken to mark its death. But all three have had the common effect of making it almost impossible to talk sensibly about the wholeness of knowledge. Science no longer has a single strand, no shared method, no common preoccupations, no values which all its various branches share.

Yet what appears to be a contradiction between institutional coherence and intellectual incoherence, or the competition between managerial and academic values for possession of the university's soul, may conceal a deeper complementarity. The development of much stronger institutional management and the more organised co-ordination of higher education systems may compensate for the waning coherence of science. As disciplines have become less able to provide a firm framework, institutions have had to be strengthened by providing external scaffolding in place of internal strength. If the disciplinary centre will no longer hold, there is a need for powerful organisations and mercenary managers.

This dichotomy, however, may not offer a sufficiently sensitive description. A more accurate account might emphasise the growing interpenetration of academic and managerial practice within higher education. In areas such as continuing education, technology transfer and special access programmes for the disadvantaged, there is no easy separation between their intellectual and administrative aspects. These hybrid activities are shaped by both centrifugal forces, which reflect the diversity and incoherence of modern science, and the centripetal character of modern higher education with its greater managerial tautness.

It is not simply that the growing institutional strength of the university has compensated for the disintegration of a common intellectual culture, or of values and rules shared by all branches of science. It is rather that academic values and managerial practice have been brought together in unusual and volatile combinations. Old demarcations are breaking down between traditional universities and other higher education institutions because both are embraced within the extended university. There, the sharp distinctions between academic and lay players in knowledge production have weakened because the latter play a key role as brokers (or even creators) of science. The divide between teachers and students has likewise become blurred because with increasing numbers of post-experience courses and mature students, the latter may possess alternative skills and knowledge. As these demarcations crumble, more fundamental ones will be called into question -- those between theory and practice, science and technology, and even knowledge and culture. These organisational and intellectual transformations are not separate, or even parallel. They are contingent phenomena.

Globalisation and International Competitiveness

Competitiveness and globalisation involve a double contingency. The first concerns the emergence of a new international division of intellectual labour as a consequence of the fact that, now, many more countries and firms have acquired the capacity to use research and scientific knowledge produced elsewhere. Science has always been the most international of activities. Despite this feature, the actual ability to engage in scientific research is unevenly distributed throughout the world. As with production, scientific research undergoes constant shifts in international competitiveness, with new countries entering and old dominance patterns breaking up -- see for example, the growing pre-eminence of India in software design and engineering. There is clearly a relationship between excellence in science, especially basic research, and international competitiveness in production, but the relationship is not linear or direct. To be a leader in science is neither a necessary nor a sufficient condition to be pre-eminent in producing technologies for the world market. As recent studies have emphasised, the skills and knowledge developed in the context of basic research are equally important in the innovation process. (Pavitt, 1991; Williams, 1986). Equally important, in addition to supply side factors such as investment in research and human resources, are demand side factors such as growing levels of disposable income, which promote consumption and social experimentation with new products. Supply and demand factors together determine overall productivity growth.

The second contingency is related to shifts inherent in the globalisation of production and its differentiating effects on the production and use of scientific knowledge. While science is international, its funding mechanisms are still national. Although there is a marked growth in international scientific co-operation, mostly because no country can afford to finance the largest

scientific projects alone, and although scientists are among the most internationally-minded and mobile workers, their career paths are still overwhelmingly shaped within the context of individual countries. Technology and production are proprietary in nature, whether their ownership is national or multinational, but consumption of scientific knowledge and of advanced technological products and systems is a function of the level and distribution of overall economic performance. Countries that perform well economically are more likely to be consumers of the most advanced scientific knowledge. Conversely, the inability to participate in knowledge consumption leaves many regions and countries locked out of the economic action.

There is little novelty in identifying competition as a force which leads to the concentration of wealth in the rich countries. But it is not yet clear that globalisation is reversing this concentration. The convergence between science, technology, and consumption has contributed to the spiral of economic growth. Yet while it has brought in its wake the global diffusion of knowledge production, the inequalities of its distribution have become more marked and visible.

Unresolved tension exists here. Changes in the balance of power globally and the consequent re-configuring of economic units imply both that the component parts of the world economic system become both more, and less, dependent upon the system. More, because a higher level of skills and knowledge will be needed to manage complexity; less, because management capabilities will spread more evenly.

But those changes are also threatening for many regions of the world. As the products of worldwide competition penetrate everywhere and countries are swept up into its vortex, local industries may lose their markets and traditional craft skills their status. The attendant concentration of knowledge and resources may make their research and teaching establishments appear irrelevant to the tasks in hand. Attempts by countries to protect their institutions, industries, farmers, or workers by closing their frontiers and their minds to what is going on globally would launch them into a *cul de sac*. This is but one illustration of the potential volatility of environments which has been discussed previously. Still, what are the alternatives?

The conventional answer -- to lower all barriers to trade and competition -- seems naive. Many countries believe that such policies will not bring results within an acceptable period of time and, understandably, resist them. Different strategies are possible. Consider for example the Asian Tigers, or what is being done for the integration of the economically less favoured regions of Europe into the Economic Community. The general rule seems to be that successful players enter the turbulent world of international competitiveness with a good safety belt on. This safety belt often takes the form of government agencies committed to long-range planning and institutions capable of long-range, non-profit- or low-profit-oriented financial commitments. Latterly, it has been evident that existing protective measures were not sufficient prevent economic disruption throughout south-east Asia.

Still, the advantage does not lie unequivocally with large scale enterprise. Other possibilities arise because the vortex of competition and concentration reaches only some segments of contemporary life. Outside of them, space still remains for the small firm, the free-lance specialist, the mobile and versatile person. Side by side with large-scale, standardised production and consumption, there is a growing market for personalised service, customised products and local initiative.

PROBLEM-SOLVING AND ACCESS TO SPECIALISED KNOWLEDGE

Access to knowledge and expertise, re-configuring it in novel ways, and offering it for sale are becoming specialised business functions. New mediating organisations are being set up to provide these services. The demand is for much more than data or information, however technical. It is for knowledge, for the identification and solution of problems. Specialised knowledge is a crucial source of value-added even in mass-produced products. Because knowledge production is now a global phenomenon, knowledge industry firms need to have access to global intelligence.

These firms do not use knowledge merely to solve problems; they also generate it in Mode 2. They employ problem identifiers, problem solvers, and problem brokers. Their raw material is the global scientific and technological communities, regardless of whether these communities operate in Mode 1 or Mode 2, or are among the growing number of sites of knowledge production. Their success depends on the full utilisation of state of the art information technology. The demand for specialised knowledge requires increasingly sophisticated means of communication and data processing. This, in turn, stimulates the microelectronics, telecommunications, and computer sectors. These demands are leading to a profound structural change in the economy and industry. The new knowledge industries are the key to a new techno-economic paradigm -- the information technology paradigm.

The shape of this new paradigm is not yet clear. In this section only those elements of the new paradigm which appear to bear directly on the diffusion of Mode 2 knowledge production will be discussed: network firms and R&D alliances, high value-added firms, the interface between competition and collaboration. Rising factor costs and intensifying competition -- exemplified in the growth of the number of active partners in world trade -- promote cost and risk sharing schemes among firms, leading to network firms and R&D alliances. These firms and alliances in turn stimulate the growth of enterprises designed to identify problems involving specialised knowledge. These enterprises (which make up the knowledge industry) are crucial sources of high-value added on which national competitiveness and prosperity depend. Mode 2 knowledge production is deeply implicated in the emergence of this new techno-economic paradigm, a radical shift in the structure of institutions to meet the new requirements of knowledge production and distribution.

NETWORKS FIRMS, R&D ALLIANCES, AND ENTERPRISE WEBS

Over the past decade firms in many countries have formed new alliances. Although the details of these agreements and the sectors covered have varied, two broad trends can be identified. The first is the reversal of an inclination towards tighter management control of more and more factors of production. This tighter control over the firm's internal and external environments was thought to lead to increased profits. To this end firms tried to absorb elements that had created uncertainties in the production process. The second is that firms have ceased to try to carry out all their R&D in-house and have opted instead for collaboration.

The reversal of the first trend has led to the network firm. This type of firm exports costs by subcontracting activities to other independent firms, or by handing over formerly internal activities to quasi-independent units. These activities may be in manufacturing (making components etc.) as well as services (maintenance, cafeteria services). The economics of network firms depend on a

trade-off between the lower costs of internal operations and the higher cost of managing an increasingly complex organisation. Spreading fixed costs between firms and their new partners leads to improved profits. However this process cannot be seen simply in terms of conventional sub-contracting. In network firms the hierarchical relationship inherent in sub-contracting is replaced by medium term co-operative arrangements, and links between partners which are set out in detailed agreements. Similarly, hierarchical structures characteristic of the integrated multinational corporations are being replaced by new, horizontal relationships. The efficiency of these relationships depends on communication networks and well worked out, standardised, management principles (just in time stock control, etc.). These arrangements encourage flexibility and adaptation to unforeseen events even though the core corporation co-ordinates the marketing, and even the final assembly of products. The growth of new types of firms to supply specialist services, products, and advice of many kinds is encouraged.

Network firms are popular in mature industries where competitiveness is largely based on lowering fixed costs. However, the spread of robots, flexible manufacturing plants, and the substitution of economies of scope for economies of scale also encourage their growth. The popularity of network firms is likely to increase as products become differentiated and the pressures of uniformity slacken. Also local partnerships may make it easier for firms to adapt to demand and come to terms with many different and complex environments.

The move from vertically to horizontally integrated organisations is also reflected in the growth of inter-firm alliances. Such alliances are not based on the desire solely to externalise costs, but also to co-operate with other firms on common programmes. R&D and technology generation are especially likely to be the subject of such alliances. The reasons for this are several: rising R&D costs, the search for cross-fertilisation between research areas, and the need to set technical standards. Because alliances require reciprocal access to the R&D capacities of partners firms have had to change their behaviour. Traditionally, R&D has been closely controlled by corporate headquarters because it generated new ideas for future products and processes. With the growth of alliances, permeability is increasing. Flows of technological knowledge between firms are becoming more common. Even if individual transfers are closely controlled and limited to pre-competitive research, alliances involving co-operative R&D programmes help to open up internal corporate markets. This opening up remains restricted because knowledge flows only take place between members of the club. But as the number of clubs increases so too will the density of communication between firms. These two strategies -- the formation of network firms and R&D alliances -- are not incompatible. The same firm may externalise some of its mature operations while simultaneously establishing high technology alliances.

These two strategies can be seen as ways to minimise the most devastating effects of cut-throat competition. But more is at stake than self preservation. In a global economy where knowledge is increasingly the commodity being traded, a new contractual environment built using networks and alliances may be necessary to stimulate competition. Alliances, because they are more or less transient, encourage the endless configuring of knowledge and so promote diversity within the economic system. Diversity stimulates rivalrous behaviour which, in turn, strengthens competition. The apparent paradox -- that collaboration stimulates competition -- can only be resolved by clarifying how alliances, particularly R&D ones, function.

TWO LEVELS OF COMPETITION

The paradox of using collaboration to promote competition takes place at two levels. The first level of competition is among products for market share. Every firm employs a particular process technology to make products or provide services in the effort to increase its market share. High quality products and services, embodying more characteristics than consumers are being asked to pay for, and more efficient production methods, which permit prices but not profit margins to be reduced, are the dominant elements of competitive advantage. Further, every business stands in a hierarchical relationship with its competitors. Its overall competitive position is measured by its distance from the average performance of the competing group. Product quality and unit cost together define average performance at a given time. Above average businesses expand their market share; below average businesses stand to lose their market share, if they do not change their ways. How rapidly relative position can change depends on the properties of the market and the propensity of its competitors to expand. Firms with a static technology cannot hold their market positions for long and unless their market is sheltered they will not survive.

The second level of competition is created by the constant pressure to innovate. At this level competition occurs in terms of a particular design configuration and the ability of a firm to develop its potentiality. Second level competition is about creativity and resourcefulness. Were this not so large firms would always dominate the innovation process. By improving its technology a firm seeks to change its relative position in the competitive hierarchy. To maintain market share it must keep pace with improvements in average practice. Competition is like a race in which the finishing line is always receding.

The ability to innovate continuously is crucial to long term performance. It is the source of "created" comparative advantage which drives forward changes in terms of products on the first level. On the first level competition is concerned with technology, on the second level with knowledge and skills. It is here that we again encounter the universities. In competition on the second level, universities, as the primary knowledge producers in most societies, operating in Mode 2 play a key role in the competitive process.

Created comparative advantage results not only from resources but also from the creative combination of resources and resourcefulness. The novel element is that the relevant resources are increasingly human ones and widely distributed. The trend towards alliances is a natural outcome of the need to access these human resources. Resourcefulness consists in the ability to configure these resources and the source of the value-added lies in the precise constitution of the collaborative groups and in the skills of its members.

Competition on the second level is founded upon collaboration. At this level market selection is group selection. Competitive advantage for the individual firm depends upon the collaborative group with which it is associated, and this would shift if the firm moved to a different group. In forming alliances firms need not be the only actors. They may co-opt other resources and competencies such as government laboratories, research institutes, and university research groups. In forming partnerships and alliances firms are in fact making key strategic choices. They are making judgements about the knowledge and skills which will be most important to their long term performance.

The choice of a design configuration is amongst the most important that any firm ever makes. Increasingly this choice concerns partners. The growth of technology alliances and pre-competitive research reflect the fact that each design configuration requires a range of resources whose precise character will be unique. Collaborative R&D is an example not of market rigging or anti-competitive behaviour, but of the dynamics of group selection. The problem is not one of replacing competition with collaboration but of managing the transition from one level to another and back again. The collaborative, pre-competitive research produced by alliances provides an excellent example of Mode 2 knowledge production. This was the case with the search for an architecture for the fifth generation computers orchestrated by the *Alvey* programme in the United Kingdom, or the equivalent *ICOT* programme in Japan. In these programmes, the search was on for a fundamental design configuration which would guide a whole series of further developments. Each included experts from industry, government research establishments, and universities. Each set the agenda which would occupy leading researchers in computer science, electrical engineering and mathematics. As the design configuration emerges one may expect to see not only a transition from collaborative to competitive modes of behaviour, but also a reconfiguration of individuals into a succession of new teams.

