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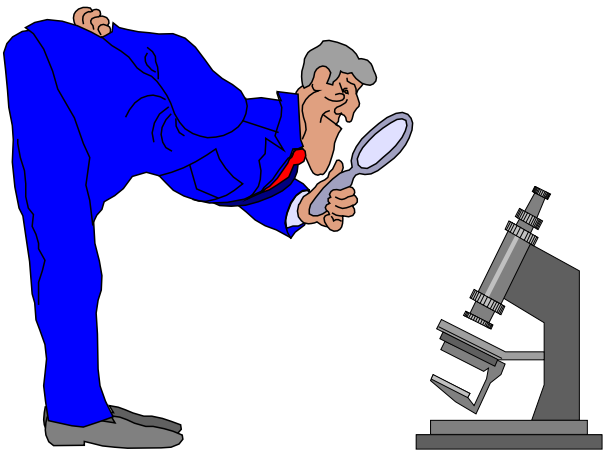
Paralysis
&
Academic Analysis



Giametti once wrote that "*a University must be a tributary to a larger society, not a sanctuary from it*". The reality, however, is that universities have, traditionally, not only been a sanctuary from the larger society in which they reside but a considerable financial burden as well.

Most developed countries also spend a significant portion of their tax revenue on research and the bulk of this research funding is channelled into universities and government-funded research agencies. Universities are one of the "knowledge engines" of society and are charged with the responsibility of creating new knowledge and transferring it to professionals who, in turn, convert that knowledge into meaningful products and/or services. Therefore, as competition between developed, developing and undeveloped countries increases, there needs to be a reassessment of the university system as a mechanism for contributing towards, and sustaining, the societal wealth that created the universities in the first instance.

If one considers the welfare of a country purely from a financial-competitiveness perspective, then the problem with universities and other government research organisations is that they consume vast amounts of money and generate outputs that are largely intangible. Even in instances where there are tangible outputs (e.g., engineering, law, medicine and science graduates), the direct financial benefits to society are difficult to quantify. At the very least, therefore, one needs to qualitatively examine the role and benefits of universities and government research agencies in society in order to understand whether or not they are a help or a hindrance to international competitiveness.

In simple terms, researchers and academics have only one central theme to rationalising their existence and their cost to society and that is, that the more intelligent educated people there are in a society, the better that society is from a financial and social perspective. This argument has great merit because most societies that have a high number of universities (per capita) are financially, and sometimes socially, more advanced than those that don't. Of course, universities don't generate, or increase, the level of intelligence in society but they can channel the existing levels of intelligence into productive areas that can benefit society.

Universities also have an important role to play in keeping young adults off the streets until they are mature enough to cause less damage than they might otherwise cause if they were unemployed or unoccupied. This,

too, is a valuable function because the changes that have been brought about in society, through technology and increases in population, have meant that overall working life (and working hours) inevitably need to decrease in order to maintain any reasonable levels of employment. Rather conveniently (but not coincidentally), the push towards a technology/knowledge-based society has meant that educational levels need to be increased in order to satisfy changing employment profiles and that the life-span of the imparted knowledge has decreased. The result is that, whereas a person in an undeveloped society might start work at the age of 12 and retire when they are too sick or too old or too dead to continue (at 60 or 70, say), a person in a developed society might start work at 22 and retire at 55 - a working-life reduction in the order of 40%, assuming similar life-spans.

Universities are not responsible for the reduction in working-life in developed societies but they are an integral part of the overall process. The fact that people need far greater educational levels in order to be employable in a developed technology-based society means that universities need to change dramatically to remain in line with societal demands. Moreover, there is an increasing recognition that the skills imparted in the original phases of schooling and university education are no longer able to sustain a person through an entire career. In other words, technology and change diminish not only the value of core education but also the value of work experience.

In the early 1990s, in the United States, the editor of a prominent industry journal made the interesting observation that companies had less and less interest in hiring experienced engineers, technicians and scientists because graduates could provide similar (often better) productivity at a much lower cost. The irony was that the further that technocratic professionals moved from their university roots, the less desirable they were to industry, despite increased maturity and project management skills. This may appear to be little more than an interesting statistic but it has serious implications for the basic notions of education and professionalism in developed societies.

Traditionally, it was assumed that universities were fonts of knowledge that imparted skills which were applicable for a life-time. It was also assumed that the bulk of new knowledge in a society would be generated by academics within universities. Given that most of the oldest universities were founded on medicine, the arts and humanities (the technology-based fields did not exist because technology, as we know it, didn't exist), there was some logic to these assumptions and, accordingly, universities around the world

were structured in a rigid fashion that went on to survive for centuries. Traits such as unlimited tenure; acquisition and dissemination of knowledge and a focus on publication, rather than development and implementation, were still evident in many traditional universities, more than seven centuries after the earliest British universities emerged. Remarkably, however, even the advent of the industrial revolution did not cause alarm bells within academia to ring loud enough to initiate major structural change. Certainly, many new engineering, science and technology-based disciplines emerged during the course of the 20th Century but all within the original rigid structures. Universities appeared to absorb little knowledge from the changing world around them and, more than seven centuries after their emergence, and despite untold industrial and societal changes, many universities still arrogantly viewed themselves as the sole creators, imparters and repositories of knowledge in society.

Victor Hugo once said that if one is to civilise a man, then one should begin with his grandmother. And so it is with universities. If one is to create innovative ways of thinking within a university, and to turn them into tributaries to modern society, then one really needs to consider the barriers created by the academic ancestors who imposed the original structures on modern academics. In order to understand the barriers within modern universities, one has to appreciate that, essentially, universities were founded on the premise that those working within them were more intelligent than those working without. This thinking was, in turn, founded on the naive premise that education and intelligence were actually related, with little regard paid to opportunity or circumstance. Ridiculous though it seems, this sort of thinking went largely unchallenged until modern times because universities were only a peripheral adjunct to society and what they did (or didn't) achieve (at great expense) had little influence on the lives of most constituents.

