CHAPTER

Universities, Businesses and Public Authorities — and the Inclusive Development of Society

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EARLIEST HIGHER EDUCATION IN THE U.S.

American higher education has reinvented itself many times since its founding in the 18th century. Originally conceived as a vehicle for educating clergy and for the evangelization of indigenous native tribes to Christianity, America's oldest private institutions were religious and focused on studies of the Old and New Testament, complemented by studies of Latin, Greek, rhetoric and arithmetic, as was fashionable in Europe at roughly the same time. Indeed, the seemingly benevolent outreach to the soon-to-be-displaced Native Americans persists to this day in the seal of Dartmouth College, which was founded in 1769. Despite such images, very few Native Americans or freed slaves, and certainly no women, were admitted to such institutions, which were populated almost exclusively by upper-class white males. Teaching was emphasized, with faculty members often called upon to act as tutors.

As American higher education entered the public realm with the establishment of the University of North Carolina at Chapel Hill in 1789, the religious focus of the private institutions/seminaries began to wane, and a roughly common curriculum focused on secular studies was adopted at public and private schools alike. Reflecting the broad interests of Thomas Jefferson, its founder (as well as the third American president and author of the Declaration of Independence), the University of Virginia offered practical studies appropriate for the gentleman farmer or the upper-class architect from its founding in 1819. However, top-quality higher education was limited to only a few such institutions.

Not until after the American Civil War (1861-1865) was serious consideration given to educating the masses beyond primary or secondary education. Given that higher education was generally considered a luxury, it remained broadly accessible only to the upper classes. But even in this unsettled period of American history, the value of education and training for practical careers was becoming increasingly apparent in a local context. However, most public higher education that was available was typically of poor quality and was narrowly focused on preparation for a career as a schoolteacher, doctor, lawyer, military officer or minister. And in a nation lacking easy transportation, only unusually highly motivated students would be able to travel the very long distances that separated their homes from the existing high-quality colleges.

LAND GRANT COLLEGES

Nonetheless, in facing the hardships associated with opening the American frontier, groups of citizens in largely rural American towns began to recognize the importance of developing an appreciation for evolving technologies. This was especially true for those advances related to improved crop yields and to the use of the newly developed tools that made efficient manufacturing possible. In the oldest of American traditions, such groups organized themselves into political alliances and took their pleas for distributed access to practical higher education to the national legislative bodies. Some of these local advocacy bodies persist to this day: for example, the Watauga Club of Raleigh, N.C., led the political charge for applied higher education in North Carolina through the founding of North Carolina Agricultural and Military College (now North Carolina State University) in 1887, and still meets monthly in Raleigh. To this day, it still counts among its members the most highly placed political figures, business leaders and higher-education presidents and chancellors in the state.

In the mid-19th century, such groups from around the nation joined forces to lobby for a new kind of higher education based on economic development of the sponsoring state. With the passage of the Morrill Act by the U.S. Congress in 1862, each state was empowered to establish a college or university dedicated to addressing the needs of local communities by applying these new and evolving technologies in solving practical local problems. To be financed through a generous donation of federal land to each state (30,000 acres for each elected member of the U.S. House of Representatives), these land grant institutions were to educate the populace in "agriculture and the mechanic arts". In this way was born the land grant college which, together with the "normal school" for teacher training, provided for the first time broad access to higher education by the working class. From their beginnings, land grant colleges have represented the best in collaboration and cooperation between the university and its state-wide community. The land grant model has prospered and continues to this day as an accessible route for practical-minded students to achieve upward mobility through higher education. In this model, service to the community and strong interaction with private concerns became valued as complements to the dominant teaching mission.

Land grant institutions have grown significantly in size from these early models, and now educate a large fraction of American students seeking baccalaureate and advanced degrees. In some states, one institution carries the land grant responsibilities (e.g., Texas A&M or North Carolina State), whereas in others the land grant tradition is shared within a state system (e.g., the University of California Berkeley, like all of its sister U.C. institutions, considers itself a land grant institution, although U.C. Davis acts as home institution for most of the state's agricultural programmes). In still others, the land grant tradition is secondary to another primary mission, e.g., at Massachusetts' land grant college, MIT, a private university.