Collaborative ventures are partly defensive innovations in that they are aimed at reducing or sharing risks and costs. They are also offensive innovations in that they extend the skill base of the firm and the range of knowledge available to it, thereby improving its ability to compete. Because specialist knowledge is produced, collaboration can be a source of sustained competitive advantage because it is very difficult to imitate.

The reason for this rather protracted discussion of globalisation and international competitiveness has been necessary because these processes are central to understanding what relevance is going to mean for universities in the 21st century. In particular, because the growth of the knowledge industries now constitutes the economic basis of international competitiveness, it has been necessary to expand the notion of competition and to drive home the point that the dynamics of competition take place at two levels. It is at the second level -- at the level of choosing a design configuration -- that firms first find it necessary to join teams, that is, to collaborate in the generation of knowledge. The parties understand that at a later time the ethos may shift from collaboration to competition.

It is at the level of choosing a design configuration that many challenging intellectual problems have to be addressed. Because significant advances in knowledge may emerge from these undertakings, some of the best scientists aspire to be part of these teams. This shift in locus of value added in the innovation chain to specialised knowledge has the effect of drawing universities, as knowledge producers, deeply into the competitive process. Thus, while massification has modified universities so that they can reach out to a broader range of students, international competitiveness is having the effect of drawing the universities, and others, into a new context of knowledge production. On both fronts universities need to enter more deeply into a different type of knowledge production process. The loop between teaching and research will be closed again as the role of knowledge in innovation continues to deepen. This is especially clear in the development of producer services.

THE SPECIAL IMPORTANCE OF PRODUCER SERVICES

The role of specialist knowledge is particularly evident in the development of producer services. Many observers believe that these will become the prime source of sustained high value-added to sectors as different as high fashion and motor cars. In each case the producer services sector uses specialist knowledge to provide solutions which give products, even mass-produced ones, their specific market edge.

Companies in the producer services sector are organised differently from those in mass-consumption sectors. They have no need of either the large investments or the hierarchical organisations employing large numbers that have characterised mass production industries. Indeed, such large scale operations are inimical to the sorts of communication upon which mutual learning occurs and problem-solving skills develop. In the producer services sector, data, information, and knowledge are the principle commodities traded. By continuously re-configuring these elements, firms are able to add value to a variety of other products and processes. Their competitive advantage lies in their ability to do this not just once, but again and again.

When the locus of value-added shifts from the creation of knowledge to its configuration, new types of productive workers must emerge to keep the process going. The groups that will give these firms their value will be problem solvers, problem identifiers and problem brokers (Reich, 1991). The form of organisation in which these groups will be most productive will not be hierarchical. It must have the capability to handle high density communications.

The producer services firm, then, takes on some of the characteristics of a spider's web. Each node is a problem-solving team possessing a unique combination of skills. It is linked to other nodes by a potentially large number of lines of communication. To survive each firm must be permeable to new types of knowledge. As this occurs, the sector as a whole becomes increasingly interconnected. These interconnections embrace not only other firms but also many other knowledge producing groups, be they in government research laboratories, research institutes, consultancy firms, or universities.

The growth of the producer services sector illustrates the importance of specialist knowledge to all sectors of manufacturing industry. It also reflects the new forms of organisation and types of skill required to capture the benefits that customised knowledge has to offer. The producer services sector is one element of an emerging knowledge industry. In this industry, knowledge, information, and data are the principle commodities being produced and traded. Competitive advantage lies in the ingenuity with which firms are able to reconfigure knowledge on a recurrent basis.

The success of the knowledge industry depends on the extent to which it is supported by an information technology infrastructure. This new infrastructure depends upon innovations in the telecommunication and computer industries that will make possible the ever closer interaction of an increasing number of knowledge centres. This new infrastructure is rapidly being put in place across the globe. Its effects will be pervasive and may in time lead to a new techno-economic paradigm.

The work of Chandler (1991) illustrates the importance of three types of investment in the genesis of industrial development in the early and middle parts of the 20th century. Briefly, these were investments in technologies capable of yielding economies of scale in production, in distribution, and in the management systems that would make both operate efficiently. This approach to manufacturing is sometimes called mass production and it is paradigmatic in the sense that it sets up a general framework for all production activities and their management. This paradigm was diffused initially within the United States but spread much more widely after the end of World War II. One of the implications of the paradigm seemed to be a trend towards increasing bureaucratisation of production. As more and more aspects of production and distribution fell under the management imperative, the size of organisations increased correspondingly. This led to a degree of horizontal and vertical integration and subsequent growth in power that Galbraith (1969) felt could only be adequately described as the emergence of a new industrial state.

It is in the nature of all systems that unchecked growth in a particular dimension eventually becomes dysfunctional, and this, in turn leads to different modes of behaviour. In the late 20th century some of the limits of the mass-production-consumption paradigm have become most evident in the ability of low wage economies to imitate advanced production systems and in the increasing demand for bespoke products. Currently, new forms of enterprise have begun to flourish with the particular purpose of supplying established manufacturing firms with much needed specialist knowledge, what are sometimes called producer services. Producer services are fast becoming a (some believe, the) principal source of high value-added in advanced industrial societies. The point is that the modes of organisation, the management, and the skill requirements of the services are very different from those which have characterised similar activities in the past. In particular, high value enterprises do not need to control the vast resources that were characteristic of some of the earlier forms of mass production. To be effective producer services do not need to be organised in large bureaucracies employing disciplined armies of workers following inflexible, technologically-determined routines. Indeed, many would argue that in fact high value enterprise cannot be organised in this way.

The emergence of producer services represents in our view the early stages of what may one day become known as the knowledge industry. In this industry, data, information and knowledge are the principal commodities that are traded. The value-added, or competitive edge, lies in the creativity to configure knowledge resources over and over again. When the emphasis thus shifts from the creation of knowledge to its configuration, new types of productive workers must emerge to drive the process. Reich (1991) has identified the groups that give the new enterprise most of its value-added as problem solvers, problem identifiers, and strategic brokers. The form of organisation in which they will be most productive will be characterised by flat hierarchies and a capacity to handle high density communications. Accordingly, "messages must flow quickly and clearly if the right solutions are to be applied to the right problems in a timely way. This is no place for bureaucracy." (Reich. 1991)

Most importantly for our purposes is the description of how knowledge is created in these organisations. It is worth quoting Reich at length because he describes very well, though in another context, what we mean by knowledge production in Mode 2. Creative teams solve and identify problems in much the same way whether they are developing new software, dreaming up a new marketing strategy, seeking a scientific discovery, or contriving a financial ploy. Most co-ordination is horizontal rather than vertical. Because problems and solutions cannot be defined in advance, formal meetings and agendas won't reveal them. They emerge instead out of frequent

and informal communications among team members. Mutual learning occurs within the team, as insights, experiences, puzzles and solutions are shared. One solution is found applicable to a completely different problem; someone else's failure turns into a winning strategy for accomplishing something entirely unrelated. It is as if team members were doing several jig saw puzzles simultaneously with pieces from the same pile -- pieces which could be arranged to form many different pictures.

"Whether you are talking about a project at the forefront of science (the human genome project), technology (fifth generation computer architecture), or a high value enterprise, the organisation that carries it looks less like a pyramid and more like a spider's web. Strategic brokers are at the centre, but there are all sorts of connections that do not involve them directly, and new connections are being spun all the time. At each point of connection are a relatively small number of people -- depending on the task, from a dozen to several hundred. If a group were any larger it could not engage in rapid and informal learning. Here individual skills are combined so that the group's ability to innovate is something more than the simple sum of its parts. Over time, as group members work through various problems and approaches together, they learn about one another's abilities. They learn how they can help one another to perform better, who can contribute what to a particular project, how they can best gain more experience together. Each participant is on the lookout for ideas that will propel the group forward. Such cumulative experience and understanding cannot be translated into standard operating procedures easily transferable to other workers and other organisations. Each point on the enterprise web represents a unique combination of skills.... Enterprise webs come in several shapes, and the shapes continue to evolve. Among the most common are: independent profit centres, spin-off partnerships, licensing, and pure brokering... The threads of the global web are computers, facsimile machines, satellites, high-resolution monitors, and modems -- all of them linking designers, engineers, contractors, licensees and dealers world-wide." (Reich, pp. 91 ff.)

This description shows very clearly the centrality of specialist knowledge in the production process and the need for very different forms of organisation to capture the benefits that this knowledge has to offer. We have described this development in terms of the emergence of a new industry to highlight the fact that in it knowledge will be the principal commodity that is handled and traded and as such it will require a new cadre of skills to make it function. New types of organisation and styles of management are required by high value enterprises. In particular, they are intrinsically global and will become more intensely interactive as the telecommunications web diffuses.

Transition to the Knowledge Industries

The dynamics of these changes point to a continuing transformation of higher education. At the core of this process lies knowledge and its modes of production and dissemination. In particular, notions of what is meant by science and how it is produced, disseminated, and ultimately absorbed into society are undergoing fundamental changes. Important kinds of knowledge are being produced not so much by scientists, or technologists or industrialists as by symbolic analysts, people who work with the symbols, concepts, theories, models, data, produced by others in diverse locations and configure them into new combinations.

The distinction between those who create knowledge and the symbolic analysts who configure it underlies the separation between knowledge-based and knowledge industries. Knowledge-based industries attempt to understand and improve the operation of a particular manufacturing process. They are concerned primarily with product and process development.

In contrast, the knowledge itself is the commodity traded by knowledge industries. It is produced in a variety of places -- universities, think tanks, government laboratories. But once knowledge is created it may be available for re-use in some other combination. In the knowledge industries, value is added by the reiterated use knowledge, reconfiguring it with other forms of knowledge to solve a problem or to meet a need. Firms in knowledge industries compete with one another in terms of the ingenuity with which they configure knowledge. This resource is the ultimate source of their created comparative advantage

The massification of higher education provides the base which enables knowledge industries to emerge. The diffusion of higher education through society had the effect of supplying a continuous flow of trained manpower for the industrial system. Research had already become a central function of the universities, initially in elite institutions and gradually in others. This process, at first slowly but later with gathering momentum, not only raised the general level of familiarity with science and technology and the methods and procedures of science, but also multiplied enormously the number of sites where research as a recognisable, professional activity could be carried out.

This process harbours an instability. By providing increasing numbers of scientifically literate graduates, the universities are continuously working to their own disadvantage by ensuring that the numbers of able, trained people outside universities rises continuously, relative to the numbers of those within. Many graduates continue to develop their specialist skills outside the walls of the university and are now in the position not only to understand what university researchers are doing but also are able to pass judgement on its quality and significance. In the future the institutions of higher education, and the universities in particular, will comprise only part, perhaps only a small part, of the knowledge producing sector. They are no longer in a strong enough position, either scientifically, economically or politically, to determine what shall count as excellent in teaching or research. Accountability -- the social demand for quality, performance, and value for money -- now involves a complex social process of legitimisation. Adjustment to these new pressures is changing the traditional organisation and structure of the university system.

Scientific research has become intrinsic to the notion of a university. Most of university research remains very small science, bringing together a professor and a few graduate students. Together, they constitute a nucleus of research activity, the research group. On the one hand, this arrangement is vulnerable; students graduate and leave if the university cannot offer them a position or continuing grants. Newer, younger students are as yet unproved as co-workers; they are an uncertain resource. To overcome the vulnerability associated with small size and high mobility, research groups become opportunistic in their search for research funding. If no long-term funding can be secured, the gap has to be filled by shorter term, more problem-oriented contract or consultancy work. Research priorities may need to be adjusted, often and quickly. On the other hand, the research group is a highly flexible. It is legitimate, even expected, that professors will work on a broad range of topics depending upon their curiosity, scientific interests, competence, and their ability to obtain the necessary funding.

From the perspective of the overall research system, the need for external funding encourages professors, and hence universities, to be responsive to societal demands. Flexibility also enables research groups to change research fields and to move quickly into new exciting areas. From the perspective of industry, this is a valuable asset and one of the reasons why universities are still seen as the primary site of competence in basic research. Since the training of young researchers is an integral part of the research process, the flow out of universities of young, inquisitive minds assures industry a continued supply of competencies trained in the latest skills and techniques. Industry, then, has a vested interest in keeping the reservoir full and flowing. So far, it has been able to achieve this at little cost to itself.

With the intensification of international competition, the extraction of economic benefit from university research, and from publicly funded research more generally, is now a matter of concern. It is seen less in terms of need for new knowledge than in terms of commercialisation of what is already available; less a matter of research than of technology transfer. This transformation is one of the most far reaching that we have described because it involves drawing the universities into the heart of the commercial process. The universities are no longer the remote source and wellspring of invention and creativity. Now they are part of the problem-solving, problem identification and strategic brokering that characterise the knowledge industries. While small university research teams are vulnerable to the mobility of young researchers, their strength lies in the knowledge networks to which they have access by dint of competence and the flexibility with which they can address new problems. These assets make them attractive to industry. The potential rewards are so great and so important for the university as an institution that no president, rector, or vice-chancellor can afford to leave the matter entirely to the whim of individual professors.

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The globalisation of the economy and the pressures of international competition are dissolving boundaries between nations, institutions and disciplines, creating a distributed knowledge production system that is becoming increasingly global. As we shall argue more fully below, universities are part this system. As such, they are now only one knowledge producing agency amongst many in an economic order where knowledge and skill are the principal commodities being traded.