Until the 20th Century, university education was still largely a status symbol and most industries functioned perfectly well without professional graduates. While the early 20th Century brought about significant advancements in engineering and science, universities were only one of many contributors to these changes. Industry, itself, was one of the major sources of advancement and other factors, such as the military stimuli of the American Civil War (and, indeed the First and Second World Wars), led to technical advances that flowed into the industrial sector and society in general.

It is also particularly interesting to note that some of the great innovators of the post-industrial-revolution, including Bell, Edison and Franklin are still referred to as inventors, rather than scientists or engineers (which is essentially what they were). It is difficult to know whether the classification of "inventor" was created by universities to demean the role of research undertaken outside the traditional sphere or whether it was the inventors themselves who wanted to differentiate their "doing" role from the university-based "*how-to-doing*" role. In any event, there is significant evidence of extra-university research and development having been a major contributor to the innovations of the 20th Century.

How much, or how little, universities contributed to society a century ago was largely unknown by the general populace because only a small percentage of society (even developed society) had ever studied in a university. Even fewer people worked within universities as academics and, of those, fewer still knew what other academics were doing, much less whether or not they were intelligent and/or achieving any great outcomes for humanity. At the very least, academics appeared to be highly literate and prolific writers which was, in itself, a rarity in 19th Century society. To the outside world, therefore, it superficially appeared that academics were the intelligentsia of society and that somehow all knowledge flowed from the portals of the universities. But has a great deal of knowledge emanated from universities and been converted into useful outcomes?

The problem with determining the influence of university outputs upon society is that the time-spans, which separate university discovery from practical implementation, can often be measured in decades or even centuries. Even then, there are often grandiose claims as to the value of outputs that originate from university research. These are often accepted, without question, as facts because they are difficult to prove or disprove. For example, the most common claims to improving the world tend to emanate from medical researchers, whose assertion is that modern medicine is largely responsible for increases in life-span in developed societies. Certainly, during the course of the 20th Century, there were considerable improvements in antibiotics; the control of communicable diseases; anaesthetics and drugs for mental disorders - all of which contributed to quality of life. However, it would also be reasonable to suggest that the increase in human life-span, in the developed world, was far more likely related to high-quality food, water, sewerage, heating and air-conditioning (in other words, farmers, plumbers and civil engineers) rather than to medical research.

The links between modern medical research and lifespan appear even more tenuous when one considers that many modern medical procedures were only made possible through advancements in electronic and mechanical engineering (i.e., biomedical and biomechanical engineering) and were themselves engineering procedures, rather than medical procedures. Further, most pharmaceuticals could never be commercially produced without considerable input from chemical engineers and industrial chemists. So, if one subtracted farming, plumbing and engineering from the societal equation, one would probably discover that medical research, in itself, contributed relatively little towards the longevity of human life.

If these statistics do not lead one to question the contribution of modern medical research towards longevity, then consider that the mortality rate in British hospitals, of the 19th Century, was in the order of 40%. This rate was dramatically reduced when it was discovered that the re-use of contaminated bandages (and a failure to wash hands after autopsies and amputations) was leading to the spread of infection and disease. The finding was said to be the result of medical research into infectious diseases but, perhaps, one could have equally argued that the introduction of indoor plumbing, and the natural tendency towards improving hygiene, in the developed world, could have ultimately led to exactly the same result, without any understanding of the physiological phenomena involved.

The point here is that academics and researchers, from all disciplines, tend to be very narrowly focused and, naturally, ascribe a greater degree of significance to their own accomplishments than might be warranted from a broader examination of the facts.

Again, taking medical research as an example, it may superficially appear that giving such researchers undue credit for their contributions to society is no more harmful than giving unions the credit for a 40-hour working week. After all, in both cases, there were many other factors at play but fame went to those who were best able to capitalise on their contributions. And, history, it is said, is always written by the victors. The problem is that when countries are involved in aggressive economic competition, these seemingly insignificant historical distortions can have significant influence on the way in which tax-payers' funds are distributed. For example, from the 1960s through to the 1990s, in Australia, Britain, Canada, New Zealand and the United States, there was considerable government emphasis (and

spending) on medical research, despite the fact that these countries appeared to be in economic decline, relative to emerging economies in Asia that, rather wisely (from an economic perspective), focused on other applied research that could be rapidly commercialised. Some of this distorted emphasis can be attributed to political expediency, rather than the researchers themselves. In the case of medical research, the activity was viewed as being altruistic and was accorded a "Florence Nightingale" reverence. This aura of "goodness" helped politicians appear benevolent and caring, while doing little more than providing one-line budgets to resolve seemingly insoluble problems:

> *"What are you doing about the XYZ disease, Mr. President?"*
>
> *"We're committing a billion dollars on research each year and, by God, over the next decade, we expect to have significant breakthroughs that may lead to partial cures for some forms of the disease in certain types of laboratory rats and these may ultimately be transferred to clinical trials on some humans suffering from some similar forms of the disease over the next century..."*

So, in many cases, large amounts of government spending on university-based medical research tended to cure short-term political problems far more effectively than they ever cured the medical problems themselves.

In fairness, it also has to be noted that some of the emphasis on university-based medical research, in developed countries, arose because it appeared that medical research was a useful backbone to a burgeoning pharmaceutical industry. However, a good deal of government spending in research arises because both the politicians and the public are naive enough to accept researchers claims without question. This phenomenon is more marked in developed countries, where there appears to be more money to spare, and where the populace likes to believe that universities are responsible for "goodness" in society (healing the sick, finding ways of stopping pollution, etc.). In any case, the philosophy helps to enlarge the demarcation between universities in the developed world and those in undeveloped and developing countries, that focus on research which can be commercialised in the short-term.

From a broader perspective, the emphasis on "non-commercialisable" research that occurs in developed countries is probably more a reflection on the universities themselves, rather than the specific fields that are funded. Research can really be divided into two types - pure (basic) and applied. In the definition of pure research, adopted by many of the older-style universities, the objective is to create new knowledge which may, at some stage, be utilised by society - in other words, finding solutions to problems that don't necessarily exist at the time the knowledge is created. Applied research involves the novel application of knowledge to existing problems. Universities have an important role to fulfil in both areas and the issue cannot be simply resolved through a decision to undertake one type of research or the other - the world, as a whole, needs a combination of the two. The difficulty, therefore, is in deciding on the most appropriate balance and in deciding which countries should be left to pay for expensive and unprofitable pure research, while others confine themselves to applied research that can be more readily commercialised.