Land grant schools emphasized two of the core values most cherished by the American people: openness to new ideas and social egalitarianism (Kellogg Commission, 1997-2000). Not only were enrolled students educated to become civic leaders and successful entrepreneurs, but the faculty were rewarded and recognized for service inside and outside the university community. University faculty engaged freely with the local agriculture and technical communities flourished, and strong contributions to problem solving for farmers and businessmen became routine, with an improved quality of life and enhanced productivity as the accepted performance criteria.

Most land grant institutions also established an institutional support unit, referred to as Cooperative Extension, with the explicit task of providing problem-based assistance free of charge to the individual who sought its assistance. Cooperative Extension, so named to emphasize the effort of the university to extend its expertise to the community in a true collaborative spirit, soon reached into many sites, with expert university employees, both faculty and research staff, being stationed in different regions of the state. University employees would take the results of agricultural research conducted at associated agricultural experimental stations which were federally funded through the Hatch Act of 1887. In North Carolina, for example, Cooperative Extension opened offices or research field stations in every one of the 100 counties and in the Cherokee Indian reservation in the western part of the state to provide easy access to farmers and small businesses.

So successful were these institutions in improving agricultural and manufacturing efficiency and productivity that even in those days of nearly ubiquitous racial segregation, Congress approved a second Morrill land grant act in

1890, designed to bring segregated states in the South to the educational standards of northern land grant institutions. With this act, a state became eligible either if race was not an admission criterion or if a "separate but equal" facility was available to non-white students.

This second land grant act made possible the establishment of historically black land grant schools, with a parallel Cooperative Extension service. Later Congress extended the concept to Native American tribal colleges. Often these minority-focused programmes operate collaboratively with operational Cooperative Extension offices already existing in each state. Furthermore, funding for all of these institutions has become formulaic within the purview of the US Department of Agriculture (USDA), making continuity a reasonable expectation, but forcing annual political lobbying by higher-education groups for maintaining the Cooperative Extension budget.

Within the last decade, the land grant concept has been applied as well to small business start-ups, whose requirements for technical advice usually involve engineering expertise. Accordingly, the Industrial Extension Service provides an infrastructural basis for the Manufacturing Engineering Partnership (MEP), which in turn is funded by the National Institute for Standards and Technology (NIST), which requires matching funding from each state. Unlike Cooperative Extension, the MEP requires annual evaluation of proposals focused on innovative technologies likely to be successful in the creation of jobs. MEP programmes have been very effective in helping academic scientists and engineers understand real-world problems that require creative applications. These, in turn, have been the basis for collaborative research at the university conducted in partnership with private sector businesses. They have also provided a forum for important continuing/executive education in many business/management colleges.

RESEARCH UNIVERSITIES

The founding of Johns Hopkins University in 1876, America's first research university, represented the next step in American higher education, emulating the German model of graduate education in which scholarly investigations are conducted within a group working under the supervision of an expert professor. The research university model emphasized the creation of knowledge over other institutional missions. Thus, teaching and professional/community service were overtaken by an emphasis on scholarly research. Ira Remsen, a professor of chemistry, became a model faculty member in advocating for strong collaborations with an emerging chemical industry. Academic rank and career progress for faculty began to be linked to research productivity, and peer review emerged as a reliable, fair and convenient means by which the quality of faculty research could be judged.

If research productivity was to be a primary measure for academic success, the value of apprentice researchers within the research group soon became apparent (Kunhardt, 2004). Accordingly, graduate education became an important component of the portfolios of the nation's best universities. In order to bring such institutions together for discussions of best practices in graduate education and to advocate for national policies that support such institutions, the American Association of Universities (AAU) was founded in 1900 by 14 institutions offering the Ph.D. degree. To this date, AAU continues its traditions of facilitating research collaborations and of acting as a forum for discussion of policy issues affecting the nation's research universities.