The question is whether universities can adapt themselves so as to be able to play a more participatory role in global knowledge production. Failure to do so must surely count negatively in assessing their relevance. Unless universities become active in the collaborative teams that are the basis of competition at the second level (see above), they will necessarily play a reduced role in national economic development. The purpose of this rather extended progress route through globalisation, competitiveness, and collaboration in the choice of design configurations has been to drive home the point that in terms of relevance universities are now required to function in a larger, more complex environment than existed when they became basic research institutions after the end of World War II.

The Diversification of Efforts to Provide Relevant Higher Education

Delivery structures for higher education are diversifying rapidly in response to an emerging global market place for higher education fostered by telecommunication advances, increased student mobility, and institutional management cultures which emphasise cost-recovery and income generation. How is this diversification likely to manifest itself in the 21st century (e.g., increasingly specialised tertiary institutions, multiple forms of distance learning, diverse public/corporate partnerships for the provision of tertiary training, self-directed computer based study options, multi-institutional consortia of educational institutions or other institutional adaptations to the changing needs and circumstances of both students and employers)? What effect is this diversification likely to have on higher education institutions as we know them, and on the organisation of society as a whole? What will be the definition of higher education relevance in the decades ahead?

The New Context of Relevance: Interacting with Distributed Knowledge Production

Our aim, so far, has been to draw attention to the existence of a number of attributes associated with the new kind of knowledge production, and to show that these attributes possess sufficient coherence to be called a new mode of production. We have contended that just as Mode 1 has become the mode of production characteristic of disciplinary research institutionalised largely in universities, so Mode 2 is characterised by transdisciplinarity and institutionalised in a more heterogeneous and flexible socially distributed system. Having outlined its main features, we are now in a position to consider the implications of this development for the relevance of higher education institutions.

The massification of higher education and the appropriation, after World War II, by the universities of a distinct research function have produced increasing numbers of people familiar with the methods of research, many of whom are equipped with specialised knowledge and skills of various kinds. Massification is now a strongly entrenched phenomenon. It is international in scope and is unlikely ever to be reversed. On the supply side, the numbers of potential knowledge producers flowing out of higher education are increasing and will continue to do so.

This expansion of higher education has an implication that has so far been little examined. Not only are an increasing number of people now familiar with science and competent in its methods, but also many of these are engaged in activities which have a research dimension. They have brought their knowledge and skills to bear on a wide range of problems in contexts and situations often very remote from the universities where they were originally trained. Scientific and technological knowledge production are presently pursued not only in universities but also in industry and government laboratories, think tanks, research institutions, and consultancy firms, etc. *The expansion of higher education, internationally, has meant that the numbers of potential sites where recognisably competent research is being performed have increased.* The implication, not yet fully grasped, is that to the extent that universities continue to produce quality graduates, they are progressively undermining their monopoly as knowledge producers. Former graduates are now competent to pass judgement on university research and many belong to organisations which might perform this function just as well. Universities are coming to recognise that they are now only one player, albeit still a major one, in a vastly expanded knowledge production process.

In parallel with this vast expansion in supply has been the growth of demand for specialist knowledge of all kinds. The interaction of supply and demand for specialist knowledge has many characteristics of a market, but there are some crucial differences. The function of a market is to bring supply and demand into balance and to establish the terms of exchange. Traditionally, markets are understood to establish the prices at which the supply and demand of particular commodities will be in equilibrium. A market is a mechanism for allocating resources -- labour and capital -- to the production of commodities. It works most effectively in cases for which there is already a clearly specified demand and for which the factors of production are available. But markets also have a dynamic component. They can call forth new commodities, the demands for which barely exist. Or conversely, they can stimulate demand for commodities whose features are as yet unclear. In dynamic markets supply and demand mutually articulate one another.

Knowledge plays a crucial role in dynamic markets. It is an important source of created comparative advantage for both its producers and users of all kinds and not only in industry. In some of these markets the terms of trade are more complex than may be indicated by comparative levels of costs and prices, and the medium of exchange more subtle than money. For example, in the those markets which articulate the supply and demand for knowledge about the environment, there are many different kinds of exchanges amongst the many participants. However, the medium of exchange is a more complex blend of individual and social values than could be captured by monetary values alone. Because comparative advantage cannot be reduced to economic criteria such markets may be described rather as social than commercial markets, but they are markets nonetheless. Within such markets, the sources of demand are manifold. They come from society in the form of public enquiries of various kinds, from governments in regard to a wide range of issues such as the adverse consequences of high risk technologies, and from a whole spectrum of institutions, interest groups, and individuals who need to know more about particular matters. This complex set of actors form hybrid fora which provide stimuli for both the supply and demand of specialised knowledge. Both theoretical and practical knowledge is generated in these fora.

The requirement of industry for knowledge, particularly for the results of scientific and technological research, is widely appreciated. The expansion of demand for a flow of specialist knowledge amongst firms is perhaps less well understood. Specialist knowledge is often a key factor in determining a firm's comparative advantage. As the pressures of international competition increase firms have tried to meet the challenges presented through the introduction of new technologies. New technology is a necessary but not sufficient condition for successful innovative performance. Increasingly, technological innovation is seen to depend upon using specialised knowledge to develop technologies in directions dictated by competitive pressures. Specialist knowledge is used partly because it provides a constantly replenishable source of created comparative advantage and partly because it can be difficult to imitate, particularly by firms whose national culture does not yet support a well articulated science and technology infrastructure. Since, in many sectors, these firms represent the vanguard of international competition, specialised knowledge is at a premium but its acquisition is difficult and often too expensive for individual firms to replicate entirely in-house. To meet this exigency firms have become involved in a complex array of collaborative arrangements involving universities, governments and other firms, sometimes, but not always, from within the same sector. In each case supply and demand are mediated by something akin to a market mechanism. But again, it is not, or need not be, a narrowly commercial one.

In these markets knowledge itself may continuously be sought, but more often than not it is not readily available to be bought or sold, off the shelf, like other commodities. It is increasingly generated in the market nexus itself. In producing specialised knowledge markets operate to configure human and physical resources in a particular context of application. As a consequence of intensifying competition, the number of these contexts is expanding, but they are also transient. Markets are dynamic. They pose new problems more or less continuously and the sites of knowledge production and their associated networks of communication move on. Knowledge is produced by configuring human capital; that is, by team building. However, unlike physical capital, human capital is potentially more malleable. Human resources can be configured again and again into different teams that generate new forms of specialised knowledge. The ability to do this lies at the heart of many economies of scope which are currently regarded as crucial to survival in the marketplace.

The core of the thesis presented here is that the parallel expansion in the numbers of potential knowledge producers on the supply side and the expansion of the requirement of specialist knowledge on the demand side are creating the conditions for the emergence of a new mode of knowledge production. The new mode has implications for all the institutions -- whether universities, government research establishments, or industrial laboratories -- that have a stake in the production of knowledge. The emergence of markets for specialised knowledge means that for each set of institutions, the game is changing though not necessarily in the same ways or at the same speed. There is no imperative for all institutions to adopt the norms and values of the new mode of knowledge production. Some firms and universities are already a long way along the path of change and this is manifested in the types of staff they recruit and in the complex range of collaborative agreements that they enter. Equally, some firms have taken on the organisational attributes of universities. However, the institutional goals to be achieved, the rules governing professional development, and the social and technical determinants of competence will all need to be modified to the extent that the new mode of production becomes established.

The new mode -- Mode 2 -- is emerging alongside the traditional disciplinary structure of science and technology -- Mode 1. Indeed, it is an outgrowth of it. In order to make clear what is involved in the new mode of production, the attributes of Mode 2 have been contrasted with those of Mode 1 (see p. 10 ff). From this analysis, it will be clear that Mode 2 is not supplanting but rather is supplementing Mode 1. Mode 2 constitutes a distinct mode with its own set of cognitive and social norms. Though some of these contrast sharply with deeply held beliefs about how reliable theoretical and practical knowledge should be generated, they should not for that reason be regarded as either superior or inferior to those operating in Mode 1. They are simply different. To some extent, however, the way in which Mode 2 becomes established in a particular context will be determined by the degree to which Mode 1 institutions wish to adapt themselves to the new situation.

The emergence of a socially distributed knowledge production system means that this type of knowledge is both supplied by and distributed to individuals and groups across the social spectrum. Communications at institutional levels tend to be by-passed because of the need for rapid, flexible responses to problems. Although one may expect variety in the extent that Mode 2 becomes dominant, it is a correlate to the socially distributed knowledge production system which is now emerging. To the extent that institutions become permeable, then Mode 2 can operate. The degree to which current knowledge producing institutions become more permeable will not

alter the fundamental fact that knowledge production is becoming more widely distributed; that is, it takes place in many more types of social setting; it is no longer concentrated in a relatively few institutions; and it involves many different types of individuals and organisations in a vast array of different relationships.

Socially distributed knowledge production is tending towards the form of a global web whose numbers of inter-connections are being continuously expanded by the creation of new sites of production. As a consequence, in Mode 2 communications are crucial. At present, this is maintained partly through formal collaborative agreements and strategic alliances and partly through informal networks backed up rapid transportation and electronic communications. But this is only the tip of the iceberg. To function the new mode needs to be supported by the latest that telecommunications and computer technologies have to offer. Mode 2, then, is both a cause and a consumer of innovations which enhance the flow and transformation of information.

It is one of the imperatives of Mode 2 that exploitation of knowledge requires participation in its generation. In socially distributed knowledge production the organisation of that participation becomes a decisive factor. The goals of participation are no longer simply to secure some national advantage, commercial or otherwise. Indeed, the very notion of what constitutes an economic benefit and for whom is at the root of many debates not only in environmental science but also in biotechnology and the medical sciences as well. For example, the current push towards "clean" technologies is about more than just economic benefit. It is also about stabilising collapsing ecological systems and the health and well being of populations as well as commercial gain. This is to say that although Mode 2 is exemplified in this paper only in relation to knowledge production, it has co-evolutionary effects in other areas, for example in economics, the prevailing division of labour, and the local sense of community.

The appearance of Mode 2 is creating new challenges for governments. National institutions need to be de-centred -- to be made more permeable -- and governments through their policies can promote change in this direction. These policies will be more effective if, concurrently, they become more pro-active brokers in a knowledge production game which includes, in addition to the interests and ambitions of other nations, the policies of supranational institutions, such as the European Union. The effectiveness of governments' brokering abilities now underlies the competitiveness of their national innovation systems. This will be reflected both in their ability to participate in knowledge production that may be taking place anywhere in the world, but also in their ingenuity in appropriating that knowledge with their innovation system.

Ingenuity is required because sooner or later collaboration must turn into competition. This is in the nature of the wealth creating process as it is presently constituted. Simply to monitor the interface between competition and collaboration would be a difficult enough task. The managing of it to national advantage is a challenge that governments will neglect to their cost. As with scientists and technologists, governments, too, need to learn to operate in the context of application. Increasingly this involves working with supranational institutions. Some of these have political, social, and economic dimensions as in the case of the European Union. Others are more narrowly economic in their aims as with the North American Free Trade Agreement (NAFTA) or the General Agreement on Trade and Tariffs (GATT). A key question is whether these supranational institutions can play a role in the socially distributed knowledge production and, correlatively, how individual nations ought to position themselves relative to these larger systems.

It is perhaps ironic that it should fall to governments to punch holes in the very institutions that in an earlier day were established to maintain national science and technology capability. But along with many other apparently fixed notions, the purpose and function of these institutions must be re-thought in the light of the emergence of Mode 2. This will reveal the need for a different approach to policy, particularly for the integration of education, science, and technology and competition policy into a comprehensive innovation policy that is sensitive to the fact that knowledge production is socially distributed. In Europe, particularly, national policies that will enhance the potential of national institutions need to be developed in concert with those of the European Union. The developing countries, too, need to take stock. For many of them, access will continue to be a problem not only because capability is lacking but also because governments there still model their scientific and technological institutions on assumptions that no longer apply to the kinds of scientific and technological activities on which their aspirations depend.

A key change to note is that knowledge production is becoming less and less a self-contained activity. As practised currently, it is neither the science of the "universities" nor the "technology" of industry. It is no longer the preserve of a special type of institution, from which knowledge is expected to spill over, or spin-off, to the benefit of other sectors. Knowledge production, not only in its theories and models but also in its methods and techniques, has spread from academia to many different types of institutions. It is in this sense that knowledge production has become a socially distributed process. At its base lies the expansion of the numbers of sites which form the sources for a continual combination and recombination of knowledge resources. What we are seeing is the "multiplication of the nerve endings of knowledge."

Effectiveness in interacting with this distributed knowledge production is going to define relevance for higher education institutions in the 21st century. It is therefore worthwhile to explore some of the main domains where the impact is likely to be great and creative responses needed.

Implications for Universities

Some of the answers to questions concerning the relevance of higher education in the 21st century can be elicited from the characteristics of a distributed knowledge production system. As has been indicated, the emergence of this system has implications for the organisation of both research and teaching within higher education institutions. Perhaps the most difficult adjustments that universities will have to make derive from the fact that knowledge production is becoming less and less a self-contained activity. Furthermore, because of the complexity of the questions now being addressed and of the costs involved, research is increasingly a matter of the sharing of resources -- intellectual, financial, physical -- with a broad range of institutions, not only other universities.

In the new economic paradigm that is expected to govern relationships between higher education and society, relevance is meant to cover many things. Yet in one way or another, higher education is expected to contribute to the strengthening of international competition and the enhancement of the quality of life. But, as we have tried to demonstrate, in operational terms, this means being able to interact more closely with other knowledge producers; configuring resources around

different problems, not just once or occasionally but again and again, according to the dynamics of the particular problem context. Accordingly, the most relevant universities will be those who are competent at creating a presence for themselves within that range of problem contexts in ways which facilitate the attainment of their institutional goals. Relevant universities will be able to bring collaboration and the use of shared resources into the heart of their value system. To do this will involve many universities in substantial re-organisation.