Many of the traditional universities, in developed countries, have been in operation for over a century and their traits have been inherited from the earliest universities of the 13th Century. Among these traits are a desire to solely pursue new knowledge, for its own sake; a quest for academic/scholarly excellence and a desire to be isolated from the "doing" sectors of society, so that the quest for new knowledge is not tainted (or restricted) by economic or commercial reality. All these traits have led universities to translate their quest for new knowledge in arts, law and humanities to areas such as engineering, medicine and science. Hence, a pure research mentality has evolved, often at the expense of applied research that can, more rapidly, lead to the economic development of a country.

A number of fundamental changes in society have contributed towards a lessening need for pure research. First, and foremost, is the recognition that universities are no longer places of academic/scholarly excellence (if they ever were in reality). It isn't simply a question of society becoming less intelligent but a question of how many members of society are expected to pass through a university. At the beginning of the 20th Century, when only five or ten percent of the population, of a developed country, might study at university, there could be some justifiable claim to academic excellence. Even then, there were significant issues of circumstance and opportunity associated with tertiary study. However, as we enter the 21st Century, and discover that some 80% of a developed society will receive a university

education, then the claims of academic/scholarly excellence become nonsensical.

Universities have become, by technological necessity, just another phase of the educational process and have little more claim to academic excellence than high schools or kindergartens. Of course, many universities would claim to be elite and to attract the better students in society but the reality is that the quality of outputs is largely judged by professional bodies (engineering, medical, architectural associations, etc.) that generally ascribe the same value to degrees, from leading British or American universities, as they do to those in, say, some developing African nations. A failure to recognise this fundamental change in the university system has led to the observation that many traditional universities are out-of-touch with modern society.

Universities, in developed countries, that try to persist with "traditional" pursuits of academic excellence, increasingly find themselves, and their research and spending, under attack from the society around them. Again, it isn't a question of society becoming more aggressive towards universities but, rather, the fact that an increasing proportion of society have the same professional qualifications as those in universities, who make assertions of excellence in their chosen fields. An educated society has a much higher propensity to see through flimsy academic arguments that are made in support of esoteric research programs, particularly when that society is responsible for funding those programs through taxes, university fees or industry contributions. An educated society also has a much greater appreciation of the costs of universities and the academic lifestyles and freedoms that are not available to others in society. Therefore, traditional universities find themselves under closer and closer scrutiny because an educated society, with limited funds, demands tangible outputs that can increase competitiveness.

The developed world's tolerance for funding research into the solution of non-existent problems has diminished considerably. By the mid-1990s, even universities in the United States (that had grown accustomed to donations from generous corporate and private benefactors) were put on notice that donations and outcomes had to be tied together.

The other fundamental change that occurred in society, and which had a profound effect on the way in which university research was conducted, was

the concept of industrial research. During the course of the 20th Century, most medium and large high-technology companies established their own research and development departments which largely focused on applied research that had a direct bearing on their products. Further, there was a recognition that knowledge, ideas and inventions, in themselves, had little or no value in modern society unless they were coupled to development programs; design for manufacture; marketing; financing; distribution and product-support networks. However, many traditional universities failed to recognise that there was more new knowledge and science in the process of taking a product from an idea to commercial reality than there was in the idea itself. Moreover, the science of product evolution was equally applicable to medical vaccines and agricultural products as it was to soap powder or automotive components.

A good example of the science of product evolution was the mobile telephone. Mobile telephones emerged commercially in the form of car phones in the United States as early as the 1960s. However, their usage was restricted to an elite few because of cost and technology. From a traditional university perspective, it could be argued that the bulk of the work had been done once it was proven that the original car phones could operate. In fact, the level of science and engineering that was invested in converting the original technology, into that which became part of the mobile phone phenomenon of the 1980s and 1990s, was orders of magnitude greater. Tens of thousands of man-years of (pure and applied) research and development had to be performed in the areas of very-large-scale-integrated-circuits (VLSI); impact-absorbing plastics for casings; digital telephone exchanges; long-life rechargeable battery cells; printed-circuit board (surface-mount) production techniques and machinery; broadcasting technologies; antenna design and so on. The level of science and engineering that separated the original idea from its practical implementation, two decades later, could never have been envisaged at the time the original innovation had taken place. And yet, the same sort of void exists between each "original" scientific discovery, within universities, and the commercialisation of most modern products.

The preceding discussions lead us to the root problem that is at hand, for universities in the modern world, and that is that the form of knowledge has irreversibly changed. Meaningful knowledge is no longer contained solely in a test-tube but is now vested in those who can evaluate existing technologies; improve upon those technologies; raise the finance involved in commercialising those technologies and market and support those

technologies. Meaningful knowledge is no longer as specialised as it once was and problems are much more multidisciplinary in nature.

In order to understand the diminishing relevance of the university system, one has to understand the arbitrary nature of the disciplines and their diminishing relevance, as a result of technology and change. One has to always remind oneself that "disciplines" in universities (and subsequently, the work-place) were created in response to societal needs at a given time in history. There is no reason why they should have continued, *ad infinitum*, in their original form or, for that matter, why they should have continued at all, if they were irrelevant. For example, the discipline of medicine was established as a discipline of science (a process of discovery) at the University of Salerno in the 9th Century. However, by the end of the 20th Century, medicine had, in practice, become far more technocratic - the simple problems could be resolved by technical procedures and the chronic problems could not adequately be addressed by pure science because of the number of dimensions involved. The fact that medicine continued as a pure scientific process of discovery, 11 centuries after its original establishment, meant that it became a very costly form of research with diminishing returns.

Similarly, in engineering, the disciplines of electrical and electronic engineering were created from the bosom of mechanical engineering in the early 20th Century. However, by the end of the 20th Century, there was a realisation that neither of the separate disciplines were equipped to cope with the majority of the world's engineering problems - which required a combination of mechanical and electronic engineering (i.e., mechatronics).