Because the success of an institution depended on research quality, so too would the ability of faculty to attract graduate students and to provide the resources and instrumentation that would allow them to conduct state-of-the-art investigations. This, in turn, required financial support which was best available at the time either through sponsored research conducted with industry or through philanthropic contributions. Wisely, private institutions worked energetically to accumulate endowments that would ultimately be used in support of faculty scholarship. Public institutions, in contrast, continued to rely on support from state legislative sources.

The growth of land grant universities was based upon a practical response to national needs. Likewise in the 1960s, the nation responded to the threat embodied by the Russian launch of Sputnik by recognizing broadly the need for broad and deep American expertise in science and engineering. Major new investments from federal sources, especially through the National Defense Education Act, enhanced the U.S. position in technical fields. For new public universities, founded in order to accommodate the "Baby boom" children, i.e., those born in the years immediately following the end of World War II, such funds were a lifeblood and a motivation for focus on top-quality scientific research of vital importance to the nation.

It was in this milieu that the University of California at San Diego (UCSD) was founded. Building on the excellent reputation of her sister schools within the University of California System and upon the unique coastal community present in San Diego, UCSD evolved in less than four decades from a single facility on a barren bluff overlooking the Pacific into one of the top universities in the world (7th in U.S. R & D and 13th in the world on the Shanghai Jong Tao University list). Its success was driven by generous state support, by the highly entrepreneurial culture of southern California and by the clarity of the research focus inherent in the California Master Plan for Higher Education. It is, perhaps, the most compelling example of the revolutionary effect of federal investment on producing world-class knowledge in a public setting. Its success is closely aligned with the development of world-class commercial clusters of technical excellence in wireless communications and in biotechnology that have followed from this model.

RESPONSE TO SCIENCE AS THE ENDLESS FRONTIER

Before World War II, many of the most prestigious universities in the U.S. funded research through their own resources. A chemistry professor now retired from an Ivy League institution told me anecdotally several years ago that when he sought permission to seek financial support for his research from the federal government, he was rebuffed by his president who told him it would be insulting to the institution to even suggest that the school would not or could not meet the research funding needs of its faculty. Nowhere in the U.S., I can assure you, would comparable advice now be offered.

This situation changed dramatically when the U.S. government during WWII recognized that research contributions critical to the war success were made by university faculty, e.g., radar, quinine, the atomic bomb, etc. Vannevar Bush (1945), then science advisor to President Truman, persuaded federal decision-makers to accede to a compact in which the nation's research universities would be identified as the primary sites for federally supported basic research. Unlike Europe, where national laboratories were the primary sites for research, U.S. basic research would be conducted in universities, with funding deriving largely from the federal government, either in support for projects proposed by individual investigators or through scholarships or fellowships for students.

And there were plenty of students, many of whom had never seriously considered a university education, much less the possibility of pursuing a graduate degree. These options became possible only because of the opportunity afforded returning soldiers through the GI Bill, which paid full tuition costs for qualified students, regardless of family resources. Support for science and engineering was significant during the Cold War years, and the launch of the Russian satellite Sputnik in 1957 shocked the nation so thoroughly that Congressionally mandated investment took off. The National Defense Education Act was so generously funded that many female Americans began to join with their male counterparts in studying science, mathematics and engineering. Not only were technical careers considered as stable and well-paying, but proceeding toward a career in science or engineering was considered patriotic. And with President Kennedy's announcement in the early 1960s that the United States would put a man on the moon before the end of the decade, interest in applied science and engineering soared.

RESEARCH FLAGSHIP INSTITUTIONS

Top-quality science and engineering would be conducted at the best universities which would be staffed by the most productive and most creative faculty. Typically, each state's leading public institution (occasionally more than one) would concentrate its research resources, including expensive instrumentation, in the so-called flagship (Ayers & Hurd, 2005). Research would be emphasized strongly at such institutions, even at the cost of teaching quality, and a major requirement of faculty at such institutions became securing external support for their research efforts. In the 1960s this source was typically the federal government, with additional funds available from the state. Indeed, about 2/3 of national R & D was funded by the government and about 1/3 by private industry.