Box 1. A Culture of Science versus a Culture of Research: A Note of Clarification.

The thesis presented in the first two sections of this paper is somewhat abstract, turning as it does on the distinction between Mode 1 and Mode 2. At the risk of considerable over-simplification, one could simply say that the argument is trying to describe a shift in the culture of knowledge production. If it is not too paradoxical, it could be said that this change reflects a shift from a culture of "science" to a culture of "research". Bruno Latour has expressed the principal differences underlying such a shift in a helpful but provocative way: "In the past century and a half, scientific development has been breathtaking, but the understanding of this process has radically changed. It is characterised by the transition from a culture of "science" to the culture of "research". Science is certainty; research is uncertainty. Science is supposed to be cold, straight, and detached; research is warm, involving, and risky. Science puts an end to the vagaries of human disputes; research creates controversies. Science produces objectivity by escaping as much as possible from the shackles of ideology, passions and emotions; research feeds on all of those to render the objects of inquiry familiar" (Latour, 1998). An abundance of writing exists on the philosophy of science, but what has been set out in the preceding pages is, in some sense, an attempt to characterise some of the elements that would have to enter into the sort of philosophy of research that Latour is advocating. It may be helpful, then, to regard the distinction between science and research as having similarities to the one we have drawn between Mode 1 and Mode 2. Some readers may find it more helpful to think about Mode 1 as "science" and Mode 2 as "research". A complication is that in contemporary parlance we have something called scientific research which seems to obscure any difference between science and research, so the distinction may not be that helpful after all.

We have argued that the current structure and organisation of universities reflect academically predominant views about the nature of knowledge production and that these views are articulated and embodied in main line philosophies of science, some of the characteristics of which are outlined in the above quotation from Latour. These beliefs are part of a larger field of shared understanding about the nature of science and how it should be organised and communicated throughout society. We need to ask about the implications for the existing structure and organisation of universities when the prevailing culture may no longer be "science" but research; or more accurately when the prevailing culture is shifting from the former to the latter. It is to be expected that a culture of research will have its particular structural organisational imperatives and that these might be different from current practice.

In the subsequent sections, we outline some the implications of a culture of research for the curriculum and the management of universities. In the final section, we will turn our attention to the implications of Mode 2 for the universities of the developing world. As we shall see, for these universities the emergence of Mode 2 is as much an opportunity as a threat. For it has not been contended in these pages that Mode 1 is going to be replaced by Mode 2 but that the former will co-exist with the latter. No doubt the forms of accommodation will vary greatly and depend, in

part, on how universities, as the primary Mode 1 institutions, respond to the potentialities of Mode 2. The key question must surely be: does a culture of research better serve the needs of developing societies than a culture of science, in the sense meant by Bruno Latour? On the surface, Mode 2 should have some advantages because, as we shall explain, a culture of research brings a wide range of knowledge and expertise to bear on the understanding of complex systems and this focus makes it more open to the needs of communities.

PARTICIPATION IN LEADING-EDGE RESEARCH

Universities, large and small, are now confronted with the challenge of how to accommodate themselves to the emergence of distributed knowledge production. In the case of research, in particular, the agenda and its funding are increasingly the outcome of a dialogue between researchers and users, regulators, interest groups, etc. Unless that dialogue produces a consensus no research will be done. Leading edge research has become a more participatory exercise involving many actors and experts who move less according to the dynamics of their original disciplines and more according to problem interest. Important intellectual problems are emerging in a "context of application" and scientists want to work on them. Pursuing problem interest means that academics will be away from the university, working in teams with experts from a wide range of intellectual backgrounds, in a variety of organisational settings. They will contribute problems and solutions that cannot be easily reduced to a recognisable "disciplinary contribution". Those individuals who would carry out research in this mode must adopt a different set of research practices and, I think, take a different perspective on their careers. But, if they do so, they will be out of "synch" with the existing reward structure of universities. Some say that the rubric of survival in academic research is changing from "publish or perish" to "partnerships or perish." How can existing university structures be modified to account of this fact?

It often seems that research centres, institutes, and "think tanks" are multiplying on the peripheries of universities, while faculties and departments are becoming the internal locus of teaching provision. This is to be expected because, as we have seen, the thrust of the new mode of knowledge production is that research in many important areas is cutting loose from the disciplinary structure and generating knowledge which, so far at least, does not seem to be drawn to institutionalise itself in university departments and faculties in the conventional way. Other modes of organisation seem to be preferred. From the point of view of the university, often the only way to accommodate new developments is to create new institutes and attach them in various ways to the university. What it means today to be "associated" with a university in the contemporary setting is reflected in a wide range of "responses."

Implications for the Curriculum

The organising power of Mode 1 is nowhere more evident than in the shape it gives to the curriculum. For example, a clearly recognisable similarity prevails in the contents of undergraduate courses in physics, chemistry, biology, mechanical engineering, economics or political science, no matter where in the world they are taught. The basic elements are similar, the structure of examinations similar, and the fact that so many graduates can go on to do post-graduate work in different universities, often located in different countries, attests to a similarity in academic and professional attainments. The delivery of these competencies is the prime job of the

faculty who, it must be noted, have been educated in a similar manner. One of the key functions of undergraduate education is to train the cadres who, it is expected, will go on to fill academic posts in universities.

For a time, this scheme of recurrence operated very well. In particular, it produced enough graduates of quality to fill the demands of the expanding higher education systems across the world as well as an expanding industrial and public sectors in many countries. During the same period, universities positioned themselves as primary knowledge producers and added a research function to their teaching function. The fact that teaching and research were carried out in proximity to one another was thought to provide a crucial link in the updating of curricula, ensuring that undergraduates were brought within sight of the latest developments in the disciplines before they completed their studies. In summary, for much of the post-World War II period curriculum development reflected a more or less continuous interaction between teaching and research. As a consequence, undergraduate curricula were driven by the intellectual development of each discipline; scientists and social scientists decided what was essential to teach, the institutions agreed and, for the most part, students accepted this situation.

With the massification of higher education, however, the demands placed upon higher education increased as well. Figure 1 illustrates very well the range of knowledge missions which a contemporary university must embrace. These missions include discovering new knowledge; developing knowledge; collecting, organising and preserving knowledge; applying and testing knowledge; transmitting and diffusing knowledge; and dialoguing with knowledge stockholders. As the figure indicates, to deliver on these missions universities as institutions must now engage in a wide variety of activities: basic research, applied clinical research, collaborative research, and expert consultations. They must award undergraduate degrees, supervise professional degrees, contribute to life-long learning, interact with civil society, and offer a number of direct services (Walshok, 1995, p. 156-7). Thus, as the knowledge missions have expanded, so too have higher education institutions differentiated themselves in order to carry them out. To continue to characterise universities as institutions which engage in teaching and research is not wrong, but it certainly does not grasp the complexity of institutional development that has taken place in the last 25 years.

These knowledge missions can be viewed as serving a number of broad social objectives: supporting economic (and increasingly regional) development; providing education across a life span; and supporting civic culture. Meeting these objectives involves different combinations of the knowledge missions and this, in turn, requires the development of much more complex sets of curricula than were necessary when the prime objective was to provide training for the next generation of academic specialists. In particular, the new curricula cannot any longer be intellectually driven to the extent they have been. To the intellectual content has now to be added suitability for purpose. Often this includes the acquisition of a number of practical skills: in problem-solving, in interpersonal communications, and in "learning to learn." But just as often it means acquiring the rudiments of more than one specialisation; for example, mathematics or statistics, computer science, some economics or management theory. In brief, the differentiation of knowledge missions has been matched by a parallel differentiation in content, duration, and mode of delivery of the curricula. The courses offered must now meet a broad range of objectives, from access to employment to life-long learning. Equally, this education must now be available in a number of formats, e.g., traditional lectures, tutorial groups, CD-ROM, and via the Internet.

Demand for higher education is diversifying. Can this demand for courses be met by the endless re-configuration of disciplinary fragments? The answer to this questions depends, in part, on another feature of contemporary science. Science itself has shifted its focus of interest from the discovery of the basic laws that will make up a unified science to the more modest and practical task of understanding the properties and behaviour of complex systems. Although "dreams of a final theory" persist, many scientists have taken the more pragmatic route of simply trying to understand how nature's and society's systems operate. It may be that one day all this knowledge will be integrated into a single unified system of laws, but many scientists doubt it. More importantly, abandoning the search for the "grand view" has not stopped them acquiring detailed understanding of discrete phenomena. Of course, such systems are of many kinds. They vary in size and complexity but they have not been constructed with the current disciplinary structure of science in mind. Rather, even the simplest systems seem to require a multidisciplinary effort to understand them. Further, understanding the properties of complex systems may lead to transdisciplinary knowledge in the sense which it has been defined above, because such understanding as is achieved is unlikely to be reducible to a set of disciplinary contributions.

MULTIDISCIPLINARITY AND TRANSDISCIPLINARITY

So far, the two factors we have discussed above, the multiplication of knowledge missions by universities and the shift amongst scientists themselves towards the understanding of complex systems, have been primary forces in the explosion of multidisciplinary educational provision. Practically, universities could do little else, being, as they were, home to the disciplines. It was natural that as scientists tried to grapple with complex problems, they constructed curricula which reflected the need for a multidisciplinary perspective. In the past decades, university courses have been hybridised into "something and something", or "something with something." So there emerged, physics and mathematics, biology and economics, and mechanical engineering with French. Each of these curricular developments were meant to meet one of the universities knowledge missions, often by targeting a particular audience or age group. Often, too, an interdisciplinary perspective was intended to provide a particular context for learning a discipline. So, for example, at Sussex University one can study economics in a school of European Studies, in a school of African and Asian Studies, or in a school of Legal Studies. The fundamental economic principles are presumably the same but the balance of relevance between them changes according to context. The curricular landscape is now crowded with multi-disciplinary and interdisciplinary products of these kinds and new ones are being created every day. There seems to be no end to the possibilities for this kind of hybridisation using as constitutive elements the knowledge produced by the disciplinary structure.

But this kind of development, as important as it is, has yet to pick up on the characteristic of Mode 2 that we described as transdisciplinarity. Transdisciplinarity is associated with the shift in the interest of scientists away from unified science to the study of the properties of complex systems. Complex systems whether natural or artificial are no respecters of the current disciplinary structure. To understand such systems requires a problem-centred approach, and such an approach will be transdisciplinary in so far as an adequate understanding, when achieved, may not be broken down, or reduced to, the disciplinary components that went into it. Often, in the course of understanding a complex system a new theoretical language is developed which is, then, used to guide experimentation and to help in the choice of the appropriate instrumentation.

In this way, the spread of Mode 2 (and with it transdisciplinarity) into the curriculum requires a shift from discipline-based learning to problem-based learning. Most universities are reluctant to embrace this possibility because their instincts tell them that solving problems requires a prior grounding in some discipline. Consequently, the tendency has been to insist on acquiring a disciplinary training first and then move onto problems later. Nonetheless, some other possibilities suggest themselves. For example, in the field of medicine, some medical schools have eschewed the normal approach to medical training based upon the prior learning of anatomy, physiology, biology and chemistry before confronting patients, in favour of teaching potential doctors how to build up "repertoires of problem-solutions." In this, student doctors learn how to find the knowledge necessary to explain the symptoms that real patients are exhibiting. In other words, symptoms set the problems and students learn how to use textbook knowledge to help solve them. Of course there may be many other sources of knowledge that are available besides that in the textbooks and, of course, finding out where to get expert knowledge and how to interpret it is a key element in this approach to learning. The belief is that by using a problem-based approach students will gradually pick up much of the knowledge that they would have acquired by going the other way around, i.e., beginning with anatomy and going on to the fundamental sciences and on from there to symptoms. This approach has been used in some university medical schools for a number of years but does not seem to have diffused very widely. It would be interesting to examine the reasons for the slow diffusion of this process and, more importantly, what difference each approach makes to the future diagnostic capabilities and clinical performance of doctors.

A second aspect of transdisciplinarity is both technical and methodical. The study of complex systems has been much influenced by the diffusion of increasingly technical instrumentation from one area of research to another. In this way, for example, instrumentation originally developed to identify the fundamental structure of atoms has diffused into various branches of medical research and even clinical treatment. But perhaps the most significant development has been the diffusion of computers and computational methods though all areas of research. Here the study of complex systems has been much strengthened by the spread of the techniques of computer simulation and modelling. The use of these techniques in so far as they make possible the identification of correlations amongst a large number of variables, have a powerful influence on the types of models that can be considered. Truly problem-based learning must include skills in computer modelling and simulations. This is the case whether one is trying to "reconstruct" an ancient archaeological site, some aspect of economic behaviour, or the properties of a molecular system. Much can be done, even now, with software packages bought off the shelf. The challenge for problem-based learning is to give students the skills to modify what is commercially available and to be able to tailor it to the needs of ever more specific problem situations.

The ability to work with complex models is a key element in transdisciplinarity. The correlations identified and the laws induced are often not reducible to those of a particular discipline. For example, in a recent report a group of scientists working on person-machine interfaces announced that they had now developed the basic "laws" of such interactions and that what was needed to was to extend the range of their applicability. One can only wonder at the "shape" of such basic laws for a system as complex as the relation of a human being to a machine. These "laws" are not universal ones like the law of gravity. Rather, they are "local solutions" to the behaviour of complex systems and no small part of the wisdom in applying them is to grasp their limitations. This, in turn, requires a firm grasp of the techniques of simulation and modelling that have been used to establish the laws in the first place. The development of curricula for Mode 2 would

Box 2. An Example from the Humanities: The Case of *Annales*.