In a larger sense, it isn't simply a question of creating new disciplines in universities, to cope with the changes in society and technology but, more appropriately, of having the wisdom and the courage to dissolve or refocus those disciplines (and academic practices) that have lost their relevance over time.

Many people still have visions of the scruffy scientist, mumbling in Latin, mixing chemicals together in a university laboratory and creating some earth-shattering new formula or vaccine. However, the era of the "earth-shattering scientific discovery" is well and truly past. Most people, working in a particular field (around the world), have had similar educational backgrounds, have been subjected to similar media influences and have read the same scientific journals. The process of discovery is therefore no longer a

question of the bright spark, within an individual, illuminating the remainder of humanity. Discovery is now a systematic and tedious process based upon the variation of themes established by other researchers. Even when research groups work in isolation from other groups, the influences of education, media and previous research tend to channel thought-processes to the extent where similar outputs emerge from widely disparate researchers in different countries. So, given that the era of earth-shattering discoveries has past, and given the similarity of research around the world, most research outputs are met with a yawn rather than a gasp. The larger issue, from a discovery point of view, is how the research outputs can be translated into tangible benefits to society, within a reasonable time-frame. In other words, how research outputs can be translated into industrial gasps (rather than yawns) that will spur on the commercialisation process.

The problem with traditional universities and researchers is that they are often too narrowly focused to convert an industrial yawn into an industrial gasp. Unless there is a broader understanding of the process of discovery, as it pertains to commercialisation, then the chances for linking research outputs to financial benefits in society are minimal. A medical vaccine is of no value to society unless a pharmaceutical company can commercially produce it, at an acceptable cost and safety level, and protect itself against litigation in those cases where it fails. So, a "mediocre" vaccine, that cures 40% of patients and can be rapidly commercialised, is a far greater scientific discovery, in the modern world, than an "excellent" vaccine, that cures 80% of patients and is never commercialised because of cost or legal factors. Similarly, a vehicle modification that reduces exhaust-emissions by five percent, and can be applied to every existing vehicle at minimal cost, is a far greater discovery than a revolutionary non-polluting engine that will never be produced, because of industry commitments to existing technology.

If the greatest challenge for universities is to convert an industrial yawn into an industrial gasp, then it is further exacerbated by the emergence of large industrial research organisations and the recognition, by industry, that research is only a small part of the overall business process. The typical formula that is applied is that, for every dollar invested in research (R), ten must be invested in development (D) and a hundred on commercialisation (C). The R:D:C ratio is really a conservative estimate of how much it costs to convert applied research into tangible end-products. However, it must be remembered that pure research doesn't even necessarily lead to knowledge that will fit into the R:D:C ratio. The interesting point here is that if one

considered a developed country, in the early 1990s, that expended, say, US$200 per capita of tax-payers' funds on research, then industry would have had to invest more than 110 times that amount (or US$22,000 per capita, roughly the order of the, then, average income per person) in order to commercialise that work - assuming that the research was applied and worthy of commercialisation! And yet, governments in developed countries are constantly inundated by requests from academics to invest more money in university and other governmental research to "bolster" the economy.

The reality is that increasing government expenditure, on either pure or applied research, in universities and other government research agencies, will probably not cause a corresponding increase in a country's economic fortunes. In all likelihood, pure research may not be commercialised for decades and, even when money is expended on applied university research, there are difficulties in commercialisation. As noted above, most developed countries spend far more, per capita, on research than could ever be commercialised by industry in those countries. Increasing the level of research funding therefore does little to address the problem of inadequate industry funds for commercialisation. The question then arises as to the mix of pure and applied research - should the existing funds, allocated to research, be more directed towards applied research than pure research. The obvious answer is that they should because at least there is a greater scope for commercialisation in the shorter term. In practice, however, a simple change from pure to applied research does not necessarily lead to an increase in a nation's economic fortunes.

In the 1980s, Britain varied its research mix by increasing applied research and decreasing pure research. The result was an increase in commercialisation of outcomes, but rarely in Britain. Interestingly, British companies were not making a great deal of use of the research outputs while other developed, and developing, countries were. Through its applied research focus, Britain had effectively provided a valuable service, gratis, to companies in other countries. On the other hand, when Britain concentrated on pure research, few companies within or without the country were interested in commercialisation of any form. So, if the pure research didn't advance the country, at least it didn't assist its developing competitors. However, the phenomenon of providing "free" applied research outputs to competitors didn't just emerge in the 1980s. Britain had similar problems, years earlier, with the development of the Hovercraft and the jet engine. Australia, similarly, had done a great deal of pioneering work in computing,

through its government research agencies, but little was gained commercially from such innovations.

The problems of providing free knowledge to international competitors is clearly not just a result of doing applied research rather than pure research. It is more a case of applied research having greater (short-term) commercial value than pure research. The fundamental problem is that many universities and government research agencies, around the world, are simply not structured to undertake applied research that can be internally (or even locally) commercialised. Firstly, universities and government research agencies around the world have a traditional university mentality that is founded on the dissemination of knowledge through publishing in journals - in other words, providing knowledge free of charge. Secondly, universities and academics, in general, have a naive attitude to the overall process of research, development and commercialisation. This is of no consequence when researchers and academics concentrate on pure research because, in the short-term, little of any commercial value is likely to arise from the outcomes. However, when researchers undertake applied research, there are significant implications at a local and international level.

The key point is that applied research has a greater propensity to be commercialised. Therefore, if applied research is to be commercialised, and it is initially funded by government, then there is clearly a responsibility to determine whether any benefits will flow back to the tax-payers who funded it. One cannot be too narrow in the definition of benefits because they could be social or financial. For example, if a university developed a new fuel-delivery system for aircraft (at tax-payers' expense), then it would be incumbent on the university to demonstrate how that technology would benefit local industry, or could be protected and sold (as intellectual property) to foreign industry. On the other hand, a university may develop a new medical vaccine that could only be commercialised by an off-shore, multinational, pharmaceutical company. In that instance, it may be that the societal benefits of having the vaccine available to the local community outweigh the fact that it is not commercialised by local industry.