Interdisciplinary research and the construction of core facilities attracted outstanding scholars, and access to researchers from non-flagship institutions and from nearby industrial research centres became more common upon establishing cooperative agreements with the centre directors. By rubbing shoulders with academic researchers, industrial scientists began to collaborate much more frequently and groups of industries began to form industrial consortia centered on research problems around which major academic research centres were founded. The federal government responded by shifting a portion of research support away from individual investigators to engineering research centres, science and technology centres, etc., virtually all of which were university-based, led and managed by a university professor with world-class expertise in a focused area.

Unfortunately, as these research parks arose, general academic support of state universities began to decline, as did federal support (in constant dollars) for the physical sciences. Only funding from the National Institutes of Health (in areas ranging from basic life sciences through translational medical research in clinics) experienced continued substantial growth. The share of national R & D shifted from the government toward the private sector, with about 2/3 of R & D (mostly development) being funded by industry by the early 1990s.

Many U.S. public institutions began to receive only a small portion of their budgets from state appropriation: for example, in 2003-04, UCSD received only 14% of its budget funding from state appropriation. The financial advantage to cooperation with industry became obvious.

RESEARCH PARKS

As relationships improved between university and industrial scientists, many universities made land available adjacent to or at least nearby the campus. Typically, an established company would sign a multi-decade land lease, with the right to sublease or sell the facility under certain conditions. A laboratory/office complex would be built, with the intention of encouraging collaborative work with the university. After expiration of the lease, the structure would revert to the university, presumably to be remodeled and reused for academic purposes or collaboration. The university would benefit immediately in deriving income from the land lease and the future expansion of company-sponsored research at the university was anticipated.

Many such parks appeared, but usually there were only a small number of tenants, and often of different interests. The financial benefit from the land lease was soon subsumed into the university budget, and the anticipated sponsored research rarely materialized at the projected level. Concerns about ownership of intellectual property inhibited the free exchange of ideas.

Michael Porter of the Harvard Business School later rationalized the muted success of such ventures, as having failed to develop a cluster of innovation, i.e., a critical mass of overlapping expertise to make the research park a site sought by new graduates as a feasible career accelerator. Richard Florida (2002), in his book *The Rise of the Creative Class*, argued that talent, technology and tolerance are key in developing such a cluster, and that geographical proximity to the university was not enough to assure the success of the research park model.

CENTENNIAL CAMPUS

An alternative model was pursued on the North Carolina State University research park. In the university's centennial year in 1987, the North Carolina Governor, James Hunt, transferred 1,000 acres of green agricultural land to the university with the intention of fostering collaborations between fledgling businesses and the university. University R & D would be a major driver for identification of partners, and, after an appropriate period of growth, the model would encourage the evolving businesses to step-up to Research Triangle Park (RTP), a cluster where large information technology and telecommunication business clusters had been developed in partnership with the N.C. Department of Commerce. The start-up businesses located on the Centennial Campus were housed in buildings constructed under several different arrangements: university buildings constructed with state appropriations; research buildings, constructed on state-guaranteed loans to be repaid from indirect costs earned on collaborative research grants; partner buildings, constructed with university bonds paid by lease payments by university or private sector tenants; and venture buildings, constructed by a third party for-profit investors who agreed to lease only to tenants approved by the university as continuing research partners. Although those businesses that located on the Centennial Campus paid full market-rate leases, their employees were also eligible to participate in university life, with benefits ranging from use of the library and fee-for-service access to instrumentation to the use of university recreation facilities and access to reduced admissions to some intercollegiate athletic events.

With this model, collaborations with the private sector flourished, with more than 60 small businesses choosing to co-locate with faculty researchers. Faculty were able to learn of practical applications and marketable products made possible by their basic research, and often served as co-principal investigators with company scientists and engineers in seeking research sponsorship. Skilled employees with advanced degrees offered to teach upper-division undergraduate classes and freshman seminars as adjunct faculty, an option that many of the industrial researchers found energizing. Students benefited by having on-campus access to well-paying part time jobs, internships within their academic interests, co-op experiences, or academic credit for faculty-sanctioned research projects supervised by business employees who qualified as adjunct faculty.