A good example of Mode 2, this time drawn from the humanities, can be found in the emergence of the *Annales* movement with its distinctive approach to history. Perhaps the most influential historical journal of the 20th century is *Annales*, founded in the 1920s by Lucien Febvre and March Bloch. One reason for its influence is that it has nurtured a glittering school of historians. Febvre and Bloch, of course, remain its iconic founders. Febvre is best known for his study of the dark-age and medieval belief that kings could cure scrofula by touching sufferers, a belief anomalously maintained into the age of Enlightenment by the *ancien régime*. Bloch, shot by the Germans in 1944, is most celebrated for his study of medieval society.

Their heir was Fernand Braudel, responsible above all for institutionalising the *Annaliste* tradition in the sixth section of the *École des hautes études* and other strategic centres of intellectual life in France. In this way the *Annalistes* triumphed over potential rivals, most notably those more traditional social and economic historians who looked to Labrousse for leadership and inspiration, and secured a hegemony over history in France which has persisted to this day.

Braudel was also responsible for exporting the *Annaliste* tradition to the wider world, in particular Britain and the United States. In this respect his powers of patronage and organising abilities were less important than his personal achievement as a historian. He is author of the magisterial two-volume *The Mediterranean World in the Age of Philip II*, in which the immemorial peasant world of the Abruzzi and the famous Christian victory over the Turks at Lapanto are set in the grand flow, the *longue durée*, of historical change; of the even grander three-volume study of civilisation and capitalism, which sweeps the globe from the European heartland to pre-Colombian America and the Ming and Manchu empires, across the span of four centuries from the 15th to the 18th; and of two volumes of a history of France sadly uncompleted at the time of his death.

The *Annaliste* tradition has been passed down to a third generation of historians. Jacques Le Goff returned to Bloch's original preoccupation with the rhythms of medieval civilisation. Emmanuel Le Roy Ladurie, as the author of the best-selling *Montaillou*, a study of the Inquisition's inquiry into the Cathar heresy in the Pyrenean foothills, and of an equally novelistic account of carnival in 16th-century Romans on the Rhone, became one of the leading figures in the France of François Mitterand and is now director of the *Bibliothèque Nationale*.

Intellectual charisma and institutional patronage, however, cannot in themselves explain the eminence of *Annales* and the *Annaliste* historians. Its and their success are good examples of the flow of knowledge, or cultural, production in the humanities--but also an ambiguous example. In one sense *Annales* and its school are manifestations of Mode 1 knowledge, because they permitted the penetration of rigorous scholarship into hitherto neglected arenas and encouraged a social-scientific rather than literary-humanistic conception of history. Often this has had a hard scientific, even positivistic, orientation. It is largely through the *Annales* tradition that French historians learnt to apply the perspectives of physical geography and demography to the study of the past (although, revealingly, this particular aspect of the tradition received much less emphasis when the influence of *Annales* spread across the Channel and the Atlantic).

In another sense the *Annales* school exhibits many of the characteristics of Mode 2 knowledge production. Its promiscuous attachment to the social sciences, not simply the classic social sciences like economics, politics and sociology but anthropology and even demography, is proof of its endemic interdisciplinarity. This is also reflected in the topics made popular by *Annaliste* preoccupations. Strange, even shamanistic, beliefs have been recovered as legitimate subjects of historical inquiry alongside the dignified routines of polite intellect. The emphasis on *mentalité*, the rediscovery of past patterns of thought (which because of an equal emphasis on history's *longue durée* are also likely to be present patterns), demand qualities of creativity and imagination which are perhaps close to the radical reflexivity characteristic of mode 2. The novel-like quality of some *Annaliste* works is also not accidental. The idea of history as a story, in a naive sense, and as discourse, with all its post-structuralist baggage, has been rediscovered. Finally, the *Annales* school is fascinated by manifestations of popular culture, the magic hidden inside daily routines. All this represents a radical contextualisation of the study of history.

require the diffusion of these methods widely across most university courses. So far, simulation and modelling seem to be confined to post-graduate training, and within this, to the physical sciences and to economics in the social sciences.

Many of the elements referred to above can be seen in the evolution of the environmental sciences. Here the focus is on complex systems -- chemical, ecological, geographical, historical. The problem is often set by the malfunction of one of these systems or sub-systems. The approach is to understand how these various systems behave and, more importantly, interact with one another. Often extensive use is made of simulation and modelling techniques. Environmental science has, by now, almost become a distinct science with a language of its own. Unusually, though, its research agenda has been formed in the complex environment of public enquiries and the hybrid fora that these often constitute. It is a good example of a Mode 2 development not only in that it has achieved a degree of distinctiveness, but also because of the backward linkages that are now made between environmental science and the research agendas of other specialisms.

A NEW FOCUS FOR TEACHING

We have tried to expand on the differences between multidisciplinary teaching and transdisciplinary teaching as a way to concretise what in terms of the future development of curricula might be the implications of Mode 2 style of research. We have given some examples of academic development which seem to us to go somewhat beyond the process of hybridisation of the disciplinary structure. Still it must be said that there are many more examples of multidisciplinary than of transdisciplinarity. Although we may have come up short in terms of concrete examples for Mode 2, we have perhaps presented enough to grasp what would be needed if the characteristics of Mode 2 were to be transferred from research into teaching. Historically, the style of research we have labelled Mode 1 has come to reflect the structure and the content of the disciplinary structure. After all, it is no accident that undergraduate courses in physics, chemistry, biology, economics and many other subjects are also the main structural lines along which research is carried out. In fact, the use of the disciplinary structure in teaching was chosen because it provides ready-made the lines of communication along which new discoveries, techniques, and methods can systematically make their way into the training of the next generation of scientists. As we have seen, the growth of multidisciplinary research has led to the development of curricula in which more than one specialism can be studied as in the case, for example, of environmental sciences or more cynically of management science or of "business studies with anything!" But, Mode 2 involves much more than hybridisation. *Genuinely transdisciplinary curricula would, among other things, involve developing teaching programmes that are oriented to understanding complex systems, are based on participation in problem-solving teams, and draw heavily on modelling and simulation techniques.*

Mode 2 is not simply about the configuration of discipline-based knowledge, though it may take off from there. Mode 2 amounts to establishing a new focus for teaching. It moves beyond the hybridisation that has given form and content to so much inter- and multi-disciplinary curricular development and puts the focus of curricular development squarely on the training of knowledge workers. The orientation of curricula focuses squarely on problem-solving. The core skills to be acquired would involve the ability to use knowledge produced by others in new and insight-generating ways. It would imply training new cadres of knowledge workers which, following a

suggestion by Reich, we could call problem identifiers, problem solvers, or problem brokers. In multidisciplinary teaching programmes these three different aspects of problem-solving are not distinguished. Yet these distinctions are necessary because the role that information and knowledge plays is different in each function (see p. 30 ff.).

THE FUNCTION OF POST-GRADUATE STUDIES

Graduate research and training can be understood only in relation to the larger research system of which they form a part. Perhaps the most important implication of Mode 2 for universities -- and therefore for graduate students -- lies in the changed relationship between teaching and research. It will be clear from what has been said above that as Mode 2 develops, the structures that support undergraduate education and those that support research are going to diverge. Universities, as currently organised, are designed to carry out disciplinary research. Because this structure is also reflected in the undergraduate curriculum, academic faculty have access to a continuous stream of young researchers who can further develop the skills acquired during their undergraduate years.

Post-graduate training has been devoted to making students more effective specialists and to instructing them in how to make contributions to their specialisms. As far as national post-graduate students are concerned, this has been made possible through a system of research councils or foundations which is also structured along disciplinary lines and which provides research funds to tackle problems identified by discipline-based scientists. The most recent Research Assessment Exercise in the United Kingdom confirms that quality control via the disciplinary peer review process is still dominant, despite the fact that some effort has been made to evaluate multi- and inter-disciplinary research. A similar dominance can also be found in many other countries.

Yet, increasingly, research at the leading edge of a number of fields is being drawn up in the context of application. The research agenda is the result of a complex set of negotiations between producers and users of knowledge and in which academic researchers comprise just one actor amongst many. An inspection of the research agendas of any research council, foundation, government, or industrial laboratory increasingly confirms this. Attracted by the intellectual challenge of the technically difficult, many professors are being drawn into net-worked teams to work on particular complex problems. They do this knowing that the solutions to these problems may not be reducible to a particular disciplinary contribution but they realise that the context that is established and the channels of communications set up will provide professional stepping stones to the next set of problems. This is the imperative which prompts them to participate in this type of research. Over time, leading academic researchers pursuing intellectually difficult problems in this way might be expected to drift further and further away from their disciplinary backgrounds as they follow the challenges -- and the resources -- of transdisciplinary problems. Again, over time, as the new research practices take root, it might be expected that leading researchers would form a looser association with their universities than they do currently, their greater loyalty being to the collaborative, albeit transient, research group.

Post-graduate students are implicated in this process. In the future, they will spend the formative parts of their training working collaboratively in teams of various kinds, more closely tied to a shifting problem-solving context than to their original disciplinary training. This intellectual environment will demand different things from them for which, so far at least, very little formal training is available. For example, post-graduate students must be able to work "creatively" in

teams comprising individuals from very different scientific backgrounds, and they must become skilled at handling more than one intellectual framework and relating it to the current research problem. Thus, the apprenticeship model remains in force but in Mode 2 different skills and training are required. The current system of post-graduate training which is aimed at developing effective specialists needs now to be augmented by new kinds of intellectual and personal skills. But which ones and whether they can be taught by formal means remain as yet unclear.

A further point concerns international post-graduate students. Most universities value the presence of foreign students on their campuses, but to draw effectively on them requires that universities rethink their own roles in collaborative research. Once they do that it will be evident that not only will post-graduates play a different role in their institutions but that they will require different training as well. To be research-active universities must have access to a range of problem-solving contexts, since that is where the most intellectually challenging work is being done. Mostly, these contexts involve the collaborative integration of a variety of skills and, increasingly, this involves partnerships with other institutions, for the simple reason that no single university can itself afford the full range of skills required to be dominant in any particular context. In contemporary research, partnerships are essential and the choice of its particular partners is amongst the most important decisions that a university is required to make.

The key choices for universities are to identify those partnerships in which it feels it can contribute effectively through the sharing of resources. What universities now require is a carefully selected range of institutional arrangements in which the exchange of international students form but one element of the collaborative context. In this, international post-graduate students can be the "grease" that helps to make these partnerships function productively. Rather than pursuing governments to develop exchange schemes for international post-graduates or providing bursaries from their own resources as some universities are doing currently, universities need to develop international institutional partnerships and exchanges as part of their research strategies. If this were done, opportunities would be increased to develop a more diverse array of international post-graduate research training opportunities, more suited to the career needs of the next generation of researchers. For example, split PhD's in which international students spend part of their time in their home institution and part in another, perhaps receiving a degree from both, could become more common as could their sharing of teaching packages via the Internet. But split PhD's or jointly taught Master's programmes require as a pre-condition much closer institutional co-operation than a simple exchange or scholarship programme usually does. Inevitably, this would mean that international students would spend less time in the sponsoring or host institution and might even imply that they contribute less income to it. But the model of generating significant income by attracting international post-graduates is severely time limited and out of tune with the ways in which research is developing. It is time limited because it can only work as long as the professional capabilities which nations are continually striving to improve remain low. It is out of tune because the organisation of research is moving away from the traditional approach based on small teams of professors and graduate students towards one involving essentially transient and complex problem-solving teams.

Partnerships will not work unless the partners themselves are willing to put something into them. Universities themselves need to invest in, not merely sign, memoranda of understanding with other institutions, which is the usual response if they intend to attract international students and foster mutually beneficial collaboration. Government-sponsored exchange schemes can help but they need to be made more flexible, perhaps by rewarding departments that build up solid

institutional arrangements in particular areas with fellowship commitments for a defined time period. Such arrangements would move the debate about exchange schemes a long way from the issue of who benefits to the more easily identifiable practical gains to be had from sharing resources with other institutions in which international students play a concrete, discernible role. All countries need to enter into international partnerships in order to advance or maintain their competitive positions at the leading edge of research. Scholarships and more supple post-graduate research awards can facilitate this, but they cannot supplant the need for strong institutional alliances, particularly within developing countries.

Implications for University Management

Change in the management of universities is currently being driven by two imperatives: the need form partnerships and alliances; and the need demonstrate the quality of the services that are provided. Oversimplifying slightly, it could be said that the former pertains more the knowledge producing missions of the university, while the latter relates more to its knowledge disseminating missions (see Figure 1). But both present particular challenges to university management.

PARTNERSHIPS AND ALLIANCES

Partnerships are important for universities was well as academics. This is well illustrated by current developments in the field of technology transfer. Of late, many universities have become interested in technology transfer and in commercialising the results of their research. Some have invested significant sums in setting up science parks, technology transfer centres, and venture capital funds to assist academics in commercialising their work. The model being used to guide these activities is not so much wrong as out of tune with the research practices of Mode 2. The model of technology transfer which is operative at the moment is based on the image of the commercialisation process as a "relay race". In this view, some of the discoveries made by scientists within university departments are deemed to be capable of commercialisation but that there is a gap between the university and the marketplace. In other words, the ideas are there but for some reason the "baton" is not being successfully passed between universities and industry in the race to commercialisation. The solution to this dilemma has been to create a range of technology transfer organisations to bridge this gap, and to reduce the probability that the baton will be dropped and the race lost.