One of the factors that complicates the research-decision-making process in governments and universities is the common misconception that academics and government researchers can be the driving force behind the commercialisation of products. Common sense (which, as many would appreciate, is not so common in academia) should tell us that, if academics

and researchers were capable of taking an idea, or research concept, and converting it into a marketable end-product, then they would probably not be working as academics and researchers in the first instance - they would more likely be industrialists in their own right. As the processes of research, development and commercialisation become more complex, there needs to be a recognition that research (both pure and applied) is only a small part of the money-making process in the developed world, and the notion that it can drive that process is akin to believing that a tail will wag a dog. There are two possible corollaries to this naive form of reasoning. The first is that research outputs will be commercialised by those who were not intended to commercialise them (e.g., companies in international competitor countries). The second is that the research work will never be commercialised.

There is another naive belief that stems from the misconception that academics and researchers can be the driving force behind the money making process - that is, that research outputs (ideas and intellectual property) have some enormous financial value and need to be protected by patents and the like. This leads to two further problems. One problem is that universities and government research agencies can spend vast sums of tax-payers' money in protecting intellectual property and the second is that they endeavour to sell that property to industry for vast sums of money. In some developed countries, there was evidence (from the 1960s to 1990s) to suggest that more money was being spent on the protection of intellectual property than was ever derived from that property. In the United States, on the other hand, a number of large research organisations became famous (or infamous) for patenting minor research outputs and then charging extravagant licensing fees that few industrialists were prepared to pay.

All these problems stem from a failure to recognise that university and government research can only have real value in terms of the man-hours and staff and equipment that were used to generate particular outputs. This leads knowledge buyers (e.g., industrialists) to observe that, in universities and government research organisations (despite academic claims to the contrary), research outputs are largely generated by individuals rather than teams. The entire concept of university research, as it stems back to the 13th Century is, in fact, related to individual excellence and not to group effort. Industrial research, on the other hand, is dependent upon group effort - that is, dividing up problems and having individuals only contribute to partial solutions (this allows industry to tackle multidisciplinary problems and helps industry to protect its intellectual property by ensuring it is not manifested in an

individual). In industrial research, therefore, the whole is greater than the sum of the parts. In academic research, the whole and the parts are often one and the same. This means that the net worth of university or government research is seldom more than the worth of an individual or small group of individuals. In other words, by purchasing an individual, an organisation can also purchase intellectual property (whether or not it is protected by patents and secrecy agreements) because the originator can generate similar, new, intellectual property.

The other root cause of the problems associated with university and government-based research also stems from the "tail wagging the dog" phenomenon. Most companies, that are involved in research, have their own agenda and time-frames for that research. Industry pursues research based upon perceived market needs and follows a research, development and commercialisation plan that may span five to ten years. Research and development in industry needs to be tailored and accompanied with systematic methods of experimentation, software development and documentation that relate to specific company requirements and, more importantly, to the commercialisation process. Hence, the academic notion that companies will suddenly need, and commercialise, some brilliant innovation, that emanates from a university or government research agency, is extremely innocent.

A further problem, for many researchers in universities and government research agencies, is that they can no longer maintain leadership in the fields in which they claim leadership. Perhaps, in an academic sense, they can claim to have read research journals and to be ahead of their academic peers/competitors. However, in a larger sense, there needs to be a recognition that industry research facilities, in major companies, are often funded at far higher levels than university and government research organisations. The result is that not only can industrial researchers access the same information as traditional academics but they also have far better facilities and staff to advance their fields and, more importantly, they do not publish their research outputs for other academics to assess. Industry-based approaches to research and development are also more productive than traditional academic approaches because they are group-based and multidisciplinary - in other words, geared towards solving real problems (which are multidisciplinary).

For as long as the tail endeavours to wag the dog, the likelihood of academics planning research in order to achieve to short-term commercial gains (as the academics see them) is very small. The end result is that, whether university research is pure or applied, the knowledge outputs will tend to be commercialised in a seemingly random manner (if at all). So, the notion of a university planning that it will undertake research in, say, particular vaccines or aerospace technologies, in order to support corresponding, local industries is rather innocent. This doesn't mean that university/government research will never be commercialised, just that the probability of commercial outcomes arising, in a planned manner, is extremely small. This needs to be considered when governments seek to expend tax-payers' funds on research - particularly where governments have notions of spending money on strategic research in order to achieve an industrial edge over developing nations.

There are methods by which university and government research agencies can be structured in order to generate research outputs (other than paper) that can be commercialised in a planned manner. Essentially, there needs to be a recognition that universities and government research agencies are a significant burden on a nation's resources and that they need to provide at least some tangible outcomes (i.e., commercial benefits) in order to justify their existence in an increasingly competitive world. There also needs to be a recognition that, to do so, the academics cannot be the driving-force behind the ideas and that this driving-force must come from those who will commercialise the ideas. In other words, industry must have some input into the process of generating ideas within the academic research system and this input must have a bearing on the research that is undertaken (and the manner in which it is undertaken) if tangible benefits are to arise in a planned manner. The problem with this is that most academics, in developed countries, find such a concept an affront to their "academic freedom". However, such academics need to be reminded that, however distasteful they find the notion, academic freedom is purchased with money (normally tax-payers' money) rather than with good intentions.

The university-industry partnerships that can lead to outcomes, which are often commercialised within the countries in which the research is performed, are an important part of the evolution of universities. Most notably, such partnerships evolved in post-war periods in Germany and Japan, where universities were created (mostly as "green-fields" establishments) to be tributaries to society, rather than as sanctuaries from society. This modern

phenomenon, that makes universities one of the driving-forces behind economic development (which, in turn, contributes considerable funds back into the university system) spread throughout developing nations as they tried to emulate the best aspects of the more-successful developed economies. Interestingly, but not surprisingly, the phenomenon of making universities relevant (and not just notionally "excellent") swept through the world in inverse proportion to the age of the universities. In other words, the older the universities, the more resistant they were to change and the more insistent they were that change would lead to a deterioration in "academic excellence". By the mid-1990s (almost half a century after Germany and Japan had adopted the principles of universities as technological tributaries to society), many of the older universities, around the world, had not changed their perspective one iota, from that which was derived from the original, 13th Century tenets. In a sense, of course, the traditional universities were very much like the dinosaur companies because both had immense inertia and a fear that change would most affect those making the change.