TECHNOLOGY TRANSFER: UNIVERSITIES AS ECONOMIC DRIVERS

Because most of the collaborative research was fundamental and because publication in the open literature was the expected course for student work, most collaborative projects avoided intellectual property (ip) concerns. When research was sponsored by companies, the disposition of ownership was negotiated before work was undertaken, and both parties were well aware of the agreement. Typically, these agreements involved exclusive or non-exclusive licensing, depending on the level of financial support being proposed, with the university retaining ownership of the patentable work. They usually also agreed on disposition of legal fees and on responsibilities for legal defence against infringement. Occasionally, such agreements would entail the university accepting equity in the start-up. The negotiations were sometimes difficult, especially if the sponsoring research organization sought sole ownership of the sponsored research or if the company wanted background ip rights or a protracted (longer than 90 days) publication delay (Lovett, 2004).

If a U.S. federal government agency, rather than an interested company, was the primary research sponsor, the provisions of the Bayh-Dole Act (1980) were applied. This Congressional law was designed to encourage more frequent utilization of intellectual property produced with federal funding. Specifically, it allowed for the transfer of inventions or intellectual property from the owner university to a partnering business for further development, including commercialization. The contracting university would typically offer a restricted licence to the invention, but would retain "march-in rights," defined as the ability to retract the disposed intellectual property if the university or the federal government determined that it was not being commercialized or made available to the public on a reasonable basis. In practice, agreements were nearly always reached if a company was serious about the intent to commercialize, but often only after a prolonged period of legal manoeuvring that could be distasteful to either party. Thus, even with the clarifications of Bayh-Dole, American universities and private partners still continue wrangling over details and shared ownership and responsibilities for every new invention.

CONNECT

An alternative method for assisting in commercialization was proposed at the University of California at San Diego (UCSD) in 1985. As part of its Extension offerings, UCSD convened over 200 private sector members, including research and academic institutions, life science and technology companies, service providers and government entities. Called UCSD-CONNECT, the organization initially focused on educational programmes on entrepreneurship. Over 100 events have been produced each year, making UCSD-CONNECT the most successful business accelerator in the country, with over 1,000 new companies with over $10 billion in financing having participated. UCSD-CONNECT has offered continuing education on evolving technologies through its Frontiers in Science and Technology programmes and through its Financial Forums and has provided invaluable recognition for new start-ups and large successful companies through its awards programmes.

A major programme of importance to efficient technology transfer is a series of confidential presentations, referred to as Springboards, which provide local inventors and technology. Recognizing that the key components of a successful technology cluster are: science and technology, talent and invested money, the officers of UCSD-CONNECT assemble representatives from each of these components to effect smooth technology transfer. Not only UCSD, but also San Diego State University and major research institutions located within walking distance of the UCSD campus (e.g., Scripps Research Institute, Salk Institute and the Burnham Institute) have benefited.

Springboards assemble the interested parties for confidential evaluations at five levels. In the first stage, Ideas/Concepts, inventors seek to obtain a candid opinion regarding marketability of their new technology and advice on how to construct a viable business plan. In the second Springboard, appropriate seed or angel financing is attained to implement the plan. At the third stage, Series A financing is identified for full product development, and at the fourth stage, the company will have reached a mature stage in which series B or C financing is required for product testing and marketing to take the company to an initial public offering (IPO) or to a stage that can lead to being acquired by a larger company. Finally, at the fifth stage, the officers of the new company engage with the business community to become contributing intrapreneurs, thus perpetuating the Springboard cycle. This sequence has had a dramatic positive effect on the local economy, particularly in telecommunications and biotechnology. It has also contributed significantly, as a consequence, to the extremely positive goodwill with which the university is regarded by local business leaders.