Technology transfer organisations are meant to mediate between the world of academe and the world of business. But in Mode 2, research is carried out in a context of application which is shaped from the beginning by an ongoing dialogue between interested parties -- including producers and users of knowledge. Accordingly, universities that want play a role in the commercialisation of research need to be involved in the research discussion from the outset. It is certainly not a game that can be played by limiting one's role to the discovery end of the process. The relay race model reflects a Mode 1 view of the knowledge production process with discovery up front and in the hands of universities. Rather than a relay race, the appropriate model for Mode 2 would be a soccer or a basketball game. In these games the ball (the baton) moves continually among the players. Nobody can afford to neglect either his own game plan or that of his competitors. In particular, no one leaves the field until the game is over. In this model, universities interested in generating an income stream from their research activities should put technology transfer amongst their core values. They need to form appropriate partnerships with

business and government and, in all probability, invest their own resources in this process. In brief, they need to become actively involved in a process which is less based on technology transfer and more concerned with technology interchange.

TECHNOLOGY INTERCHANGE

Over the past three decades most universities, whether in the developed or the developing world, have expanded their technology transfer/interchange functions. This reflects one aspect of the imperative to form alliances and partnerships. Change is rapid in this area and it is instructive to look at the predictions that have been made concerning the future shape of technology transfer/interchange in universities. An excellent scenario in this respect has been produced by Matkin (1990). By way of summary, and internationalising somewhat his observations, Matkin *predicts* that:

- Every major university will eventually articulate in formal policy and mission statements its commitment to technology transfer efforts and will reflect this commitment in its organisational structure and its resource allocations.
- At the same time that universities will be expected to increase their efforts at technology transfer, including the commercialisation of university research and support for economic development only indirectly associated with teaching and research, they will also come under increasing attacks. They will be told by both faculty and other stakeholders that they are being too commercial, not sufficiently protective of their reputation for objectivity, and that they are violating the traditional tacit agreement with the rest of society that they are not to be commercially-oriented.
- Institutional policy and practice, as well as academic culture, will increasingly allow those university faculty members who wish to become involved in activities associated with commercialisation of their research to do so. This will be accomplished without serious damage to the collegial atmosphere or to the notion that faculty owe their primary allegiance to the university. As universities recognise their obligations to serve society through technology transfer activities, institutional purpose and individual interest will converge.
- Organised units within universities staffed by professionals and dedicated to specific tasks related to technology transfer will continue to be formed and will increase their activity. Technology transfer (or some other expression for the same concept) will become the structuring principle under which these activities will be co-ordinated and overseen. One major thrust of this new organisation will be the co-ordination of relations with industry. The seemingly disparate activities of donor relations, corporate research partnerships, corporate-university economic development initiatives, student employment opportunities, continuing education, and technology licensing will come to be viewed as parts of a pattern of important and unitary interactions with corporations which need to be fostered and maintained over a long term.

- Every major university will eventually become a financial partner in start-up companies created to exploit that university's intellectual property. This financial involvement will extend beyond the passive ownership of equity in these new companies to some form of active participation in the generation of venture capital. In most cases this involvement will be formally separated from the university through buffer organisations.
- Total financial contributions to the university by industry will steadily increase relative to government funding. These contributions include gifts, research funding, payments of licensing fees and other direct payments for the use of university property, and membership dues and other special payments for access to the university. In addition, federal and state governments will increasingly recognise and reward universities for their efforts to interact with industry.
- Continuing education, both as an activity instrumental in the technology transfer process and as an organisational form within the university capable of facilitating technology transfer efforts, will become more important and visible. Depending upon a given university's academic culture, continuing education units may be empowered to undertake significant additional functions. In some situations the development of technology transfer may even contribute to the decentralisation of continuing education.
- Policies governing university and faculty interaction with commercial concerns will become more process-oriented and less proscriptive. This will result in the formation of special review committees designed both to protect university values and to foster appropriate university commercial involvement.

What these predictions amount to is a shift of technology transfer activities from the periphery of the university into the centre of its core values. While it is no doubt true that many of the activities described in Matkin's predictions can already be seen in various universities, there are very few cases where all of the changes he forecasts are occurring. And this is the point. *Both in the case of technology transfer and in the case of Mode 2 research, it is not that this or that aspect can be seen to be already operating in the university environment that is significant. It is only that when all (or most) of these activities or characteristics begin to appear together that sufficient cohesion will exist amongst them to initiate a major transformation.*

The CONNECT programme at the University of California at San Diego illustrates this point (Walshok, 1995, p.163 ff.). This programme was initiated by the university to foster economic development through entrepreneurship. Its specific mission and structure include:

- Providing financial skills and management support to entrepreneurs, typically scientists and engineers.
- Increasing interaction between campus-based researchers and industry scientists on important research issues as a way of accelerating the technology exchange and transfer process.

- Providing technical briefings on characteristics of new products, financing, R&D manufacturing, and marketing for service providers accustomed to working in traditional industries, as a way of building the competencies of regional attorneys, bankers, accountants, and marketing professionals.
- Creating opportunities for entrepreneurs, research scientists, and business service providers to interact on a regular and informal basis as well as through structured information and educational activities.
- Providing one-on-one technical and managerial assistance to individual entrepreneurs and companies.
- Increasing local companies' access to national and international sources of R&D funding and capitalisation.
- Increasing community awareness of the issues affecting the development of high-tech enterprises and of its potential economic returns through a programme of community education and media relations.
- Providing a community resource for data and information on the status of research activities and business development in the high-tech sector.

As with the predictions about the future technology transfer cited above, there is no element in the CONNECT programme which cannot be found in other universities. What is distinctive about CONNECT is the holistic approach to the University of California at San Diego's role in economic development, the creation of a suite of supporting institutions and programmes, *and the density of communications that characterises the interaction amongst those who are participating in the scheme.* The CONNECT programme offers a concrete example of the sort of developments which Matkin and others predict are going to become commonplace in universities throughout the world. Universities vary, of course, in the degree to which they are committed to change of this kind. But for most it is a major management and resource challenge to develop CONNECT-type solutions. Yet it is on the efficiency and effectiveness of programs such as these that university relevance in the 21st century will be bench-marked.

VIRTUAL UNIVERSITIES

Each of the knowledge missions of a modern university is affected by the provision of life-long learning (see Figure 1). As a major function of the university, continuing education is still in the very early stages of development. Indeed, few universities have attempted to work through just what a commitment to life-long learning would mean in terms of staff changes and modifications to the standard formats of teaching. For example, a university dedicated to life-long learning would need to be able to deliver an increased number of smaller course units, each of which would need to be accredited, and which, collectively, would need to build towards a recognisable qualification whether at the graduate or post-graduate level. Those universities that have begun to explore the possibilities of life-long learning (e.g., the Open Universities in the United Kingdom, Canada, and India) have realised that many of the course units need to be bespoke; that is, they need to be fit for purpose and be responsive to the needs of the "customer." Most realise that

these courses cannot be produced by simply cutting up existing syllabi into smaller units for consumption by the life-long learners. But if new course units are required on a significant scale, which will be the case if life-long learning moves to the centre of the university value system, sizeable amounts of new resources will be required.

A good example both of the scale of resources required and of the implications for universities that wish to become active in life-long learning can be seen in the recent establishment of the British Aerospace Virtual University (BAeVU).¹ This company-owned university regards itself as having 47,000 students (employees) who are in need of more or less continual educational investment. In other words, the British Aerospace is committed to a programme of life-long learning for all its staff, who for this purpose are regarded as "students." This is the demand side of the equation. On the supply side, BAeVU intends to fulfil its learning requirements by drawing, in the first instance, on the United Kingdom's higher education system. In the longer term, its intention is to tap expertise in universities internationally. The point is that BAe (the company) is developing clear ideas of what training its employees will need if the company is to prosper into the next millennium. And so a process has begun of trying to match supply to demand. It seems unlikely that any university will be able to respond to this demand by pulling courses "off the shelf", as it were; not because these courses are not good in themselves, but because they will not be matched precisely enough to the needs of BAe employees. To remedy this problem all universities will need to make major investments on the supply side if they intend to "capture a share of this market." As we have already indicated, if this were to take place on a significant scale the internal structure of universities would need to be re-shaped significantly.

The British Aerospace Virtual University may be an example of a movement that could become a trend. But what kind of "university" is it? BAeVU will draw for most of its course requirements on the conventional university system. It sees no point in duplicating this expertise in-house. All course elements that are agreed with existing universities would, de facto, be approved university courses. So there are two sorts of university in this equation: traditional universities supplying specialist courses on the supply side, and the configuring of the elements into a learning trajectory for each student-employee on the demand side. The value-added by BAeVU is precisely in configuring courses to its own needs, on the one hand, and to those of its staff, on the other hand. BAeVU is a virtual organisation providing a framework for life-long learning. It will not only make use of existing expertise but in the process it will also generate new courses with distinctive characteristics, such as the one already running in systems engineering. BAeVU is an example of a Mode 2 organisation. *It is the very embodiment of a knowledge institution, rather than a knowledge-based institution. Its primary functions are problem identification, problem resolution, and problem brokering* (see the above section on Implications for the Curriculum).

QUALITY ASSURANCE

If the formation of partnerships and alliances has more to do with research than with teaching (note the example of the BAe Virtual University above), then quality assurance under Mode 2 has more to do with teaching than research. In some countries, notably the United Kingdom, the pressure on universities to demonstrate that they have in place appropriate structures which ensure that they are delivering teaching of high quality is mounting all the time. As is the case with

¹ Other contemporary examples include the University of the Highlands and Islands in Scotland, and the University of Phoenix and the Western Governor's University in the United States.

research, quality assurance can be guaranteed in many different ways. In the United Kingdom, Australia, and, in time, other European countries, the process may be centralised in a government agency. In the United States and Canada, by contrast, it is likely that universities will maintain the privilege of guaranteeing their own quality assurance mechanisms, using the argument that the market will ultimately determine whether the courses offered are good enough. Whatever system comes to dominate, quality assurance will have to be much more complex as universities move to broaden the range of their knowledge missions. Hybridisation of the disciplinary structure is likely to continue to be the main mode of expansion in teaching provision. If Mode 2 research practices diffuse more widely throughout universities, however, entirely new assurance mechanisms will be necessary for the problem-oriented teaching that will accompany it. For example, if universities were to take on board the requirement of producing a new cadre of knowledge workers (i.e., problem identifiers, problem solvers, and problem brokers) both the curricula and the structures that carry them will need to be reassessed.

The development of quality assurance is a trend that is not going to be reversed. Therefore, one can expect to see the development of a new bench-marking methodologies and the production of a range of bench-marking studies right across the higher education sector. These studies will help to rank universities according to various quality indicators by region, by country and even globally; not only according to teaching and research but across the entire range of knowledge missions that we have set out in Figure 1 (Schofield, 1998).

We have already stressed that one of the distinctive characteristics of Mode 2 is new forms of quality control. In science as well as in university teaching, quality control has been exercised through essentially the same type of peer review system. Quality has been a matter for academics and academics alone. It has been up to them to determine when quality in both teaching and research has been achieved. In the quality assurance processes which are now emerging, a much wider range of factors is being considered. In the Mode 2 arena, universities will not be able to insist on criteria which reflect their intellectual interests alone. Universities will be one actor amongst several and the challenge for them will be to ensure that their legitimate interests survive the negotiation process.

THE RELATION BETWEEN TEACHING AND RESEARCH: A PRELIMINARY CONCLUSION

These developments in research, teaching, and management have consequences for the relation between teaching and research. Universities that wish to participate at the forefront of research will need to develop Mode 2 capacities. At the very least, they will have to become more open, porous institutions *vis-à-vis* the wider community, with "fewer gates and more revolving doors." They will have to become much more entrepreneurial in the ways that they utilise their "intellectual" capital, and this may mean experimenting with a much broader range of contractual employment arrangements. Numerous universities have already responded to some of the changes in the knowledge environment. But, to the extent that universities follow this path, they will be helping to establish two parallel structures within universities; one for teaching (Mode 1), and another for research (Mode 2).

If these developments are allowed to proceed, how will the structures which support teaching be related to one another? If they are to be related, what would the organisation of such universities look like? The most widely predicted outcome of these developments is that universities will respond by becoming either primarily research or primarily teaching institutions. Again, such

responses can only constitute a temporary solution that merely puts off the day when they will have to face the imperatives of distributed knowledge production in research and the provision of a corps of knowledge workers in teaching.

It should be clear from what has been said already that the emergence of distributed knowledge production has important implications for university teaching. As we have outlined above, advanced societies are experiencing an increasing demand for specialised knowledge of all kinds. The emergence of the distributed knowledge production system tells us that knowledge is now produced in a wide variety of institutions and that gaining access to that knowledge requires a new cadre of knowledge workers. As with research, teaching provision will require universities to access information and expertise from a wide range of sources -- including multi-mode delivery. Thus, on the teaching side the appropriate response of universities to this development should be to seek the teaching expertise they need wherever they can find it. But in doing so, they should see themselves more as curriculum configurers than providers of teaching. Teaching expertise will, in the future, be available from a wide range of providers. The best universities will make increasing use of this resource.

For the future, the key question facing each university has less to do with deciding whether to be a research or a teaching institution than deciding which modes of research (and teaching) it will adopt. To the extent that universities choose move in the direction of Mode 2, they set themselves the difficult internal problem of keeping research and teaching in some sort of relationship -- if, that is, it is still thought worthwhile to argue that a close association of teaching and research ought to be the hallmark of a university.

CORES AND PERIPHERIES: UNIVERSITIES AS "HOLDING" INSTITUTIONS

Universities that see technology interchange as a core value, that have "multiplied up" the number of partnerships and alliances that they are involved in, and that share their staff and other resources with problem-solving teams distributed around the world, need to be organised and managed differently. The existence of Mode 2 must induce changes in current organisational structures and this is perhaps nowhere so evident as in the perspective that universities will have to take concerning their intellectual capital.