Universities do not necessarily have to become mere tools in the technology transfer process in order to be relevant to society. It is also possible that universities could endeavour to commercialise their own research outputs and thereby minimise the burden that they place upon tax-payers' funds. There have been numerous instances, around the world, where software developments (for example) have provided an income to university-based research groups. Many universities also encourage contract research and development for industry and, so, academics sell their acquired knowledge as an end-product. There are advantages to allowing university staff to experiment with selling products. The most obvious one is the realisation that the "idea" is only a small portion of an end-product. With this realisation comes a much better perspective of the role of the university within society (or, at least the money-making aspects of society). However, the notion of converting universities and government research agencies into an amalgam of small entrepreneurial businesses can also create problems.

The building of enterprises, within universities, is fraught with both moral and business dilemmas that are difficult to resolve. From a moral perspective, there is the issue of universities competing against external companies for business, when the universities are subsidised by government and/or by tuition fees, rendered in exchange for an unbiased impartation of knowledge. There is also an issue of universities focusing on money-making activities over and above academic standards. From a business perspective,

there is the fundamental problem that universities tend to employ staff that do not wish to be in business (and that is why they choose to be in academia). While an individual academic may be entrepreneurial enough to create a small business in his or her spare time, the translation of that small business into a viable university-based company is extremely difficult because of the differing and individualistic aspirations of academic staff.

Finally, in converting universities into "shops", there is the issue of university credibility. Once a university is seen to sell products or knowledge to industry, on a large scale, then its credibility is no greater than any other manufacturer, software house or consulting house. This can have a serious impact on the other facets of a university's mission in society because the university is then viewed, by outsiders, as a shop and academics are viewed as salesmen with a vested interest in products.

The problems associated with university credibility are somewhat lessened if a university sells intellectual property to other companies, who then commercialise that property on a larger scale. In all cases, however, there is the issue of a university defending its intellectual property. Many universities around the world do not have the resources to successfully protect intellectual property. Even when they do have such resources, those universities that are funded by tax-payers are put into an extremely embarrassing position when they are seen to be preventing tax-payers (e.g., local industry) from commercialising knowledge that may have been paid for through the taxation system (i.e., government funds). Universities can, therefore, face a no-win situation - if they defend intellectual property (against local users) they are perceived as greedy ogres, attempting to double-dip into tax-payers' funds and sales revenue from tax-payer-funded research. If the universities don't protect that property, then they risk being perceived as being careless with government funds. This problem can be exacerbated, in the case of research that is perceived to be "life-saving", because large corporate users of such knowledge can strongly argue that "life-saving breakthroughs" cannot be commercialised because universities are restricting access to information (e.g., not publishing).

All the problems relating to intellectual property and the publication of knowledge may appear to be administrative in nature but they do impinge upon the core definitions of a modern university's role in a society. In particular, as developing countries follow the path of other 20th Century technocratic and business-oriented societies, such as Germany and Japan, in

establishing technological universities (which bridge the void between principle and practice) it is clear that the traditional university concepts, that originated in the 13th Century, are of less and less relevance. On the other hand, the seemingly administrative tasks, of how to target university research, in line with the industrial needs of society, and how to protect tax-payers' investments in university and government research, are becoming of immense importance to both developed and developing countries.

A further driving-force behind the changing face of universities and university research is the emergence of the technocratic society. A century ago, it may have been acceptable for universities to divide a society into those who were suitable for tertiary education and those who were not. The hard reality is that technology has now intervened to the extent where academics can no longer be allowed to make decisions on the suitability of individuals for tertiary education. A modern developed society needs a high proportion of its population educated in technological fields and, if universities are unable to achieve this level of output through traditional academic means, then it is clear that new educational methods will need to be adopted. The academic snobbery that has existed in universities around the world, for centuries, is no longer relevant to societies that need to compete internationally at a technological level. However, overcoming that snobbery and recognising that tertiary education is now an integral part of a developed society's educational process, just like primary and secondary education, is not a simple task for universities founded on the notion of academic excellence.

The changing role of universities in society is even further complicated by the, now somewhat meaningless, distinctions between technical/community colleges and universities. Over the course of the 20th Century, technical training became more and more complex as former technical functions (e.g., tool-making, fitting and turning) evolved into computer aided design; programming of computer controlled machine tools, etc. On the other hand, professionals became far more technocratic and there was far less industrial demand for the catholic forms of education that were once embodied in courses such as engineering, medicine, science and so on. Moreover, university-based academic disciplines, such as engineering and science, irreversibly changed through a greater focus on computer programming and computer applications, rather than applied mathematics, physics and chemistry. In other words, during the 20th Century, technical colleges, evolved into pseudo-universities and universities devolved into

pseudo-technical colleges. In many instances, it was difficult to even differentiate the nuances between the courses in technical colleges and those in universities. The only significant (philosophical) difference that remained between the two forms of tertiary education was the university focus on the acquisition, creation and conversion of knowledge, and the technical-college focus on the application of knowledge.

The highly-successful post-war-developed societies, such as Germany and Japan, were very heavily dependent on the application of knowledge, during their meteoric rise, far more than they were on the creation of new knowledge. Hence, universities, in such countries, became far more analogous to high-powered technical colleges in, say, Britain or the United States, because the focus was in "doing" and linking with industry partners that could turn ideas into commercial products Moreover, the modern universities recognised that the notion of academic excellence was becoming increasingly irrelevant if it was divorced from the reality that the majority of a society (not just an elite few) had to be highly educated in order for that society to be economically successful. The fact that such approaches proved to be highly successful led to a wave of similar university structures in other then-developing countries such as Singapore, Taiwan and so on. If one considers these technologically and industrially-oriented universities as being the modern successors of the traditional universities then, as countries become more "internationalised", the traditional universities that are unable, or unwilling, to accept change will have great cause for concern.