More recently, members have called on UCSD-CONNECT to act as well as an aggressive political advocate on behalf of research and innovation. Since political lobbying lies outside the university's educational mission, a sub-set group, to be called CONNECT, will soon split away from UCSD-CONNECT as a public non-profit entity. This group will seek to provide an independent voice for the San Diego technology community on legislative matters of concern to these members. Among these issues being addressed in the coming year are: quality of K-12 education, state funding for university outreach programmes focused on academic preparation, proper levels of investment in public higher education, state and national R & D tax credits, government restrictions on stem cell research, handling of H-1B visas, easy entry restrictions for foreign graduate students, and more narrowly interpreting the deemed export restrictions.

OPEN SOURCE AS AN ALTERNATIVE MODEL FOR TECHNOLOGY TRANSFER

Many of the problems arising from partnerships between universities and private sector research collaborators ultimately rest on adaptable intellectual property policies. An alternative to owned/licensed intellectual property has arisen within the last decade within the information technology community. Thus was born the open source movement that posited that when information is publicly viewable and modifiable, a better product will result than if a restricted set of knowledge workers attempt to solve a problem.

The open source movement grew from an increasing frustration with a limited number of options in managing and adapting commercial computer operating systems (i.e., Microsoft products) for special or local applications. Without access to code, as a result of protected ip, software evolution is thwarted, according to this philosophy. Linus Torvalds began this movement by writing and making available Linux, a variant of the UNIX operating system that could run on his home personal computer. His belief is that when many people work on a common serious problem it can be more easily solved when the source code is available to the general programming community. In this approach, individuals can modify, evaluate, improve and release publicly an enhanced source code, thus facilitating the evolution of the code itself. When such improvements are shared over the internet, better software is rapidly produced compared with that attained with a traditional closed model for software development. Access is typically available through a GNU General Public License (1991) intended to guarantee freedom to share, change and distribute free software without warranty or unlicensed patents.

Two examples of the open source movement are found in Red Hat, a publicly traded open source software company, and Wikipedia, an open source encyclopedia providing information contributed by users (Wikipedia). Red Hat's philosophy is to take open source software to the enterprise market through purchased subscriptions that deliver ongoing service, product updates and performance reassurance to commercial enterprises. Wikipedia is a free-content encyclopedia that anyone can edit. Available in over 50 languages, the English language version contains over half a million contributed entries.

If comparable arrangements can be devised between universities and industrial consortia, a new era in information exchange might be expected. Participation by individual academic personnel has been broad and deep, so a future where the open source philosophy more prominently figures in university technology transfer and commercialization seems likely.

GUIRR

As such alternatives evolve, an open platform for discussion among affected groups becomes apparent. By sponsoring periodic gatherings of high-level representatives of government, industry, and research universities, the Government–University–Industry Research Roundtable of the U.S. National Academies addresses such topics as training a science workforce for the U.S., the effect of globalization on cutting-edge research, the impact of government policies and regulations, etc (Government–University–Industry Research Roundtable). In many ways, GUIRR provides a forum analogous to the early interventions into practical dimensions of higher education as provided by the land grant colleges.

CONCLUSION

Recently, many instances have appeared that challenge the American science community's compact with the American people as described by Vannevar Bush over a half century ago. A perplexing disdain for the scientific has emerged: for example, science illiteracy evidenced by widespread American curiosity about "intelligent design" as an alternative to evolution; the title of a recent *New York Times* magazine supplement article "How does the Brain Work? Who Cares?" (Holt, 2005); publication of a book by journalist Jennifer Washburn (2005), entitled *University, Inc. The Corporate Corruption of American Higher Education*, that asserts the financial corruption of the public mission of public research institutions cries for equal distribution of university funding across all schools, irrespective of mission, and hence away from research flagships; and the lackadaisical political response to cries from the science community for in-depth explorations of the effects of globalization on the free movement of scientists.

Even with such concerns, the unsurpassed achievements of American research universities in driving a technological future are based on excellence in basic research. And this excellence in turn is based on flexibility in proposing and collaborating on exciting research directions across sectors. From the initial contributions of land–grant universities to today's efforts to devise productive means by which international collaboration and competition will drive innovation, university education, enhanced through flexible new technologies, has never been so important. New and innovative ways to handle intellectual property by evolving universities will contribute toward achieving excellence in higher education.

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