Heretofore, universities have been seen as "factories" in which a variety of intellectual capital is employed. Faculty have been specialists, working according to the research practices which we have identified with Mode 1. The unit of organisation has been the department and graduate students have been the apprentices. Following the dictates of Mode 1, universities have elaborated the departmental structure and have recruited the best staff they could afford. Universities have often seen themselves as "owning" this intellectual resource and have used it to establish their reputations *vis a vis* one another. Permanent faculty working on specialist topics according to the criteria of "good science" set down by Mode 1 is the arrangement that dominates the university scene, despite the fragmentation it encourages and financial resources it requires.

In Mode 2, as we have seen, different rules operate. In the context of application the research agenda is formed and funds attracted in a different way. Researchers work in relatively transient teams on problems that are set in a very complex social process. And they move about according to the dictates of problem interest. Participation in these problem contexts is necessary to keep abreast with developments in one's professional specialisation. As a consequence, some of the

best academics are "tunnelling out" of their institutions to join problem configurations of various kinds. To some this is seen as a weakening of loyalty both to their institution and to their discipline. The responses to this institutional "brain drain" have varied but at their most benign they aim to "capture" the intellectual property of their staff before it is given away. Clearly, this will be a difficult exercise for those research activities which take place in the context of application.

If universities intend to operate at the leading edge of research, they will need to alter their view of intellectual capital. They will have to ensure that they are able to participate in the appropriate problem-solving configurations. If universities don't contribute "up front" in both money and in kind to these efforts, they will certainly not be able to claim any share in the commercialisation of the results. Yet so diverse and volatile are these configurations that no university can afford to keep "in-house" all of the human resources they would need to guarantee a competitive presence in a range of areas. If universities are short of cash, they possess considerable human capital resources which they can bring to the table. Universities will have to learn to exploit all the advantages to be had by sharing resources. The extraction of any commercial rewards will depend upon their willingness, as institutions, to become full partners in particular projects. Here, I believe, lies a fundamental challenge of the distributed knowledge production system for the future shape of universities.

A model exploiting the economies of shared resources would seem to demand a relatively small core of permanent full time faculty together with a much larger periphery of other "experts" that are associated with the university in various ways. To achieve this, universities will need to experiment with a much wider range of employment contracts, accepting the fact that they will not be able to own outright all the human resources that they need. To an extent this puts the universities in a Catch-22 situation. On the one hand, demands on universities in terms of both teaching and research are not only growing but are also diversifying and will continue to do so. On the other hand, the costs of holding in-house all the resources it needs to accommodate this expansion are too expensive and not flexible enough to meet changing demand. University vice-chancellors, rectors, and presidents in the future will be distinguished by their ability to utilise their intellectual capital together with intellectual capital held by others in a way that maximises their institution's goals. Such a strategy does not presume that every member of staff needs to be a full time employee. Once again, however, structural tensions will arise from these changes. How will these "part-timers" fare in the traditional university setting? How will their contributions be recognised? Will they be promoted? According to what criteria? How much will they cost? How will they relate to graduate students? Will they have to do any teaching? These are some of the questions that need to be asked. Nevertheless, it seems clear to me that they cannot be answered without changing the nature of universities substantially.

Implications for the Developing World

The universities of the world, whether developed or developing, are built around Mode 1 production of knowledge. In Mode 1, research is organised according to the disciplinary structure of science and the curriculum is built around the knowledge produced by the disciplines. In this paper, it has been argued that a new mode of knowledge production is emerging with distinctive characteristics and imperatives of its own, and that these touch, though in different ways, on the performance of research and teaching in universities.

The diffusion of Mode 1 is now a global phenomenon, in intention if not yet in fact. This means that research agendas in each speculum are to a degree set globally by the relevant disciplinary peer groups and that, again to a degree, a strong similarities characterise teaching programmes in the sciences and social sciences of universities around the world. The degrees of similarity are of course limited by the stage of economic development of each country. Given the dependence of Mode 1 on the use of increasingly sophisticated methods and instrumentation, the research agendas of science globally are more or less determined by the wealthiest countries. It follows that countries which are less well off economically will be compelled to accept research problems and priorities in which they participate little, if at all. Yet if they intend to be international players, and most of them do, then they must follow the agendas set by global scientific communities.

As we have stressed though these pages, one of the characteristics of Mode 1 is a very carefully maintained relationship between knowledge production and the socio-economic context. In brief, the relation is intended to be tenuous and considerable effort goes into keeping it that way. Science advances according to its own internal processes and these generate the range of problems that are thought by the relevant peer groups to be the ones which need to be addressed. While it is true that even in the wealthiest countries of the developed world this "aloofness" from social context has been gradually weakening over the past thirty years, it is still the case, particularly in universities, that the ideal of pure science remains intact.

Unfortunately, the ideology of pure science continues to retain considerable force in the universities of the developing world, despite the fact that it is precisely in the better universities that research practices are being changed. It is unfortunate because few of these institutions have the resources to pursue research agendas set by the developed economies. The dilemma for the universities of the developing world might be expressed in this way: most universities are "locked into" a mode of knowledge production that is based on the disciplinary structure, is capital dependent, and works on problems which are relatively context free. In contrast, scientific development in many developed countries is moving in the direction of "research in the context of application", aimed at understanding complex systems, involving fluid configurations of experts drawn from a range of institutions, in which capital and other costs are shared.

Naturally, many universities are reluctant to abandon a proven and familiar structure for another, unproved one. In them, the deeply held belief that Mode 1 is the only way to acquire fundamental knowledge continues unquestioned. But the fact remains that as a mode of knowledge production Mode 1 is not well suited to providing contextualised knowledge, except perhaps in the long term. Nor is it set up to work in the context of application. Yet the understanding of complex systems, many of which are local, is precisely what so many developing countries need. Moreover, they cannot wait until the disciplinary structure gets around to addressing their particular needs. Throughout the developed world, a certain impatience is emerging with regard to disciplinary science. This is manifested precisely in the formation of transdisciplinary groups to attack particular problems which each regards as important for it. Examples include many areas of health and medicine, environmental protection, and risk analysis. It could be said that in the developed world a certain "individualisation" of science policy is occurring. Fewer individuals, groups, and organisations in the developed world are content to wait for governments (through their national science policies) to put problems requiring research on the public agenda. In response, they are adopting Mode 2 forms of organisation to ensure that their concerns are addressed. Why should similar groups in the developing world not do so as well?

To meet both national and community needs a different organisation of knowledge production than Mode 1 is required. The elements of that organisation lie not necessarily in the wholesale abandonment of Mode 1, but rather in the developing of linkages between Mode 1 and Mode 2. Mode 2 needs to grow out of Mode 1. It is not expected to replace it in a simplistic way. The key elements have already been given: a focus on understanding complex systems, an intellectual orientation towards problem-solving, the use of computer simulation and modelling techniques, the teamed involvement of broad ranges of interest and expertise. All countries possess particular complexes of natural resources, local ecologies, and distinct economic and political systems. These could become the objective of exhaustive research, the more so if local teaching programmes were oriented to providing problem-solving skills. As soon as one begins to focus on understanding complex systems, the need for different types of expertise becomes obvious -- and the need for partnerships and alliances becomes an imperative.

The key mental shift in all this, which is already embodied in the distinction between Mode 1 and Mode 2, is to grasp that the understanding of complex systems requires the use of shared resources. These resources are now distributed both nationally and, increasingly, globally. That is why alliances and partnerships will be so important to both the developing and the developed worlds. No one country can expect to have "ready at hand" all the human, technological, and financial resources that are needed to reach an appropriate understanding of complex systems. Neither should it put in place policies which try to do this. Such a process is simply too slow and too expensive.

For similar reasons, the sharing of resources need not be a grand undertaking. Indeed, it can be eminently practical. Consider for example the proposal to establish the Southern African Universities Network in Extractive Mining (SAUNEM). All of the SADC countries possess abundant mineral resources. In each country, a mining industry and universities with a department of mining engineering or something cognate to it have been established. SAUNEM is simply a way to draw this distributed expertise into closer collaboration by pooling human and physical resources. It is not an exercise aimed at gathering the whole enterprise under one large research centre, but rather aims at simply improving the linkages between the various interests. Financial resources will flow from industry, government, and the universities themselves, but this is not a government project or even a priority. Donor agencies may be persuaded to assist, perhaps by purchasing particular items of expensive equipment. But it is more likely that they will choose to use their resources to strengthen the network properties of SAUNEM by promoting conferences, seminars, and exchange schemes for staff and students.

In terms of the language we have developed in this text, SAUNEM could be regarded as a "Mode 2 object," a device for aligning various interests and holding them together while project work gets underway. The universities of the developing world could do worse than develop a special expertise in setting up such Mode 2 objects. To be sure, the SAUNEM-type models already exist in many different areas of research. The point to note is that these initial experiments are forerunners of future models, and that many more of them will be needed to cope with the complexity of local environments and the needs of local communities.

There is a separate research agenda here which the countries of the developing world need to take charge of. It will not emerge from Mode 1. Left to its own devices, Mode 1 has a deep-seated interest in other (disciplinary) problems. As we have argued above, to produce competence in

setting up Mode 2 undertakings requires a different view of how research should be organised and of the type of "management" necessary to implement it.

Professor Brenda Gourley, Vice-Chancellor of the University of Natal (South Africa), has observed on a number of occasions that the contemporary rubric of academic survival has shifted from "publish or perish" to "partnerships of perish." She is surely right. Every knowledge producing organisation in the world has grasped the essential point that the production of knowledge needs to be a collaborative affair. From the point of view of universities, what needs to be recognised is that the existing organisational structures for research and teaching are not particularly well adapted to the formation of diverse partnerships which draw researchers from a variety of institutions into problem-solving contexts which are just as challenging as but are different from those that arise from within the disciplines. Why must challenging intellectual problems arise from only one quarter? The argument that there is only one way to arrive at genuinely fundamental knowledge is increasingly seen to be self serving. Fewer and fewer people believe that such knowledge will be of assistance in transforming their societies.

The challenge for the universities of the developing world, then, is to use their Mode 1 resources to extend their capabilities by means of programmes of collaboration in which the sharing of resources is central. This effort at extension will draw these universities into the distributed knowledge production system, focus their attention on the needs of their communities, direct their efforts to the understanding of local and national complex systems, and, in the end, create a new culture of teaching and research -- with relevance built in! If science will not help to solve the problems that the developing countries face, then maybe research should be given a chance.

IMPLICATIONS FOR DEVELOPMENT ASSISTANCE²

For the last half-century, higher education in the developing countries has been the beneficiary of considerable international development assistance. The World Bank, for example, has since 1980 contributed \$5.1 billion through 262 projects in 74 different countries. Other multilateral donors, notably the United Nations Development Programme, the Inter-American Development Bank, and the African Development Bank, have also made significant contributions. Bilateral assistance programs, particularly those of Canada, France, Germany, Italy, Netherlands, Sweden, and the United Kingdom, have likewise been major funding partners in disciplinary and management capacity-building efforts within national higher education systems. These efforts have been strongly complemented by smaller but well-targeted donations from private foundations such as Ford, Rockefeller, Carnegie, and Kellogg in the United States, and the Sasakawa Peace Foundation in Japan. Foreign training accounts for a significant share of this assistance. Other frequent uses of donor funding for higher education include library acquisitions, purchases of scientific equipment, research support, and the rehabilitation of buildings.

Whether by accident or design, development assistance has played a formative role in the higher education systems of developing countries. Although international funding generally contributes only a small fraction of higher education budgets at the national level, it produces effects much greater than what might be suggested by the size of these contributions. This is because while students, their families, and their governments provide the sizeable financing required for

² The following short section was contributed by William Saint, Senior Education Specialist, Africa Region, the World Bank.

university salaries, campus overheads, physical facilities, and consumable materials, development assistance tends to form the intellectual values and culture which prevail within institutions of higher learning in developing countries. It does this by concentrating on the transfer of knowledge, information, and professional behaviours which are deemed necessary in order for nations to progress. These transfers most often occur through training abroad, academic exchanges, north-south linkages, technical assistance, external examiners, research support, and the provision of textbooks and scientific journals. In the process, these activities may shape both a university's research agenda and the structure of its curriculum.

In this way, development assistance to higher education spreads and reinforces the dominant Mode 1 paradigm, facilitates the control of global disciplinary agendas by elite academic groups in the developed world, and helps to set the standards by which higher education quality and relevance are judged. By doing so, it may also impede efforts by universities in developing countries to prioritise local research problems, forge relationships with the local productive sector, and serve local constituencies. In Africa, for example, a decade of continental effort during the 1970s to create "development universities" ultimately had little impact, in part due to the reservations of foreign-trained disciplinary academics who were uncomfortable with problem-oriented approaches and to traditionalism among development assistance agencies that might have provided seed money for alternative approaches to higher education.

Because of the influential role played by development assistance to higher education, it is appropriate to ask whether a Mode 2 orientation might improve the impact of these programs in terms of national development goals. At a minimum, Mode 2 challenges a number of long-standing operational assumptions within the development assistance community. This creates opportunities for constructive reflection on prevailing models of assistance to higher education, and may lead to greater effectiveness and responsiveness in development co-operation. The following questions, cast in a Mode 2 context, seek to stimulate such reflection within the international development assistance community:

- Might not development assistance to higher education be more effective if assistance agencies worked through trans-sectoral or transdisciplinary teams shaped by the particular institutional development or capacity-building issues of the country in question, rather than using sectoral teams of education staff augmented by higher education specialists?
- Is it not more important to develop national innovation policies than national education policies?
- Should it not be a high priority for development assistance to enable universities in developing countries to establish strategic partnerships with other universities that share their interests, wherever they may be located?
- Should more concerted attention be given to building capacities for research and particularly for research management, and less to the provision of inputs for university teaching?