The distinction between technical colleges and universities will undoubtedly disappear over the coming decades if, for no other reason, than because it is difficult to market the idea of technical colleges to society. The more obscure the demarcation between technical education and university education, the more obvious it becomes that there is some form of snobbery involved in making distinctions between the two. The confusion as to the roles of technical colleges and universities tends to lead society to the conclusion that technical colleges are second-rate universities and, therefore, as a first priority, children should be encouraged to attend university and, if they fail to achieve this objective, they should be punished by being sent to a technical college. Needless to say, these perceptions (however invalid) are very real and will inevitably lead to technical colleges becoming universities and universities subsequently emulating the role of technical colleges (because a far greater proportion of society attends university). The end-result is that society will ultimately only have one form of tertiary education

and that is the university, albeit with a much wider spread of activities and a broader mission.

In the short-term, the traditional universities will be able to cling to the notion that they are generating some form of academically-elite output that is beneficial to society. Certainly, such notions were espoused in Britain when waves of new universities and polytechnics emerged in the 1960s and 1970s. This was partly due to the underlying British class system but, more likely, due to the long history of perceived academic achievement associated with the traditional universities in that country. The problem is that, as more and more members of society become educated (to a tertiary level), the diminishing relevance of the original university ideals becomes more and more apparent. In other words, a modern technology-based society cannot survive solely by providing education to an academic elite - industry and society require that the bulk of the populace is educated to a very high level in order to support the ever-increasing complexity of the industrial structures that are emerging.

The other problem for traditional universities is that the prestige of the more modern universities around the world is growing, particularly in terms of industry acceptance, and hence both graduates and academic staff become far more employable. The result is that such organisations become a magnet for higher quality students and staff and provide greater career opportunities (i.e., the ability to move between academia and industry) for both. In the longer-term, therefore, there is a sense of inevitability that the traditional universities will either have to change or face a gradual demise.

The above discussions may appal traditionalists who see the mercenary pursuit of knowledge (in search of money and career opportunities, rather than wisdom) as being an anathema to the ideals of education. The reality, however, is that academic excellence has little value if one is unemployable and, as the competition for jobs in developed societies increases, so too does the need for vocationally-oriented universities. From an educational-purist's point of view, this means that there is a fundamental change in the way in which we view the university system - that is, as a service industry for developed society, rather than a place of enlightenment and enrichment. Perhaps, this shouldn't come as a surprise because it is simply a recognition that society and technology have become so complex that it is difficult enough for universities to serve the present, much less muse over hypothetical scenarios for the next century.

If we assume that there is some inevitability of universities moving away from their altruistic mission of vision and excellence, towards a new mission of educational service provision, then there are far-reaching implications that need to be considered. The most obvious one is that society accepts the loss of one of its few long-term planning tools. In other words, if universities spend all their time coping with today's problems then they cannot put forward scenarios that may have a bearing on society over the course of the next century. Again, we may need to accept that such a role is no longer tenable because of the rate of change in society and its existing complexity, but what of the role of the university as a creator of new knowledge? The problem with universities undertaking only applied research is that they eventually end up exhausting all their capital (i.e., their knowledge) and, without pure research, they have no mechanism for creating new knowledge. What then do they have left to offer society other than an educational service?

It may be that developed societies will have to accept that the mechanisms for creating new knowledge have irreversibly changed. Where knowledge was once solely embodied in an idea, in the modern world it is a complex web of ideas and legal issues and commercialisation issues and environmental issues and so on. So, for example, the scientific idea that the "*earth is getting warmer and we ought to do something about it*" has as much value to society as yesterday's weather, unless it is coupled to knowledge of what the "*something*" is that we ought to do and how that "*something*" should be funded. As a result, finding "*something*" to do in order to fix the problem of, say, global warming is as much related to politics, economics, industrialisation, consumerism, etc. as it is to science or engineering. For example, deciding to move from internal combustion engines to solar energy has far less engineering and scientific connotations than it does political, commercial, legal and industrial ramifications in a world where many hundreds of billions of dollars are invested in existing technologies. These complex multidimensional problems leave traditional universities with a need to assess the forms of knowledge that they are capable of "creating" within a society.

If one accepts that the changing forms of knowledge have severe implications for traditional universities, then the other issue that such universities will need to face is in terms of their "value-adding" role in society. In the past, traditional universities have been able to attract the most

intelligent young students and to process them into intelligent graduates. The fact that these universities attracted intelligent students and converted them into intelligent graduates usually meant that little value was added along the way. To a large extent, universities were places of learning rather than teaching and, so, intelligent students went to traditional universities to learn a particular discipline based upon a curriculum laid down by those universities. The university's role in society, in terms of graduate creation, was somewhat limited because the university only provided a shell in which intelligent students could teach themselves enough to become intelligent graduates. The broader role of the university was therefore to create the knowledge (e.g., by writing text books and papers) and the curriculum that "smart" students could use to teach themselves. However, if traditional universities cease to become creators of knowledge in society (i.e., stop creating new theories, writing text books, etc.), then they also cease to have any purpose, in adding educational value to that society, because their traditional role is not to teach but to provide mechanisms for the impartation of knowledge.

In the early 1990s, most developed countries began to realise that their notions of "doing the high-value-added" things, while undeveloped and developing countries "do the low-value-added" things, were a nonsense. Undeveloped and developing countries were as mindful of the need to undertake high-value-added activities as their developed counterparts. All countries therefore recognised the potential that universities and other government research agencies had in terms of being an engine for industrial development (i.e., creating industry-oriented graduates and bridging the gap between pure research and industrial development), provided that they were structured in an appropriate manner. However, in creating industry-oriented universities and government research agencies, there was always some naive hope (expectation) that some other countries would be able to accept or retain the burden associated with creating new knowledge (i.e., pure research). Certainly, countries such as the United States and Britain were always expected to go on fulfilling such roles. But how long are such countries likely to provide such enormously expensive resources, to countries that use the new knowledge derived from them (free of charge) to better themselves industrially?

The above question, of basic research funding, will ultimately be resolved if, for no other reason, than because universities and government research agencies are such a costly commodity - they are not an insignificant or invisible expense and their cost to society rises as more and more members

of that society study at university. It is quite conceivable, that within the early decades of the 21st Century, some developed countries will expend in the order of ten percent of their tax revenue on universities and government research agencies. This is not a level of expenditure that can be conveniently hidden from the public and it is inevitable that governments will address the issue in terms of tangible benefits to their own community - in other words, by isolating research that benefits society in the short-term (i.e., applied industrial research) from that which may or may not benefit society in the long-term. If such an issue is addressed in terms of political expediency (as such issues generally are) then the level of pressure on traditional universities will increase significantly. Firstly, there will need to be a reassessment of universities as creators of new knowledge (rather than as mechanisms for translating knowledge into industrial benefits) and secondly, there will need to be a reassessment of universities and government research agencies as providers of "free knowledge" (potentially to industrial competitors in other countries).

The rising tide of development that has swept through the world has raised many similar issues in terms of who is expected to pay for things that benefit other countries. The most obvious examples, over the course of the 20th Century, were of a military/defence nature where it was always assumed that "wealthy" countries, such as the United States and Britain, would always be prepared to pay for the privilege of being the "policemen" of the world. Following the military conflicts in the Middle East in the early 1990s, tax-payers in such countries naturally began asking why they should have to pay to defend other countries, particularly when there were many other "wealthy" countries who had avoided military commitment but had benefited greatly from the commitment of others.

The exact same scenario has occurred with the international university system, where some countries have carried the financial responsibility/burden of creating new knowledge while others have benefited from that knowledge without contributing to the overall pool. Tax-payers in Country "A" could then well ask why they were contributing funds to researching, say, vaccines (for tropical diseases) when the results of such research would be commercialised by pharmaceutical companies in Country "B", and then used to the benefit of Country "C", whose own universities only expended funds on applied industrial research. The only answer to such questions is "*for the betterment of mankind*". However, this answer carries less and less weight with tax-payers who visit their department stores and find more and more

consumer products from competitor countries, that do not appear to be contributing to the "*betterment of mankind*" through their own pure research.

There has, surprisingly, been some recognition of the fact that pure research within universities needs an international effort if there is to be any equity in the way in which it is funded and the way it is used. From an academic perspective, basic research has always tended to be conducted in an international frame-work but there have been a number of countries notable for their contributions to the "total knowledge pool" and a number of countries (including wealthy countries) notable for their lack of contribution. So, to some extent, there has been a recognition of the fact that new knowledge is an international commodity and that it is unrealistic to expect a small number of countries to pay for a commodity that is used by many other countries. In the early 1990s, numerous attempts were made to formally internationalise basic research in high-cost areas such as manufacturing and the like. However, these government-inspired attempts tended to be grandiose in concept and highlighted the differences between research cultures in different countries rather than the similarities. A number of attempts were also enormously expensive, requiring member countries to contribute to multi-billion dollar research pools in order to derive benefits (which were sometimes published free-of-charge at a later time).

Governments can only create unnatural and untenable alliances between research groups by targeting funds towards internationalised research efforts. Moreover, if there is a push towards creating international research networks, to which each country needs to contribute financially (before extracting returns), then poorer countries are automatically excluded from the new-knowledge pool and the "network" is isolated from potential sources of new knowledge in poorer countries. Therefore, the real contributor towards a genuine internationalisation of research is communications technology. Computer networking has not only enabled researchers to communicate around the world, at a low cost, but it has also opened up possibilities for group interaction and the creation of universities that transcend political and social boundaries. The "cyber universities" or "virtual universities", that have emerged through networking, allow researchers around the world to create research centres (and entire universities) that only exist within global computer networks. A group of individuals, with common interests, can have lectures, meetings, seminars, etc. through the network and share information in a relatively efficient manner.

Within the early decades of the 21st Century, it is quite likely that mobile telephone services (and VLSI technology) will have evolved to the stage where telephones will be of comparable size to a hearing aid and will be universally available as a result of reduced production costs. If one then considers that cochlear implants, of assistive hearing devices, were already in place in the 1980s then, what was once science fiction (mental telepathy between beings) becomes close to reality as people in different countries can converse, almost telepathically, with one another as though they were in the same room. The integration of cable/satellite-based voice, video and data services will further erode political, international and geographic boundaries and enable research groups to interact more effectively than they currently do within their own campus. So, the mechanisms for the total internationalisation of the knowledge creation and impartation process are fast falling into place and the justification for enormous amounts of government expenditure on buildings, etc. is diminishing (as it is in many work-place environments where the concept of the "virtual office" is embraced). However, this technological change dramatically enhances the need for structural changes within the traditional university system.

When universities first emerged, the cost of knowledge (relative to its benefits) was the most important factor in determining the proportion of society that should be educated and the extent to which it should be educated. For example, in the 13th Century, the need for intellectuals and technocrats, in a relatively primitive agricultural society, was somewhat limited and so only a small proportion of society was educated at all and even fewer at university level. Many centuries later, the same criteria need to be applied. However, we now find that a technocratic society requires most of its constituents educated to university level and we also find that the incremental cost of educating more and more people can be reduced through the application of communications technology. Again, however, there needs to be a recognition, in the traditional university system, that university-level education is no longer just for the academically elite. In addition, there needs to be a recognition that the life-span of knowledge has reduced considerably as a result of increasing technological change and, therefore, that universities must become part of an ongoing educational process if they are to have meaning to their students and to the industries that employ their students.

In some countries, traditional universities (most notably in the United States) retained their prestige positions and their competitive-edge over other universities through endowments from companies and philanthropists that may have had some alumni connections with those universities. In Commonwealth countries, traditional universities retained a competitive advantage through government funding arrangements that were preferentially geared towards older universities. As a consequence, many of the ideals that emerged in the 13th Century are still evident today, despite untold changes in society and technology. Inevitably, these traditional structures have become less and less relevant, and the structures that supported them (industry and government benefactors) have become more and more inquisitive of their worth. Therefore, as developed countries face greater competition from developing countries, with more modern university structures, even the most traditional universities will need to assess their long-term role if they are to survive at all.

In the final analysis, it needs to be recognised that, while universities commenced as islands of knowledge, they are now part of a much more complex societal and economic structure, that has both national and international significance. If universities are to be tributaries to a society, and not museums of learning, then they must be no more immune from the changes in that society than the people and industry that support their existence.