- Are development assistance efforts right to place so much emphasis on increasing enrolments in science and technology, or should they be emphasising curriculum reform to develop the skills needed for effective knowledge generation and problem-solving under the new paradigm: team-building, group creativity, information management, networking, communication, negotiation/mediation, and social sensitivity?
- Why not explicitly recognise the fundamental role now being played by communications in the process of knowledge generation, and consequently be more aggressive in promoting investment in electronic communications systems which enable universities in developing countries to link up with sister institutions and to access global reservoirs of knowledge?
- Finally, how can assistance agency staff possibly hope to initiate meaningful change in higher education when they themselves are products of Mode 1 and work closely with vested interests concerned with preservation of the traditional disciplinary structure?

In recent years, World Bank projects in various countries have sought to encourage such innovation and experimentation in higher education through the inclusion of funding earmarked for these purposes. For example, higher education projects in Argentina, Chile, Egypt, Indonesia, and Tunisia have incorporated competitively accessed funding for institutions seeking to test and learn from innovative efforts to improve educational quality, educational relevance, and management effectiveness. Likewise, Bank projects have supported research capacity-building and networked collaboration among research institutions in Brazil, China, Indonesia, and Korea. While none of these projects is designed specifically to promote Mode 2 approaches to research and training, they certainly provide opportunities for national higher education systems and institutions to explore and develop Mode 2 potentialities as their interests and circumstances permit.

The Social Return to Relevant Higher Education

How can higher education best contribute to the advance of societies and world-wide civilisation in the decades ahead? What kind of citizens will be required by the global village of the 21st century? What types of skills and values should they possess (e.g. cross-cultural communication, cultural adaptability, problem analysis, information management, negotiation/mediation, self promotion) in order to function effectively in an internationalised economy and society? What institutions in society are most likely to be effected by crisis in the next century, and what steps might higher education take to ease the disruptive impact of these transitions?

Who benefits? What kind of society are we creating? The thesis advanced in this paper has portrayed a university system that is caught in the midst of a major structural transformation in the way that knowledge is produced, legitimised, and transmitted. We have pointed to the emergence of a distributed knowledge production system as the vehicle that is going to support the emerging knowledge industries which, for the developed countries at least, will be necessary to sustain

international competitiveness. Distributed knowledge production is going to run alongside the existing institutional structure of knowledge producing institutions in which discovery and application have been separated, if not totally isolated from one another. In this set-up, the universities in particular were placed (or placed themselves) at the discovery end of the innovation chain, leaving the remainder of the chain -- development, production, marketing and sales -- to others.

In the new arrangements, not only are discovery and application now more tightly tied together, but also many more knowledge producers are involved. In the new arrangements, the definition of relevance has changed. Relevance is now less tied to generating new knowledge -- to making discoveries -- and more dependent on the ability of higher education institutions with link with others in the production of knowledge in the innovation process. Relevance in this context means

that universities will play a more explicit and active part in economic development, whether at regional or national levels. If universities don't take on this new role, they are going to be marginalised because other knowledge producers will emerge to meet the demand for what is required. That is the significance of the distributed knowledge production system, and many of the world's best universities have for some time now grasped the point.

The Emergence of a Culture of Accountability

The developments in knowledge production described above form part of a much larger shift within society. They are part of the emergence of what has been called a new techno-economic paradigm. This new paradigm involves, in addition to the massification of higher education and the globalisation of the world economy, a major shift in the nature of work, and the nature of employment, in general, and of the career expectations of researchers, in particular. One aspect that runs through all these social changes is the emergence of a culture of accountability that applies to all institutions, public or private. This culture has many dimensions, but the one which gets the greatest attention when talking about the future of universities is that aspect of accountability which is firmly linked to the spread of managerialism and to the ethos of value for money throughout higher education. Much of the angst in higher education about the spread of this culture arises from the rather one-sided view in which accountability is seen as a threat to university autonomy. Through the incursion of government into the determination of quality in teaching, the spread of an ethos of commercialism into the performance of research, and of attempts to abrogate the universities' mandate to act as the "conscience of society," accountability is thought by many to signal the end of independent universities. This is a mistake. Accountability is only one aspect of any institution's relations with the wider society. Other relationships, if cultivated along side accountability, can work to strengthen university autonomy rather than weaken it.

The kind of relevance that seems to be accompanying Mode 2 does indeed involve the closer integration of higher education to society and its needs. But this closer integration should not be conceived narrowly, nor can it be applied mechanically. As we have seen, collaboration amongst a wider range of social actors is now among the imperatives for the production of knowledge at the forefront of many of the most advanced areas of science and technology. Indeed, one of the attributes of Mode 2 knowledge production is the greater sensitivity to the context in which research is being carried out that we have called "enhanced social accountability."

The problem lies, I suspect, when one associates increased accountability with reduced autonomy. This is a false dichotomy. The opposite of accountability is not autonomy but trust. What has happened *vis a vis* the universities (as well as many other public institutions) is the collapse of public trust. It is this, perhaps more than any economic imperative, that has led to the growth of an accountability culture. During the "golden years" of government largess, trust was allowed to atrophy when many universities temporarily forgot that they had other constituencies to serve besides government. That these relationships had been neglected became clear to the universities when the flow of government funds, particularly for research, began to slow.

Universities and Society: Accountability, Markets and Trust

Accountability is only one of three fundamental ways in which the university is linked to its supporting society. The others are trust and the market. Every institution is linked to its support community through some combination of these links. Each institution has a kind of social contract with its society, and its support community in that society, that defines the relative weight and combination of these three kinds of links. Over the past fifty years, it is arguable, the pattern of those links has been distorted in many countries by the injection of public funds (including foreign development assistance) into higher education. During that period, accountability -- the obligation to report to others, to explain, to justify, to answer questions about how resources have been used -- was allowed to go unarticulated as were higher education's links to its local community (relationships of trust) and to industry (links to markets). During the process, the autonomy of universities was thought to be well established but it wasn't, as soon became evident when questions about accountability became more frequent and more searching. At this point the universities woke up and found that market and trust relationships to their communities were not in place to help them. Situation: panic.

Universities need to rebuild these other dimensions of interaction with their supporting communities. The emergence of Mode 2, and of the socially distributed knowledge production system, provides imperatives which if universities take them on will strengthen the universities' links to the wider community and also keep them in the forefront of teaching and research. A university which stands on the three legs of accountability for public money, close links with the market for its services, and the trust of its local communities is surely not only more stable but also more autonomous (Trow, 1996).

Perhaps we have gone too far in developing our thesis because we have accepted for the purposes of presentation a managerial vision of the future university. We did this for two reasons. First, because we believe that this will become the dominant paradigm governing the evolution of the university's relationship with society and thereby come to define what relevance in higher education is going to be, as far as public funding is concerned. And second, because the economic paradigm provides a springboard from which to raise the deeper issues concerning relationships between the university and society that never seem to be discussed as long as one is focused on the managerial/autonomy-reducing aspects of the new regime.

We have outlined above three dimensions of the university/society relationship among which the economic -- the sphere of accountability, managerialism, and the ethos of value for money -- is only one. The others have to do with the establishment of a working relationship with markets,

not in any narrow sense but in terms of how the university might consider expanding its range of services to potential customers beyond first degree programmes for the 18 to 21 year-old age group, and with the degree of trust that governs the university's relationships with local communities and with alumni. There is little doubt that each of these three should play a part in defining the relevance of higher education in the 21st century. In the short- to medium-term, it may be true that coming to terms with the emerging culture of accountability is more pressing. But it does not follow that other linkages should be neglected altogether.

Summary

The model we have presented articulates a view of higher education relevance in the 21st century that founded on changes that are presently taking place in the production of knowledge. This point of departure has been chosen not because we regard research as the most important function that universities carry out. Rather, it is to draw attention to the fact that for the most part universities are organised according to the structures of disciplinary science and that these structures are being altered by social forces. Further, if the rules governing the production of knowledge are changing, then it is to be expected that the criteria of relevance will shift as well. Change at such a fundamental level is bound to affect not only research but also teaching. With regard to the latter, it is in the context of the increasing demand for specialised knowledge of all kinds that developments in teaching, including multi-mode delivery, need to be placed.

A major transformation is the emergence of a distributed knowledge production system. Within this system knowledge is characterised by a set of attributes that we have labelled Mode 2. The significance of distributed knowledge production for universities can hardly be underestimated. The main change, as far as universities are concerned, is that knowledge production and dissemination -- research and teaching -- are no longer self-contained, quasi-monopolistic activities, carried out in relative institutional isolation. Today universities are only one amongst the many actors involved in the production of knowledge, and this is bound to govern, to some extent, the future relationships that universities will seek to establish. Equally, teaching must take account of the fact that more and more knowledge may not find its way into textbooks as conventionally defined and that disseminating knowledge, at the leading edge, may take place in the context of the research process itself. In this situation, more use will have to be made of the potentialities of the new information and communication technologies. The challenge here is not really one of delivering teaching on the Internet or via CD-ROM's as is so often discussed, though it may be expected that as software improves so too will the quality of the courses delivered in this way. No, the real challenge for universities of the distributed knowledge production system will be to take the lead in the training of knowledge workers -- individuals who are skilled and creative at making use of knowledge that may have been produced anywhere in a global distributed knowledge production system.

In distributed knowledge production systems, as we have indicated, the research practices of universities and industry, as well as other knowledge producers, are drawing closer together. All are now, in effect, in the knowledge business. The fact of globalisation means that for each actor, the bulk of the knowledge that they will want to use will be produced elsewhere. Admittedly somewhat impressionistic statistics indicate that over 90% of the knowledge produced globally is not generated in the place where its use is most required.

The challenge is how to get knowledge that may have been produced anywhere in the world to the place where it can be brought to bear effectively in a particular problem-solving context. This requires the creation of a cadre of knowledge workers -- people who are expert at configuring knowledge to a wide range of applications. We identified in the text some labels for this new corps of workers -- problem identifiers, problem solvers, and problem brokers. Universities have been far more adept at producing than re-configuring knowledge. It therefore remains an open question at this time whether they can make the necessary adjustments.

Universities will need to explore this possibility vigorously because universities are expensive to run and it is not out of the question that, in terms of economics alone, disseminating "textbook" knowledge using the potentialities of information technology can be more efficiently done by others. The consumers of "higher" education will increasingly be those who want to acquire specific expertise in the configuring of knowledge. This may come to replace the traditional teaching role in which students were brought to a level of competence in one of the disciplines. Universities active in knowledge production could have an advantage in terms of producing the next generation of knowledge workers, but it may mean leaving the provision of a more or less standardised undergraduate education to a whole new group of "other providers," except perhaps at post-graduate level.

In order to operate efficiently, universities will be much reduced in size, and they will learn to make use of intellectual resources that they don't own fully. This is the only way that they will be able to interact effectively with the distributed knowledge production system. As a consequence "members" of the university will comprise a small core of faculty and a much larger periphery of experts of various kinds that are linked to universities in diverse ways. We have suggested an image of the university as a sort of "holding institution" in the field of knowledge production, perhaps limited to accrediting teaching done primarily by others while in research doing their part by forming problem-solving teams that work on fundamental issues.

In this new context, universities will play major roles not only in national but also in regional economic development, in life-long learning, and in the evolution of civic culture. In order to be effective here, the values of technology transfer will have to be brought from the periphery of universities, where they reside at the moment, to their institutional core. Universities that are serious about playing a role in the complex game of technology interchange will enter into a complex array of partnerships, the dynamics of which will involve a combination of collaboration and competition. This, as in so many other areas of social life, will contribute to a blurring of the lines between the private sector and higher education.

We have also drawn attention to the way in which knowledge is produced through problem-solving teams. In particular, we noted that the new mode shows little tendency to become institutionalised in universities in the usual ways. In both research and teaching, arrangements will have to be more flexible. Because of this, graduate students, in particular, will be apprenticed and learn their skills through participation in problem-solving networks oriented towards what we have called the context of application. The usual way of providing this type of applied learning is through day release schemes. However, short-term exchanges may be too inflexible to cope with the demands of knowledge workers. Acquisition of research skills will take place "on the job" through participation in problem-solving teams and will become the prime way in which knowledge and skills are transferred, particularly for graduate students.

Perhaps the biggest adjustment that the universities will have to make in this sphere is to develop structures which promote group creativity. So far, the emphasis in universities -- and it is a consequence of the disciplinary structure -- has been on individual creativity. Little if any attention is given to the challenge of teaching people how to be "creative" in a team situation. This will need to change.

For similar reasons, the relevance of higher education will be judged in the future by a cluster of criteria which reflect the ability of institutions to connect with a wide range of partners at various levels and to work creatively with them. To avoid wasteful duplication, an ethos based on sharing resources will need to be developed at the centre of an institution's management policies.

In sum, universities of the 21st century will develop many more and different kinds of links with surrounding society. Perhaps they will one day be ranked in terms of their "connectivity" to the distributed knowledge production system. Although universities still enjoy a privileged place in the distributed knowledge production system, existing structures are too inflexible to accommodate emerging modes of knowledge production or the demands that a more diverse group of "students" will make. Students realise that their personal success lies in being able to find a niche in the emerging knowledge society. The problem is that the universities no longer have this turf to themselves. And herein lies the danger; or is it the opportunity?

June, 1998

Figure 1. Matrix of Key Institutional Activities of the Research University in the Twenty-First Century

Key Knowledge Missions	Basic Research	Applied Clinical Research	Collaborative Research	Expert Interactions and Consultations	Undergraduate, Graduate Degrees	Professional Degrees	Continuing Education/ Lifelong Learning	Information Media, Public Libraries, Friends Groups	Direct Service
Discovering new knowledge	X		X	X					X
Developing knowledge		X	X	X			X	X	X
Collecting, organising, and preserving knowledge		X	X	X			X	X	X
Applying and testing knowledge		X	X	X	X	X	X		X
Transmitting and diffusing knowledge		X	X	X	X	X	X	X	X
Dialoguing and interacting with knowledge stakeholders	X	X	X	X	X	X	X	X	X

Source: Mary Lindenstein Walshok, op. cit., p. 156

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